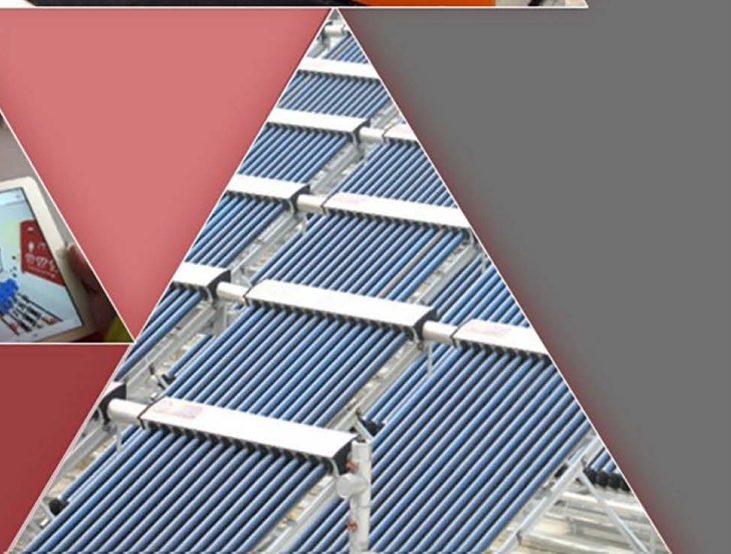
Architectural Services Department
The Government of the Hong Kong Special Administrative Region

General Specification for Building Services Installation in Government Buildings of The Hong Kong Special Administrative Region

2022 Edition
(Incorporating Corrigendum No.GSBS01-2022)



INTRODUCTION

This General Specification for Building Services Installation 2022 Edition aims to lay down general obligations; technical requirements of materials and equipment; standards of workmanship; requirements on installation, operation, maintenance, testing and commissioning; as well as requirements on document submissions for building services installation in Government premises of the Hong Kong Special Administrative Region (HKSAR). The present edition is developed from the 2017 edition of the General Specifications for various types of building services installation by the Architectural Services Department (ArchSD).

This document has incorporated applicable international standards and codes as well as technological developments with applications in Hong Kong. To align with the Government's policy on smart city development, this document also introduces Modular Integrated Construction (MiC); MultiTrade Integrated Mechanical, Electrical and Plumbing (MiMEP); decarbonisation features; as well as innovation and technology (I&T) applications.

Electronic version of this document can be viewed on or downloaded for free from the ArchSD Internet homepage. As part of the Government's efforts to limit paper consumption, hard copy is not available for sale.

This document has been circulated to stakeholders within and outside the Government before finalisation. Nevertheless, ArchSD welcomes comments on its contents at any time since updating of this document is a continuous process to include any new developments that can help meeting the needs of our community.

DISCLAIMER

This document is solely compiled for building services installation Works carried out for or on behalf of the ArchSD in Government premises of the HKSAR.

There are no representations, either expressed or implied, as to the suitability of this General Specification for purposes other than that stated above. Users who choose to adopt this General Specification for their works are responsible for making their own assessments and judgement of all information contained here. The ArchSD does not accept any liability and responsibility for any special, indirect or consequential loss or damages whatsoever arising out of or in connection with the use of this General Specification or reliance placed on it.

The materials contained in this document may not be pertinent or fully cover the extent of the installation in non-government buildings and there is no intimated or implied endorsement of the sales, supply and installation of the materials and equipment specified in this General Specification within the territory of the HKSAR.

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SCOPE OF SPECIFICATION

1.1.1.1 INSTALLATION TO COMPLY WITH THIS GENERAL SPECIFICATION

The Installations shall comply with this General Specification which details the intrinsic properties (including materials and workmanship) of the Installations so far as it is not overridden by the Conditions, Particular Specification, Drawings and/or written instructions of the Supervising Officer.

1.1.1.2 SCOPE OF THE INSTALLATIONS

This General Specification, Particular Specification, Tender Equipment Schedule and Drawings detail the scope and performance requirements of the Installations. The Installations to be carried out in accordance with this General Specification shall include the design where specified, installation and supply of all materials necessary to form the complete installation including any necessary tests, adjustments, commissioning and maintenance as prescribed and all other incidental sundry components together with the necessary labour for installing such components, for the proper operation of the Installations.

Unless otherwise specified, the Installations also includes the supply of sufficient quantity of consumable materials /fuels (such as Liquefied Petroleum Gas, refrigerant, coolant, lubricant, chemicals, water, gas, electricity etc.) for inspection, testing and commissioning, the specified quantity of consumable medium as indicated in the Particular Specification and Drawings, and the loan of container (such as Liquefied Petroleum Gas bottles, etc.). On loan container shall be taken away upon the instruction by the Supervising Officer.

1.1.1.3 TERMS AND DEFINITIONS

In this General Specification, the following words and expressions shall have the meaning as assigned to them except when the context otherwise requires: -

Building Contractor	The contractor employed by the Employer for the execution of the building works.
Conditions	The "Conditions of Contract" as defined in the Contract. For Nominated Sub-contract works, the "Main Contract Conditions" and the "Sub-contract Conditions" as defined in the Nominated Sub-contract as appropriate.

Installations	The building services installation, system and associated accessories within the scope of the Contract.
equivalent standards	Internationally recognised standards acceptable to the Supervising Officer having similar requirements and specification as regards to the type of construction, functions, performance, general appearance and standard of quality of manufacture and approved by the Supervising Officer.
Proprietary brand name products or materials	The phrase "or alternative products or materials having equivalent functions or performance" shall be deemed to be included wherever products or materials are specified by proprietary brand names. Alternative products or materials of different brands or manufacture having equivalent functions or performance may substitute for the specified proprietary brand name products or materials if prior approval from the Supervising Officer has been obtained. Appropriate licences shall be obtained from the relevant rights owners.
Supervising Officer	The Supervising Officer or the Maintenance Surveyor defined in the Contract as appropriate.
Works	The works or services for the building services installation forming parts of the Contract.

1.1.1.4 ABBREVIATIONS

The abbreviations detailed in Annex I shall have the meanings assigned to them except when the context otherwise requires.

1.1.1.5 SINGULAR AND PLURAL

Words importing the singular only also include the plural and vice versa where the context requires.

1.1.1.6 DESIGN RESPONSIBILITY

Where design is specified for any part of the Installations /Works in this General Specification or Particular Specification, the design shall be checked and endorsed by a Registered Professional Engineer in Hong Kong under the Engineers Registration Ordinance (Cap. 409) in Fire, Building Services, Mechanical or Electrical discipline (or person having equivalent approved professional qualification) with proof of experience of at least 3 years in relevant Installations. The professional qualifications and experience

of this Registered Professional Engineer shall be accepted and approved by the Supervising Officer. The design of the Installations as required shall comply with the statutory requirements as well as the requirements specified in this General Specification or Particular Specification.

Where design is not specified, the detailed configuration, wiring, connection, interface, control, setup, equipment selection and installation methodology of the Installations shall be included under the Works. All drawings, calculation and installation details shall be submitted to the Supervising Officer for approval.

SUB-SECTION 1.1.2

STATUTORY OBLIGATIONS AND OTHER REGULATIONS

1.1.2.1 STATUTORY RQUIREMENTS, STANDARDS AND GUIDELINES

The execution of the Installations shall conform to all statutory enactments, Ordinances, subsidiary legislations made under the Ordinances, Code of Practices, Practice Notes, Technical Memorandum, Circulars, Guidance Notes, guidelines, manuals, specifications and procedures issued by the Government of the HKSAR. Relevant international standards, guidelines and rules of utility companies shall also be complied as appropriate. They shall be deemed to include all amendments, revisions and standards superseding the standards listed herein, which are published before the date of first notice of tender invitation for the Contract unless otherwise specified or unless the latest amendments are not allowed or approved by relevant authorities under the statutory regulations. The following are listed for particular attention.

1.1.2.1.1 Ordinances and subsidiary legislations made under the Ordinances

- Air Pollution Control Ordinance (Cap. 311);
- Boilers and Pressure Vessels Ordinance (Cap. 56);
- Building (Ventilating Systems) Regulations;
- Buildings Energy Efficiency Ordinance (Cap. 610);
- Buildings Ordinance (Cap. 123);
- Child Care Services Ordinance (Cap. 243);
- Construction Site (Safety) Regulations;
- Dangerous Goods Ordinance (Cap. 295);
- Electrical Products (Safety) Regulation;
- Electricity Ordinance (Cap. 406);
- Electricity (Wiring) Regulations;
- Energy Efficiency (Labelling of Products) Ordinance (Cap. 598)
- Environmental Impact Assessment Ordinance (Cap. 499);
- Factories and Industrial Undertakings Ordinance (Cap. 59);
- Fire Safety (Buildings) Ordinance (Cap. 572);
- Fire Safety (Commercial Premises) Ordinance (Cap. 502);

- Fire Service (Installations and Equipment) Regulations;
- Fire Services Ordinance (Cap. 95);
- Gas Safety Ordinance (Cap. 51);
- Hotel and Guesthouse Accommodation Ordinance (Cap. 349);
- Land (Miscellaneous Provisions) Ordinance (Cap. 28);
- Lifts and Escalators Ordinance (Cap. 618);
- Noise Control Ordinance (Cap. 400);
- Occupational Safety and Health Ordinance (Cap. 509);
- Ozone Layer Protection Ordinance (Cap. 403);
- Places of Public Entertainment Ordinance (Cap. 172);
- Provision of Municipal Services (Reorganisation) Ordinance (Cap. 552);
- Public Health and Municipal Services Ordinance (Cap. 132);
- Radiation Ordinance (Cap. 303);
- Residential Care Homes (Elderly Persons) Ordinance (Cap. 459);
- Security and Guarding Services Ordinance (Cap.460);
- Telecommunications Ordinance (Cap. 106),
- Waste Disposal Ordinance (Cap. 354);
- Water Pollution Control Ordinance (Cap. 358); and
- Waterworks Ordinance (Cap. 102).

1.1.2.1.2 Code of Practices

- Code of Practice for Building Energy Audit issued by the EMSD, hereafter referred as the “Energy Audit Code” or “EAC”;
- Code of Practice for Building Works for Lifts and Escalators issued by the EMSD;
- Code of Practice for Energy Efficiency of Building Services Installation issued by the EMSD, hereinafter referred as the “Building Energy Code” or “BEC”;
- Code of Practice for Fire Resisting Construction issued by the BD;

- Code of Practice for Fire Safety in Buildings issued by the BD (hereinafter referred as the “Fire Safety Code”);

- Code of Practice for Fresh Water Cooling Towers issued by the EMSD;

- Code of Practice for Lift Works and Escalator Works issued by the EMSD;

- Code of Practice for Means of Access for Firefighting and Rescue issued by the BD;

- Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment issued by the FSD;

- Code of Practice for Prevention of Legionnaires' Disease issued by the Prevention of Legionnaires' Disease Committee, the Government of the HKSAR;

- Code of Practice for Safety at Work (Lift and Escalator) issued by the LD;

- Code of Practice for the Electricity (Wiring) Regulations published by the EMSD;

- Code of Practice for the Provision of Access Facilities in Buildings for the Supply of Telecommunications and Broadcasting Services issued by the OFCA;

- Code of Practice for the Provision of Means of Escape in Case of Fire issued by the BD;

- Code of Practice for the Structural Use of Steel 2011 issued by the BD;

- Code of Practice on Avoidance of Damage to Gas Pipes issued by EMSD;

- Code of Practice on the Design and Construction of Buildings and Building Works for the Installation and Safe Use of Lifts and Escalators issued by the BD;

- Code of Practice on the Design and Construction of Lifts and Escalators issued by the EMSD;

- Code of Practice on the Handling, Transportation and Disposal of Asbestos Waste issued by the EPD;

- Code of Practice on the Handling, Transportation and Disposal of Polychlorinated Biphenyl (PCB) Waste issued by the EPD;

- Code of Practice on the Packaging, Labelling and Storage of Chemical Wastes issued by the EPD;

- Code of Practice on Wind Effects in Hong Kong 2019, issued by the BD;

- Code of Practice on Working near Electricity Supply Lines issued by EMSD;

- Code of Practices and other requirements issued by the Gas Standards Office (GasSO) of EMSD; and

- Code of Practices issued by the LD.

1.1.2.1.3 Practice Notes, Technical Memorandum, Circulars, Guidance Notes, Guidelines and Manuals issued by the Government of the HKSAR

- A Guide to the Water Pollution Control Ordinance issued by the EPD;

- Circular Letters issued by the FSD;

- Circular Letters issued to Licensed Plumbers and Authorized Persons by the WSD;

- Circulars on Lifts and Escalators issued by the EMSD;

- Construction Site Safety Manual issued by the Development Bureau, the Government of the HKSAR;

- Design Manual: Barrier Free Access published by the BD;

- Grease Trap for Restaurant and Food Processors issued by the EPD;

- Guidance Notes for Solar Photovoltaic (PV) System Installation issued by the EMSD

- Guidance Notes for the Electrical Products (Safety) Regulation, published by the EMSD;

- Guide to Application for Water Supply issued by the WSD;

- Guidelines for the Design of Small Sewage Treatment Plants issued by the EPD;

- Guidelines on Maintenance and Repair of Drainage System and Sanitary Fitments issued by the BD;

- Practice Notes for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers issued by the BD;

- Practice Notes of Professional Persons Environmental Consultative Committee issued by the EPD;

- Public Lighting Design Manual issued by the HyD;

- Requirements from relevant authorities for licensed premises.

- Stormwater Drainage Manual issued by the DSD;

- Technical Guidelines for Connection to District Cooling System issued by the EMSD;

- Technical Guidelines on Code of Practice for Building Energy Audit issued by the EMSD;

- Technical Guidelines on Code of Practice for Energy Efficiency of Building Services Installation issued by the EMSD;

- Technical Guidelines on Grid Connection of Renewable Energy Power Systems issued by the EMSD;

- Technical Memorandum - Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters, issued by the EPD;

- Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites, issued by EPD;

- Technical Memorandum on Environmental Impact Assessment Process, issued by the EPD;

- Technical Memorandum to issue Air Pollution Abatement Notice to control Air Pollution from Stationary Processes, issued by EPD;

- Technical Requirements for Plumbing Works in Buildings issued by the WSD; and

- Technical Specifications on Grey Water Reuse and Rainwater Harvesting by WSD.

1.1.2.1.4 Specifications and Procedures issued by the Government of the HKSAR

- General Specification for Building issued by the ArchSD;

- General Specifications and requirements issued by EMSD;

- Green Specifications on green procurement of items adopted by Bureaux and Government Departments maintained by the EPD;

- Specifications issued by the Office of the Communications Authority; and

- Testing and Commissioning Procedures issued by the ArchSD.

1.1.2.1.6 Rules, Requirements and Regulations issued by the Utilities Companies

- The Supply Rules and other requirements issued by the relevant local electricity suppliers; and

- Rules and regulations for town gas supply of The Hong Kong and China Gas Co. Ltd..

1.1.2.1.7 Standards, Codes and Guidelines issued by Institutions

- American National Standard/NSF International Standard Number 50 "Circulation System Components and Related Materials for Swimming Pools, Spas/Hot Tubs";

- ASME A17.1:2013, Safety Code for Elevators and Escalators;

- ASME A18.1:2020, Safety Standard for Platform Lifts and Stairway Chairlifts;

- British Effluent and Water Association "Code of Practice for Ozone Plant for Swimming Pool Water Treatment";

- BS 5839-1:2017 (Incorporating Corrigendum No.1) Fire Detection and Fire Alarm Systems for Buildings – Part 1: code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises, FSD Circular Letter No. 6/2021 and all the subsequent amendments by the FSD (hereinafter referred collectively as Modified BS 5839-1);

- BS 6440:2011, Powered Vertical Lifting Platforms having non-enclosed or partially enclosed liftways, intended for use by persons with impaired mobility – Specification;

- Chartered Institution of Building Services Engineers (CIBSE) Guides: Guide G – Public Health and Plumbing Engineering Chapter 10 Swimming Pools.

- Codes of Practice published by the UKLPGA, or acceptable equivalent;

- DIN 19643-1 to -4:2012, Treatment of water of swimming pools and baths;

- EN 81-40:2008, Safety rules for the construction and installation of lifts. Special lifts for the transport of persons and goods. Stairlifts and inclined lifting platforms intended for persons with impaired mobility;

- EN 81-41:2010, Safety rules for the construction and installation of lifts. Special lifts for the transport of persons and goods. Vertical lifting platforms intended for use by persons with impaired mobility;

- GB 50011-2008, 'Code for Seismic Design of Buildings' where seismic design consideration is required;

- Loss Prevention Council Rules for Automatic Sprinkler Installations (including all the LPC Technical Bulletins, Notes, Commentary, and Recommendation) incorporating BS EN 12845: 2015, FSD Circular Letters No. 4/2010, No. 2/2017, No. 5/2020, and all the subsequent amendments by the FSD (hereinafter referred collectively as LPC Rules for Sprinkler Installations);

- IEC 60364-7-704:2005: Low-voltage Electrical Installations – Part 7-704: Requirements for Special Installations or Locations - Construction and Demolition Site Installations;

- ISO 10523:2008, Water quality – Determination of pH;

- ISO 6107-1:2004, Water quality – Vocabulary;

- ISO 9386-1:2000, Power-operated lifting platforms for persons with impaired mobility – Rules for safety, dimensions and functional operation – Part 1 : Vertical lifting platforms;

- Rules of Fire Offices' Committee (Foreign), United Kingdom, for the Installation of External Drenchers;

- WHO Guidelines for Safe Recreational-water Environments Vol. 2: Swimming Pools and Similar Environments; and

- International Standards and Code of Practices issued by the following internationally recognised institutions: -

    - American National Standard Institute
    - Air-conditioning and Refrigeration Institute
    - American Society of Mechanical Engineers
    - American Society for Testing and Materials
    - British Standards Institute
    - Committee for European Normalisation
    - Factory Mutual, United States
    - Loss Prevention Council, United Kingdom
    - The Institute of Electrical and Electronic Engineers
    - International Organisation for Standardization

- Japanese International Standard
- National Fire Protection Association;
- Underwriters' Laboratory, United State

1.1.2.2 CASE OF CONFLICT

The documents forming the Contract are to be taken as mutually explanatory of one another but in case of ambiguities or discrepancies the same shall be dealt with in accordance with the Conditions.

1.1.2.3 REGISTERED PERSONNEL AND CONTRACTOR

The Installations shall be carried out by relevant registered contractor(s) and personnel as required by the Ordinance, in particular the following:

(a) Fire Service Installation works – Fire Service Installation contractor(s) and personnel registered under Fire Services Ordinance, Cap 95, Laws of the Hong Kong Special Administrative Region in the class(es) relevant to the type(s) of installation concerned;

(b) Electrical works – Electrical contractor(s), electrical worker(s) and Approved Competent Persons for Locating Underground Electricity Cables registered under Electricity Ordinance, Cap 406, Laws of the Hong Kong Special Administrative Region in the grade(s) relevant to the type(s) of installation concerned;

(c) Escalator works – Escalator contractor(s), engineer(s) and worker(s) registered under the Lifts and Escalators Ordinance, Cap 618, Laws of the Hong Kong Special Administrative Region;

(d) Lift works – Lift contractor(s), engineer(s) and worker(s) registered under the Lifts and Escalators Ordinance, Cap 618, Laws of the Hong Kong Special Administrative Region;

(e) Ventilation works – Ventilation contractor(s) registered under the Buildings Ordinance, Cap 123, Laws of the Hong Kong Special Administrative Region;

(f) Water works – Licensed plumber(s) registered under the Waterworks Ordinance, Cap 102, Laws of the Hong Kong Special Administrative Region; and

(g) Town gas, liquefied petroleum gas and natural gas works - Registered gas contractor(s) under Gas Safety Ordinance, (Cap. 51). Such registered gas contractor(s) shall be registered in the appropriate class of work with the Gas Authority;

(h) Any other works requiring for registered personnel or contractor under the standing statutory requirements.

Mechanical fire service installation, including ventilation/air conditioning control system, pressurisation of staircases system and smoke extraction system, shall be carried out by Registered Fire Service Installation Contractor of relevant Class registered with the FSD and under the List of Approved Suppliers of Materials and Specialist Contractors for Public Works in the Category of Air-conditioning Installation. A Registered Professional Engineer in Hong Kong under the Engineers Registration Ordinance (Cap. 409) in Fire, Building Services, Mechanical or Electrical discipline (or equivalent approved professional qualification) with proof of experience of at least 3 years in relevant design works, who emphasises on and is specialised in mechanical ventilation and air handling installation shall be employed to carry out the design and supervision of the submission, installation and testing of the mechanical fire service installation. The professional status and qualifications of the Registered Professional Engineer shall also be acceptable by FSD and the Supervising Officer.

The Installations, where applicable, shall be inspected by Registered Energy Assessor under Buildings Energy Efficiency Ordinance (Cap. 610) to ensure the installation complies with the standards and requirements under the Building Energy Code.

SUB-SECTION 1.1.3

EXECUTION OF INSTALLATIONS

1.1.3.1 THE INTERNATIONAL SYSTEM OF UNITS (SI)

The International System of Units of weights and measures shall be used for all materials, equipment and measurements.

1.1.3.2 PROGRAMME OF INSTALLATIONS

A detailed programme of the Installations shall be submitted to the Supervising Officer within 4 weeks from the contract commencement date showing the intended method, stages and order of work execution in coordination with the building construction programme, together with the duration he estimated for each and every stage of the Installations. The programme shall include at least the following: -

(a) Dates for the placement of orders for equipment and materials;

(b) Expected completion dates for builder's work requirements, i.e. when work site needs to be ready;

(c) Delivery dates of equipment and materials to the Site;

(d) Dates of commencement and completion of every stage of the Installations in line with the building construction programme, i.e. each floor level and/or zone area;

(e) Dates of documents/drawings submissions to relevant Government departments to obtain the necessary approvals;

(f) Dates of expected readiness of documents/drawings from relevant parties for all the Installations and works carried out by others for consolidated submission to the statutory authorities for comment, approval, inspection and certification;

(g) Dates of requirement of temporary facilities necessary for testing & commissioning, e.g. electricity supply, water and town gas;

(h) Date of power energisation from power supply company;

(i) Dates of fire alarm direct link application and connection;

(j) Dates of statutory inspections, testing and certifications;

(k) Dates of completion, testing and commissioning; and

(l) Short term programmes showing the detailed work schedules of coming weeks and months shall also be provided to the Supervising Officer.

Programmes shall be regularly updated to reflect the actual progress and to meet the obligations under the Contract.

In addition, detailed submission schedules for installation drawings, equipment and testing and commissioning shall be submitted to the Supervising Officer for approval. The formats and information to be included in the schedules shall be as directed by the Supervising Officer.

1.1.3.3 BUILDER'S WORK

Associated builder's works for the Installations shall be carried out by the Building Contractor unless otherwise specified in the Contract. The works shall include, but not limited, to, the following: -

(a) Construction of pits, wells, concrete supporting beams, concrete plinths, permanent access, structural steelwork, drain outlet, sump pit, permanent access for the Installations;

(b) Provisions of necessary holes, chases, openings, drain outlet, vents and other associated builder's works as required for the Installations;

(c) Provisions of concrete fill and/or grouting in for architraves, landing door frames, sills and associated safety guard, etc.;

(d) Provisions and fixing steel joists and scaffoldings required for the hoisting of equipment /materials of the Installations;

(e) Provision of anchorage point for attaching fall arrester and safety harness; and

(f) For multiple lift wells, provision of shaft dividing steelwork for supporting guide brackets, inter-well screens, partition either in the form of solid reinforced concrete or prefabricated wire mesh screen to separate each lift from an adjacent lift or its counterweight, etc.

Full details of the builder's works requirements shall be submitted within a reasonable time to the Supervising Officer for approval, so that due consideration may be given before the Building Contractor commences the builder's works in accordance with the building construction programme in the areas concerned. After obtaining the said approval of the Supervising Officer, the exact positions and sizes of all such works shall be marked and detailed information of such works shall be provided to the Building Contractor to facilitate him to carry out the builder's works as the Works proceed.

All "cutting-away" and "making-good" as required to facilitate the Installations will be carried out by the Building Contractor, except for minor provisions required for the fixing of screws, raw plugs, redhead bolts, etc. Drawings and/or mark out on Site of all "cutting-away" shall be provided to the Building Contractor within a reasonable time.

All expenses properly incurred and losses suffered by the Employer as a result of the Contractor's failure to comply with the above requirements are recoverable by the

Employer from the Contractor as a debt under the Contract or via the Building Contractor as if it is a debt liable to the Building Contractor under the Sub-contract as appropriate.

The builder's work as required in the Drawings or marked on Site shall be essential but not excessive for the execution of the Installations. In the event that any of such works is proved to be non-essential, unnecessary and/or abortive, the works shall be reinstated and rectified as instructed by the Supervising Officer, or the associated cost for making good the unnecessary works shall be recoverable by the Employer as a debt under the Contract.

All builder's works upon completion by the Building Contractor shall be checked and examined that they were so executed in accordance with the requirements to facilitate the Installations works. If at any time, it becomes apparent that any builder's works completed by the Building Contractor does not comply with his requirements in any respect whatsoever, notice in writing specifying the details of the extents and effects of such non-compliance shall be given for the attention by the Supervising Officer. The builder's works is deemed to have satisfied for the Installations after a period of 14 days from the date of completion of the builder's works if the above notice is not served to the Supervising Officer within such period. All additional expenditure properly incurred and all loss suffered in this connection by the Employer in having such works re-executed and rectified shall be recoverable by the Employer as a debt under the Contract or via the Building Contractor as if it is a debt liable to the Building Contractor under the Sub-contract as appropriate.

1.1.3.4 COORDINATION OF INSTALLATIONS

The Installations shall be coordinated with other contractors in related to the works.

The Drawings supplied only indicate the approximate locations of the Installations. Modification, if required, shall be made reasonably on the work programme, work sequence and physical deployment of the work to suit the outcome of coordination or as necessary. It shall ensure that all cleaning, adjustment, test and control points are readily accessible while keeping the number of loops, cross-overs and the like to a minimum.

Particular attention to the building works programme shall be paid so that the planning, coordination and work programme of the Installations shall suit and adhere to the building works in accordance with the building programme.

Any significant problems encountered during the coordination work which are beyond control shall promptly be reported to the Supervising Officer.

1.1.3.5 COOPERATION WITH OTHER CONTRACTORS

The works and activities necessary for the Installations shall be cooperated with the Building Contractor and all other contractors and sub-contractors of the Building Contractor in order to achieve efficient workflow on the Site and keep the Site in a clean and tidy condition.

Any significant problems encountered during the coordination work which are beyond control shall promptly be reported to the Supervising Officer.

1.1.3.6 SITE SUPERVISOR, FOREMAN AND TRADESMEN

Competent and technically qualified site supervisor shall be provided to control, supervise and manage the Works on Site as specified in the Particular Specification. The site supervisor shall be vested with suitable powers to receive instructions from the Supervising Officer and his Representative.

The site supervisor shall be technically competent and have adequate site experience for the specified Installations. The site supervisor shall have minimum 5 years on-site experience for similar type of installation works. Other specific requirements on site supervision, if any, shall refer to the Particular Specification.

Approval by the Supervising Officer shall be obtained prior to the posting of the site supervisor on Site. The site supervisor shall be replaced immediately whose experience, skill or competency is, in the opinion of the Supervising Officer, found to be inadequate for the particular work.

All tradesmen must be experienced in the trade and the work carried out shall be consistent with good practice in Hong Kong and to the satisfaction of the Supervising Officer. Attention is drawn to the Special Conditions of Contract under the Contract for the requirements relating to Qualified Tradesmen/Qualified Skilled Workers and Intermediate Tradesmen/Qualified Semi-Skilled Workers.

At least one full time competent foreman shall be provided on Site for each sub-contract and direct contract of the Installations unless otherwise specified in the Particular Specification. The trade foremen shall be registered tradesmen/skilled workers of the relevant works.

Works shall be carried out by or under the direct supervision of registered personnel as appropriate in accordance with the statutory requirements.

1.1.3.7 SAMPLE BOARD

Within 6 weeks of the acceptance of his Tender and prior to the commencement of the Installations, a sample board of essential components proposed to be used in the Contract shall be submitted to the Supervising Officer for approval. Request for longer period for the submission may be requested in writing with full justification and subject to the approval by the Supervising Officer.

Items displayed shall be deemed to be adequate for the Installations unless otherwise clearly indicated. Each sample, with clear numbering and labelling, shall be firmly fixed onto a rigid wooden or metal board. A list shall also be affixed on the sample board to show the item description, make and brand, country of origin and locations of installation (if not generally used). Samples rejected by the Supervising Officer shall be replaced as soon as possible. Upon approval of all items, the Supervising Officer will endorse the list on the sample board and the board shall be delivered to the site office of the Supervising Officer’s Representative for reference.

The board shall contain samples of all "compact" sized materials and accessories to be used in the Installations. Written approval of all samples and technical details shall be obtained from the Supervising Officer before commencement of any installation work.

In the context of this General Specification the term "compact" means any item that will fit into a 300 mm cube.

The following items, if applicable, shall be included in the sample board as a minimum unless otherwise approved by the Supervising Officer: -

(a) Air Conditioning, Refrigeration and Mechanical Ventilation Installation

- Conduit and accessories;
- Trunking and accessories;
- Cable and accessories;
- Ductwork and accessories;
- Fire damper;
- Refrigerant pipework;
- Vibration isolator;
- Acoustic and thermal insulation;
- Valves; and
- Automatic air vent.

(b) Electrical Installation

- Conduit and accessories
- Trunking and accessories
- Cable and accessories
- Wiring accessories

(c) Fire Service Installation

- Pipework, fitting and their support complete with fixing accessories;
- Cable and accessories;
- Conduit/trunking and accessories including adaptor for flexible conduit;
- Fire alarm call point, bell and flashing light;
- Sprinkler head complete with escutcheon and adaptor;
- Automatic fire alarm detector and remote indication unit;
- Flow switch, pressure switch and gauge;
- Exit sign;
- Emergency lighting;
- Duct detector with probe unit;
- Fire damper complete with fusible link/electro-thermal link/actuator;
- Automatic actuating device for fire shutter;
- Indication lamp, switch, push button etc for control panel; and
- Gas discharge nozzle for gaseous extinguishing system.

(d) Lift, Escalator and Passenger Conveyor Installation

- Lift car direction indicator;
- Lift car position indicator;
- Control station to be installed inside a lift car;
- Ceiling light to be installed inside a lift car;
- Call buttons to be installed at lift lobbies;

- Handrail to be adopted inside a lift car;
- Finishing materials to be adopted inside a lift car;
- Finishing materials to be adopted for car doors and landing doors; and
- Colour chart.

(e) Broadcast Reception Installation

- Copper coaxial cables;
- Fibre optical cables;
- Splitters units;
- Tee-units;
- Bandpass filters; and
- FM/TV/DATA outlets.

(f) Plumbing Installation

- Pipework, fitting and their support complete with fixing accessories;
- Valves; and
- Taps, shower mixers and solder materials if used.

(g) Drainage Installation

- Pipework, fitting and their support complete with fixing accessories; and
- Valves.

(h) Swimming Pool Water Treatment Installation

- G.I. Trunking
- G.I. Adaptable Box
- LSOH Cable;
- Galvanised Iron Conduit;
- Flexible Conduit
- Gun Metal Puddle Flange;
- Push Button;
- Pilot Lamp;
- Selector Switch;
- PVC Ball Valve;
- UPVC Pipe (Ozone Gas & Vent Pipe);
- UPVC Pipe Fitting (Ozone Gas & Vent Pipe) 90° Elbow;
- UPVC Pipe Fitting (Ozone Gas & Vent Pipe) Tee; and
- GMS Pipe Bracket.

(i) Mechanical Installation

- As required by the Supervising Officer and/or specified in the Particular Specification.

(j) Liquefied Petroleum Gas Installation

- Pipework, fitting and support; and
- Flexible rubber hose and tubing.

(k) Catering Equipment Installation

- Stainless steel panel;
- Valves;
- Water taps;
- Cables; and
- Electrical wiring accessories.

(l) Burglar Alarm and Security Installation

- Signal cables;
- Access card reader;
- Door release button;
- Breakglass unit; and
- Duress push button.

Additional items may be required by the Supervising Officer and/or specified in the Particular Specification.

1.1.3.8 ADVICE OF ORDER PLACED

Copies of orders placed for major items of equipment and materials shall be submitted to the Supervising Officer for record.

Where the country of origin is given in the tender offer, documentary proof of orders placed for equipment and materials supplied from relevant countries shall be submitted.

Delivery schedule for major items of equipment and materials shall be submitted to the Supervising Officer to demonstrate the adherence to the building construction programme.

1.1.3.9 RECORD OF MATERIALS DELIVERY

All materials and equipment delivered to Site shall be accurately listed and recorded in the site record books maintained by the Supervising Officer's Representative on Site or the approved Digital Works Supervision System (DWSS). Such materials and equipment shall not be removed from Site without the prior approval of the Supervising Officer in writing. Where the Building Contractor is in overall control of the Site, the Building Contractor may also be required to record details of all incoming/outgoing materials and equipment.

Technical details on equipment/materials or supporting documents (e.g. delivery note), or written declaration to confirm compliance of the equipment/materials to the Contract shall be provided to facilitate checking of equipment/materials delivered on site.

1.1.3.10 PROTECTION OF MATERIALS AND EQUIPMENT

The work shall include the safe custody of all materials and equipment as stored or installed unless the responsibility is clearly defined in the Contract that the protection on Site for delivered equipment, materials and installations is solely by other contractors. In addition, all work shall be protected against theft, fire, damage or inclement weather. All materials and equipment received on Site but not yet installed shall be carefully stored in a safe and secure place unless otherwise specified.

All cases of theft and fire must immediately be reported to the police, the Building Contractor, the Supervising Officer and the Supervising Officer's Representatives on Site with full details.

Lockable steel container or other equally secure enclosures shall be provided where necessary. The container or enclosures shall be placed within a securely fenced-in compound provided by the Building Contractor on Site for the storage of materials and equipment.

Clean, reasonably finished and lockable secure accommodation shall be provided for the storage of sensitive and/or expensive items before installation.

For temperature and/or humidity sensitive electrical or electronic control panels and equipment, temporary dehumidifiers and/or air conditioners shall be provided in the enclosures containing this equipment in order to protect them against high humidity and/or temperature. In order to protect this equipment against dust infiltration, they shall be stored in a dust free room or enclose them in heavy duty PVC sheets or bags. Where necessary, filters shall be provided in the temporary air conditioning systems.

All stainless steel parts shall be covered with PVC wrapper of tape until handover. All ferrous parts shall be painted or greased (whichever is most suitable). All bright parts (chrome plates, polished stainless steel or aluminium, etc.) which are liable to deterioration shall be covered with tallow or a suitable protective coating during the progress of work. Upon completion of work, the protective coating shall be removed and the parts polished as appropriate.

Any damage to the primer or protective coatings shall be made good. When it is necessary to remove, or partly remove the protection for installation or making connections, the standard of protection provided originally shall be re-applied at the earliest possible time.

All plants, pipes valves, and fittings shall be, as far as possible, thoroughly cleaned and cleared of rust and other foreign matters both before erection and before subjection to pressure tests.

For protection against system internal corrosion, chemical treatment of the internal water as described in Part 6 of this General Specification shall be applied. The provision of sacrificial anodes and bonding to eliminate electrolytic action shall also be applied wherever applicable.

1.1.3.11 LABEL AND NOTICES

1.3.11.1 Labels and Related Information

Labels of engraved multi-layer laminate or similar material shall be provided to all, pipework, valves, electric circuits, tanks, vessels, pumps, switches, gauges, indicators, cables, internal wiring terminals, lamps, handles, keys, instruments, gauges, control and other equipment as directed by the Supervising Officer to facilitate maintenance. All labels shall make cross reference to the operation and maintenance manuals and as-built drawings. Wording shall be submitted to the Supervising Officer for approval before manufacture.

Labels and notices required by statutory requirements shall be inscribed accordingly whereas other labels shall indicate name and purpose of the equipment together with ratings and commissioned set values where applicable.

Notices for safety warning and instructions shall be constructed of heavy gauge aluminium sheets painted with symbols or wording as appropriate.

Notices for instruction for operation and use of the equipment shall be provided as appropriate and necessary. Instructions shall be provided to all equipment for use by the general public and for operation by the operating staff.

Instructions for oiling and/or greasing of all motors, etc. shall be attached to the relevant greasing or oiling points.

Each cable core shall be cramped at both ends with cable ferrules for identification.

The standards for identify pipes, including colour coding, label location, and information about pipe contents shall generally follow BS 1710: 2014.

All labels shall be of adequate size as to give clearance between lettering and fixings to ensure an aesthetic arrangement on completion. Pipeline labels shall generally be not smaller than 100 mm x 20 mm.

Where applicable, labels shall be fixed by non-ferrous bolts and nuts or stainless steel/brass screws. Where drilling and tapping of the equipment is impracticable, approved means of glue fastening may be used subject to prior approval of the Supervising Officer.

For pipelines or valves, where applicable, labels shall be fixed by means of a key ring attached to the upper corner of the pipe mounting bracket or the hand wheel of valves. The labels shall be suspended from brass or stainless steel chain loops over the relevant pipe.

A schedule for all labels, notices, identifications and instructions shall be submitted for the Supervising Officer’s approval prior to order and

installation. The information of the schedule shall include the description of the items, height and font type of the text, dimensions of the labels and material used.

All lettering used on labels shall be "Bold" capitals (except otherwise directed) and the coloring as follows, unless otherwise specified or directed: -

- Black on white for normal purposes
- Red letters on white where connected to essential supply
- Green letters on white where operated by direct current

All labels and instructions shall be in English complete with translation in Chinese characters. The Chinese translations shall be referred to the "Glossaries of Terms Commonly Used in Government Departments" issued by Civil Service Bureau of the Government of the HKSAR. Sample of label and notice shall be submitted to the Supervising Officer for agreement. Heights for the English lettering shall be as follows with that for Chinese characters to match: -

Pipelines, valves, motor valves, fans, doors, etc.	8 mm
Greasing instructions for motors, fan bearings, etc.	6 mm
Thermostats, sensors, thermometers, pressure gauges, general instructions, etc.	3 mm
Identifying equipment in cabinets of electrical components	3 mm
Door cabinet	8 mm
Switches & indicators on panel faces	3 mm

All major equipment and components such as chiller, heat pump, boiler, heat exchanger, air-handling unit, air compressors, pumps and motors, flow switches, alarm valves, expansion joints etc. shall have factory applied permanent nameplates indicating, where relevant: -

- Name of Manufacturer;
- Model;
- Serial Number;
- Rated Duty (capacity, flow rate and pressure, etc);
- Operating Voltage, Phase, Ampere, and Frequency;
- Full Load Current and Power;
- Power Factor;
- Date of Manufacture;
- Technical standards or other Authorities' markings to indicate the compliance and grades of application; and
- Any other necessary data to conform to specified requirements and to indicate the equipment performance.

Instructions for oiling and/or greasing of all fans, motors etc. shall be attached or located near to the relevant greasing or oiling points.

A data plate shall display the information applicable to the appliance. The data plate shall be fixed in such a position that it can be easily read with the appliances in position.

Where the equipment has an operating life less than or equal to 10 years, the expiry date or the “end of service life” date has to be clearly stated on the label attached to the equipment. Labels of approved types shall be supplied and installed for fire extinguishers, fixed sprayer units, batteries, detectors and gas extinguishing system showing the expiry date of the design operating life. The label shall have a serial number of the equipment and the serial number shall be recorded on the as-built drawings.

Labels or approved identification shall be supplied and installed for the emergency luminaries, for quick identification in routine inspection.

All isolators and protective devices for protecting and/or isolating the supply from the fire alarm system shall be properly labelled to the requirements of relevant system design standards and to the approval of the Supervising Officer and the FSD.

The direction of flow of fluid shall be indicated by an arrow over the basic identification colour and painted white or black in order to contrast clearly with the basic identification colour.

Where proprietary type, rail mounted terminals are utilised in electrical cabinets, the manufacturer’s "clip-in" identification tabs shall be used.

The front plate of each switch socket or control switch feeding an essential circuit or a fixed electrical appliance, such as water heater, cooker, wall-mounted fan, wall-mounted radiator, room cooler, etc., shall be engraved according to the appliance being controlled. Details of the inscription shall be submitted to the Supervising Officer for approval. Additional engraving to accessories shall be provided as requested by the Supervising Officer.

Where distribution board is fitted with labels provided by the manufacturer of the distribution board, these labels may be used in lieu of the white plastic label provided that they are of equivalent quality and approved by the Supervising Officer.

Appliances incorporating an electrical system shall display a circuit diagram of the system, preferably on the inside of the main terminal box cover.

Where specified, barcode labels shall be fixed to the equipment and portable handset equipment for scanning and reading the barcodes shall be provided, including necessary provisions for transfer/download the data to personal computer. It shall be complete with LCD display, rechargeable batteries and software for categorising the data. Details shall be submitted to the Supervising Officer for approval.

1.3.11.2 Coded Labels

Where appropriate, items such as valves, sensing points, etc. may also be identified by "Codes" on the labels which shall relate to the items as detailed on plant room mounted diagrammatic drawings or the mimic diagrams on operational control panels. At the diagram or control panels, the function of each coded item shall also be detailed. Such systems of labelling and related diagrams shall be approved by the Supervising Officer before implementation.

Valves etc. required for emergency shutdown purposes must under all circumstances be fully detailed at the valve.

1.1.3.12 WARNING NOTICE

Warning notices shall be provided as required by the standing statutory requirements, such as Electricity Ordinance (Cap. 406), Occupational Safety and Health Ordinance (Cap. 509), the Code of Practice for the Electricity (Wiring) Regulations (Cap. 406E), etc. In addition, the following warning notices in English and Chinese shall be provided at the appropriate positions: -

(a) A label having minimum size of 65 x 50 mm marked with the words ‘DANGER - HIGH VOLTAGE’ in Chinese characters and English lettering of not less than 5 mm high to be fixed on every container or enclosure of ancillary equipment for discharge lighting installations operating at voltages exceeding “low voltage”.

(b) Danger notices worded: DANGER - PLANT ON AUTOMATIC START (危險 - 機器隨時開動) in English and Chinese shall be provided adjacent to all automatically controlled motor-driven and engine-driven pumps.

(c) A label to be fixed in such a position that any person may gain access to any moving parts of an item of equipment or enclosure will notice or be warned of such a danger.

(d) A label to indicate the maximum voltage present in an item of equipment or enclosure within which a voltage exceeding 250 V exists, or items or equipment or enclosure which can be reached simultaneously and a voltage exceeding 250 V exists between simultaneously accessible terminals or other fixed live parts: such voltages are normally not expected to exist with the equipment or enclosure.

(e) A label to be fixed in such a position that any person gaining access to the live parts of an item of equipment or enclosure, which are not capable of being isolated by a single device and not provided with an interlocking arrangement to isolate all circuits concerned, will be adequately warned of the need of taking special precautionary measures to use the appropriate isolating devices.

(f) A label with the words 'FOR EQUIPMENT OUTDOORS' for each socket outlet intended to supply equipment used at outdoors or area outside the same equipotential zone.

(g) Other labels and notices as required by the statutory requirements shall be provided where appropriate.

Warning notice sufficiently durable and legible throughout the life of the equipment shall be fixed to the appliance in a prominent position drawing the attention of the operator to any potential hazard.

All valves, isolators and protective devices for protecting and/or isolating the service or power supply of life safety system, such as fire service installation, shall be properly labelled for alerting.

Notices and instructions of use complying with the requirements of Labour Department and Occupational Safety and Health Ordinance (Cap. 509) shall be provided.

1.1.3.13 PAINTING AND FINISHES

All surfaces except otherwise specified in the particular specification, other than those indicated to be left self-finished such as stainless steel, PVC, anodised aluminium, shall be finished in first class paint work. All metallic surfaces shall be wire-brushed and cleaned to make it free from rust, scale, dirt and grease prior to painting. Primer shall be applied to metal surface on the same day as they have been clean. All work shall be carried out by qualified tradesmen/skilled workers.

All internal surfaces including cladding walls, floors, ceiling and equipment plinth of AHU and fan rooms or plant rooms affecting IAQ shall be painted by Building Contractor unless otherwise specified.

Painting shall be carried in accordance with the appropriate Clauses in the current General Specification for Building issued by the ArchSD and any amendments or revisions made thereto.

Schedule of paint colours shall be to BS 4800: 2011.

Items that do not require to be painted unless otherwise specified shall include: -

(a) Insulated ductwork with aluminium or hammer-clad finish;

(b) Insulated pipework or ductwork concealed within duct shaft or false ceiling.

(c) Copper pipework and fitting, (except where specifically stated);

(d) Stainless steel surface;

(e) Galvanised pipework, ductwork, conduit or cable tray where concealed within duct shaft or false ceiling;

(f) UPVC pipework or ductwork; and

(g) Materials with a factory applied anodised, baked enamel or painted finish, provided that the colours are approved prior to application.

All pipework in the plant rooms shall be finished generally in accordance with BS 1710: 2014 and ISO 3864-1:2011. All pipework, where exposed on surfaces outside the plant room, shall be painted either as in the plant room or to match the surrounding surface with distinguishing colour code bands plus flow arrows in the specified colour scheme as directed by the Supervising Officer.

Pipes and pipelines shall be painted in colours either in accordance with BS 1710: 2014 and ISO 3864-1:2011 or as directed by the Supervising Officer completed with the identification colour code indicators. The basic identification colour or the decoration colour shall be applied over the whole length of the pipe with colour code indicators placed at all junctions, at both sides of valves, wall penetrations and at any other places where identification is necessary as directed by the Supervising Officer.

Copper pipes and fittings for refrigerant, which are not insulated shall be polished bright by sanding, wiped with mineral spirits and coated with an approved heat resisting clear synthetic varnish.

Valves may be painted in the same colour as the associated pipework. However, if the pipeline is part of the fire service installation and has been coded only with the safety colour, the valves involved shall be fully painted "safety-red".

Insulated pipes and ductwork running in visual positions shall be plastered or otherwise finished as specified. They shall be painted in the appropriate identifying colour or as directed by the Supervising Officer another colour plus identifying colour code bands.

Uninsulated pipes and ductwork running in visual areas shall be painted in the appropriate colour throughout or painted in another colour as directed by the Supervising Officer but identified with appropriate colour code bands.

The final external treatment for insulated pipes and ductwork shall be as specified in Part 6 of this General Specification or as indicated in the Particular Specification or as directed on Site by the Supervising Officer.

All machinery, unless otherwise specified, shall be finished in a colour as instructed by the Supervising Officer at the time of installation. Supervising Officer’s instructions shall be sought in good time to obtain the materials required. In the event that no instruction is given, the plant shall be painted in opaline green with black relief on flanges in accordance with BS EN 60073:2002.

All finishing to factory assembled appliances shall be factory applied in accordance with the manufacturer’s normal practice and to a standard suitable for the duty and location of the appliances.

Where factory applied finishes are approved, touch-up paint kits and detailed instructions for making good after completion or any damage to finishes which may occur during transportation, storage, installation or commissioning. Must be obtained from the manufacturer.

Agreement on the type, brand and colour of the paint to be used shall be obtained from the Supervising Officer before the work commences. Undercoat and finish coat shall be of properly matching type and the finish coat shall give a hard gloss finish or as required.

All surfaces requiring to be painted on site shall generally be painted with at least one coat of an approved primer, two coats of an approved high gloss-finishing coat. Ferrous surfaces shall be painted with one coat of an approved primer, one coat of an approved undercoat and two coats of an approved high gloss.

All paints shall be submitted for the approval of the Supervising Officer. The volatile organic compound (VOC) content, in grams per litre, of all paint and primer shall not exceed the prescribed limit under the Air Pollution Control (Volatile Organic Compounds) Regulation or the limit set by EPD, whichever is more stringent.

VOC content of paint shall be determined by methods stipulated in Air Pollution Control (Volatile Organic Compounds) Regulation or other methods acceptable to EPD.

All painting works shall be completed and left in ventilated environment for at least 1 week, or the curing period recommended by the paint manufacturer whichever is longer, before occupation or handover of the renovated area to minimise VOC exposure.

Where painting is carried out in occupied areas with central air-conditioning or areas without good natural ventilation, pre-painting preparation and primer coat shall be carried out off-site and only the finishing coats shall be painted on-site.

Where normal painting is not practicable, all possible measures to prevent corrosion to the plant shall be applied such as special protective coverings, special anti-corrosive paints, etc. as recommended by the supplier or specified in the Particular Specification.

1.1.3.14 IDENTIFICATION OF CABLE AND CONDUIT

Cables for control circuits, inter-communication circuits, signalling circuits, and bell wiring shall be identified as required for each particular circumstance. Cables for power and lighting circuits shall be identified in accordance with IEC 60364-1:2005/Corr 1:2009 and the associated parts of the standard.

Electrical conduits, where required to be distinguished from pipelines or other services, shall use orange (BS colour reference No. 06 E 51 to BS 4800:2011) as the basic identification colour in compliance with BS 1710:2014.

1.1.3.15 IDENTIFICATION OF PIPELINES

The direction of flow of fluid shall be indicated by an arrow over the basic identification colour and painted white or black in order to contrast clearly with the basic identification colour.

Colour code numbers are those of BS 4800:2011. The schedule of colour for ready mixed paints and BS colour reference shall be in accordance to Table 1.1.3.15 (1) and Table 1.1.3.15 (2).

Table 1.1.3.15 (1) – Schedule of Colours

Description of Services		Basic Colour	Colour Code Indication 100mm approx.			Basic Colour
Pipework:						
Water	Drinking	Green	Blue			Green
	Cooling	Green	White			Green
	Boiler Feed	Green	Crimson	White	Crimson	Green
	Condensate	Green	Crimson	Emerald Green	Crimson	Green
	Chilled	Green	White	Emerald Green	White	Green
	Mains supply, cold	Green	White	Blue	White	Green
	Mains supply, hot	Green	White	Crimson	White	Green
	Sea, river, untreated	Green	Green			Green
	Fire fighting	Green	Safety Red			Green
Gases	In either gaseous or liquefied condition (exception)	Yellow orche				
Compressed Air		Light blue				
Steam		Silver grey				
Oil Lubricating		Brown	Emerald Green			Brown
Gas	Town	Yellow orche	Emerald Green			Yellow orche
	Natural	Yellow orche	Yellow			Yellow orche
Drainage		Black				
Acids & Alkaline		Violet	Black & Yellow Stripes			Violet
Equipment:						
Plant		Opaline Green				
Electrical Conduits and Ductwork		Orange				
Ductwork		White				

Table 1.1.3.15 (2) – BS Colour Reference

	BS Colour Reference Code of BS 4800:2011
(1) Basic Identification Colours	
Green	12D45
Silver grey	10A03
Brown	06C39
Yellow ochre	08C35
Violet	22C37
Light blue	20E51
Black	00E53
Orange	06E51
(2) Safety Colour	
Red	04E53
Yellow	08E51
Auxiliary blue	18E53
(3) Code Indication Colour	
Crimson	04D45
Emerald green	14E53
Yellow	10E53

1.1.3.16 GUARD AND RAILING FOR MOVING AND ROTATING PARTS OF EQUIPMENT

All dangerous, moving or rotating parts of equipment shall be provided with an approved guard and railing complying with the Factories & Industrial Undertakings (Guarding and Operation of Machinery) Regulations, (Cap. 59Q), together with any amendments made thereto.

Guards shall be rigid and of substantial construction and shall consist of heavy mild steel angle frames, hinged and latched with either heavy galvanised mild steel wire crimped mesh securely fastened to frames or galvanised sheet metal of 1.2 mm minimum thickness. All apertures shall be such that finger access to dangerous part is not possible. All sections shall be bolted or riveted. Railings shall be made of 32 mm dia. galvanised mild steel pipe and railing fittings.

(a) Temporary Guards

All moving parts shall be adequately guarded by temporary guards during the execution of work.

Adequate temporary guard railings etc. around dangerous floor/wall openings in the vicinity of any work for the protection shall be provided.

For the safety of workers, guard railings etc. are to be provided by the Building Contractor.

(b) Permanent Guards on Plant

Unless specified otherwise in the Particular Specification, removable guards or railing for protection from moving or rotating parts shall be provided. The configuration and construction of safety guards for moving parts such as belt drives shall conform to the requirements laid down in the Factories & Industrial Undertakings (Guarding and Operation of Machinery) Regulations.

1.1.3.17 SERVICE CONDITION

The following service conditions shall apply to material and equipment: -

Climate	:	Hong Kong (tropical);
Ambient temperature	:	–5°C to +40°C (continuously 4 hours) Average 0°C to +35°C (over 24 hours);
Altitude	:	up to 2000 m above sea level; and
Relative humidity	:	99% maximum non-condensing.

1.1.3.18 VOLTAGE COVERED BY THIS GENERAL SPECIFICATION

Unless otherwise specified, all apparatus, equipment, materials and wiring shall be suitable for use with a 3-phase and neutral, 4-wire, 380/220V±6%, 50 Hz ±2%.

To cope with the possible interruption of the electrical power supply and/or the fluctuation of frequency or voltage value outside the acceptable range specified above, all apparatus, equipment, materials and wiring shall be able to ride through and function properly on any unavoidable disturbance to the European Standard EN 50160:2010+A1:2015.

All apparatus, equipment, materials and wiring shall also comply with Semiconductor Equipment and Materials International (SEMI) F47, IEC 61000-4-11: 2004/AMD1:2017, BS 61034-2: 2005 + A1: 2013 and IEC 61000-4-34: 2005+AMD1: 2009 on voltage dip ride-through capability.

1.1.3.19 GENERAL REQUIREMENTS ON MATERIAL, EQUIPMENT AND INSTALLATIONS

1.1.3.19.1 Use of Approved Equipment

Equipment for the Installations shall be of approved type and shall possess the relevant approval by the statutory authorities or by the product certification bodies acceptable to the statutory authorities if required.

For equipment requiring statutory authorities' approval or product certification bodies' approval, only those equipment and materials that

have been approved by relevant authorities or the product certification bodies shall be selected and submitted to the Supervising Officer for approval. Copies of the approval letters, certificates and relevant approval documents from the statutory authorities and product certification bodies shall be submitted together with the equipment catalogue to the Supervising Officer for approval.

For equipment that has been exempted from approval by the statutory authorities or does not require the approval of the statutory authorities, such information shall be stated in the submission to the Supervising Officer and the evidence or documentary proof where necessary on such exemption shall be provided.

The approval by the statutory authorities, product certification bodies and/or any other parties shall not exempt materials and equipment from complying with all other requirements in this General Specification, Particular Specification and the Contract. Materials and equipment approved by the statutory authorities or product certification bodies will not be accepted automatically. Only materials and equipment that can comply with all the requirements in the Contract will be considered for acceptance.

All domestic gas appliances supplied and installed in the Installations shall have the approval by the Gas Authority in accordance with the Code of Practice GU05 "Approval of Domestic Gas Appliances" published by the Gas Authority, the Government of the HKSAR.

1.1.3.19.2 Materials and Equipment Standards

All materials, equipment and installation work shall be carried out by adoption of the best available quality materials and workmanship and shall, where applicable, comply with the latest edition of the appropriate standards and/or codes of practice issued by the relevant recognised international institutes, standard bodies and authorities and as specified in the Specification which are published before the date of first notice of tender invitation for the Contract or the Nominated Sub-contract as appropriate. This requirement shall be deemed to include all amendments to these standards and codes before the date of first notice of tender invitation for the Contract.

The standards shown in brackets for the materials and equipment in this General Specification are also considered as acceptable standards for the respective materials and equipment.

When material or equipment complying with other standards that are not specified in this General Specification is proposed, justifications shall be provided for the acceptance by the Supervising Officer if the quality, performance, functions and general appearance of the material and equipment offered is equal to or better than that specified in this General Specification.

1.1.3.19.3 Compatibility of Materials and Equipment

Where different components of equipment are interconnected to form a complete system, their characteristics of performance and capacities shall be matched in order to ensure efficient, economical, safe and sound operation of the complete system.

1.1.3.19.4 Equipment Catalogues and Manufacturer's Specifications

Catalogues and manufacturer's specification of the proposed equipment shall be submitted for the examination and approval of the Supervising Officer in writing or approved electronic means before any equipment is ordered.

Equipment catalogue and manufacturer's specification related to the proposed items of equipment shall be in Chinese or English language, be specific and shall include all information necessary for the Supervising Officer to ascertain that the equipment complies with the Specification, and Drawings. Data and sales catalogue of a general nature are not acceptable. Unless otherwise approved by the Supervising Officer, all data and catalogues submitted shall be in SI units i.e. mm, m, kPa, m/s, Hz, kW, l/s etc.

1.1.3.19.5 Equipment Deviations

Subsequent to the acceptance of Tender and only in exceptional circumstances where it is demonstrated in writing that the original equipment offered cannot be obtained, the Supervising Officer may, subject to the Conditions, consider and approve, in writing, alternative equipment and materials proposed provided that these equipment and materials are fully in compliance with the relevant Specifications and Drawings and do not impose any additional contractual or financial liabilities onto the Employer.

1.1.3.19.6 Selection of Equipment

Selection of equipment shall be based on this General Specification, Particular Specification and the technical data contained in the BIM models and/or Drawings for a particular installation.

Any equipment or appliance supplied shall deem to warrant its satisfactory performance under all local working conditions within the Maintenance Period. In the event of anything described in the Contract or shown in the Drawings being unsuitable for or inconsistent with the guarantee or responsibilities, Supervising Officer's attention shall be drawn thereto at the time of tendering.

1.1.3.19.7 Manufacturers' Technical Support in Hong Kong

All equipment listed in the Equipment Schedule or requiring approval by the relevant authorities including the WSD, FSD or by the product certification bodies stipulated in Circular Letters issued by the statutory

authorities shall be supplied through authorised agencies of the manufacturers in Hong Kong or through the Hong Kong offices of the manufacturers. These local agencies or offices shall have adequate technical staff to provide pre-sale and after-sale services. Unless otherwise specified in the Particular Specification, equipment supplied directly by the manufacturers, which do not have local agencies or offices will not be accepted. Spare parts should also be available in the local market easily.

1.1.3.20 WORKMANSHIP

1.1.3.20.1 Tools and Instruments

Proper tools shall be used for the works. Adequate and accurate testing/measuring instruments shall be used to demonstrate compliance of the Installations with the Relevant specifications and regulations. The Supervising Officer shall have the right to stop any work in which the correct tools and/or instruments are not used.

Instruments used for acceptance tests shall be calibrated at a yearly interval unless otherwise as required in the Contract for a particular project.

1.1.3.20.2 Workmanship Standard

The installation works shall be in line with the good practice accepted by the local industry and verified by commissioning and testing results.

The installation works shall be in compliance with the Specification and Drawings.

The Installations shall be in compliance with the statutory requirements as specified in this General Specification in respect of labour safety, fire safety, structural safety, electrical safety and environmental protection.

Apart from those requirements as stipulated in this General Specification and other statutory requirements, due care shall be taken to secure public safety and health both during the execution of the works and in the selection of equipment and materials for the Installations.

1.1.3.20.3 Space for Plant and Equipment

All plants, materials and equipment supplied shall be able to accommodate and install within the spaces as generally shown on the Drawings with adequate access and space for maintenance and servicing of all items supplied.

Access to plant and equipment shall be adequately allowed for operation, maintenance, removal and/or ultimate replacement. Where this is considered not possible or necessary the Supervising Officer shall be consulted for alternative arrangements.

1.1.3.20.4 Water Proofing

Where any work requires piercing waterproofing layers or structures, the method of installation must have prior approval, in writing, from the Supervising Officer.

Unless otherwise specified or instructed, all necessary sleeves, puddle flanges, caulking and flashing shall be provided as appropriate to make these penetrations absolutely watertight.

1.1.3.20.5 Quality Assurance Standards

All materials and equipment shall be manufactured by factories with acceptable quality assurance procedures. Factories having valid ISO 9001:2015 certifications are deemed to have acceptable quality assurance procedures. Other similar quality assurance standards may be accepted by the Supervising Officer on their individual merits. Details of such other quality assurance standards shall be submitted with the equipment submission.

1.1.3.21 PIPEWORK PENETRATION BUILDING STRUCTURE

1.1.3.21.1 Pipes Pass Through Walls or Floors

Where pipes pass through walls or floors, the following shall be complied: -

(a) Cast or build in UPVC sleeves to BS 3505: 1986 or BS EN ISO 1452-1: 2009 with 2 to 25 mm clearance to allow for expansion and movement of pipe.

(b) Finish sleeves flush with finished face of walls and ceilings and projecting at least 100 mm above finished floor level.

(c) Provide loose plastic or chromium plated steel cover plates to ends of sleeves visible in completed work. Plates shall be 50 mm larger than the external diameter of pipe and either clipped to the pipe or screwed or plugged and screwed to the adjacent surfaces.

(d) Fill the annular space between pipe and sleeve for the full length with approved fireproof materials and non-flammable type sealant if required.

(d) If required to be water tight, apply with approved mastic sealant.

(e) No split PVC sleeves shall be permitted.

1.1.3.21.2 Pipes Pass Through Fire Rated Construction

Where pipes pass through fire rated construction, the following shall be complied: -

(a) For metal pipes pass through fire barriers

The requirements of pipes pass through walls or floors shall be complied.

Cast or built in fire rated pipe sleeve with 2 to 25mm clearance.

Firmly fix sealing system around the pipes to properly seal up the gaps between the pipes and the fire barriers to maintain the required FRR of the fire barriers and in compliance with the Code of Practice for Fire Safety in Buildings. The sealing system shall be tested to BS EN 1366-3: 2009 or BS 476-20: 1987 and the installation of which shall be in accordance with the manufacturer's recommendations.

(b) For non-metal or plastic pipes pass through fire barriers

Suitable fire collars shall be used. The fire collars shall be tested to BS EN 1366-3: 2009 or BS 476-20: 1987 with integrity not less than of the fire barriers as prescribed under the relevant Building Regulation and the Code of Practice for Fire Safety in Buildings. The fire collars shall be fixed at underneath of fire barriers or other locations around the pipes in accordance with the manufacturer's recommendations.

1.1.3.21.3 Pipes Through Basement Wall

Where pipes pass through external basement walls, the following shall be complied: -

(a) Cast or build in cast iron or 2.5 mm galvanised mild steel sleeve to BS EN 10255: 2004 after fabrication with 2 to 25 mm clearance.

(b) Caulk space and point both ends with approved mastic sealant.

1.1.3.21.4 Pipes Pass Through Basement Wall with Ground Water Pressure

Where pipes pass through external basement walls where ground water pressure is significant, the following shall be complied: -

(a) Cast or build in short length of cast iron pipe as sleeve with split bolt on puddle flange and with socket on outside.

(b) Well caulk socket around pipe with yarn and lead including a cast iron plug drilled to take long screw and backnuts if necessary.

(c) Point inside with an approved mastic sealant.

1.1.3.21.5 Pipes Pass Through Roof

Where pipes pass through roof, the following shall be complied: -

(a) Cast or build in fire rated pipe sleeves with 2 to 25 mm clearance projecting 150 mm above roof finish.

(b) Fill the annular space between pipe and sleeve and caulk all spaces and voids at both ends for the full length with approved fire rated materials and sealant, e.g. mastic sealant, add waterproof protection and sealant where necessary;

(c) Cover tops of sleeves with stainless steel collars or cover as per roofing specification or as specified by pipe manufacturer.

1.1.3.22 NOISE AND VIBRATION

Necessary steps shall be taken to prevent the transmission of any objectionable noise and vibration which affects the occupied areas of the building. Measures shall also be provided to meet with requirements in Occupational Safety and Health Ordinance, Cap 509.

Pumps and motors shall be balanced and aligned such that the measured vibration velocity at all three axis shall not exceed 1.8 mm/s rms in the range of 10 to 1,000 Hz as defined in BS ISO 2954: 2012 and BS ISO 21940-31: 2013.

Motor driven pump set shall be mounted upon a common base plate supported by approved spring-type isolation mountings on concrete plinth.

Flexible connectors shall be installed at pump connections to take up vibration. Unless otherwise specified, flexible connector of single sphere or double sphere type made from rubber, EPDM and similar materials shall not be used. Flexible connector shall be used to absorb the vibration and shall not be used to take care of the misalignment during installation. All pumps and pipes shall be properly aligned on completion.

1.1.3.23 SURVEY AND MEASUREMENT

Necessary horizontal and vertical measurements shall be taken and/or applied to establish bench marks such as design drawing grid lines, finished floor levels, etc. and shall thus establish satisfactory lines and levels for all works. All measurements on Site shall be verified and checked on the correctness thereof as related to the work.

All works shall be installed to these established lines and levels.

Primary bench base line, datum level, horizontal reference grid, secondary grid and transferred bench mark on each structural level will be provided by the Building Contractor. Co-ordinate with the Building Contractor shall be carried out to obtain all necessary datum and reference grids prior to their surveys and measurements.

1.1.3.24 PROVISIONS ON OPERATION AND MAINTENANCE

All Installations shall be provided with facilities, permanent accesses and sundries for its proper operation, maintenance, inspection, repair, overhaul, testing and servicing after installation.

Adequate facilities for future inspection, monitoring, operation, maintenance, testing, overhaul and replacement shall be provided and allowed in the equipment installation. All heavy equipment shall be provided with lifting eyebolt or the like for lifting. All equipment that has a limited operating life shall be accessible and shall be easily removed for maintenance or replacement. Adequate special tools shall be provided where necessary.

The Installations and equipment shall be provided with adequate gauges, meters, measuring devices and monitoring facilities for indicating all the essential or necessary parameters for quick inspection and monitoring. All such measuring and monitoring facilities shall be deemed to include in the Installations whether they are shown in the drawings or not. Where necessary measuring and monitoring facilities are found missing or not provided during testing and commissioning stage or in the Maintenance Period, alterations or additions shall be made as in the opinion of the Supervising Officer as necessary to remedy such non-compliance. No approval given by the Supervising Officer on the installation drawings and materials submission shall absolve from the liability for this aspect.

Where applicable, drains shall be connected to the nearest drain points for carrying out future flow test during routine maintenance.

1.1.3.25 PROVISION OF SPARE FUSES

The Low Voltage Cubicle Switchboard (LVSB) works and the Motor Control Centre (MCC) works shall include the supply and installation of one complete set of spare fuses for each rating of switchfuse, fuseswitch and fuses in control circuit installed for each LVSB and MCC. The spare fuses shall be hung on a wooden board fixed at a convenient position inside the main switch room or the position as directed by the Supervising Officer.

The wooden board shall be smoothed on the front face and edges, and shall be painted to the approval of the Supervising Officer.

1.1.3.26 PROVISIONS FOR INSPECTION, TESTING AND CERTIFICATION REQUIRED BY AUTHORITIES

All necessary provisions, sampling, examination, logistics, manpower, temporary work, access, documents and information etc. to facilitate the mandatory inspection, testing and certification by the statutory and licensing authorities shall be arranged and provided. Adequate manpower strength, provisions, measuring instruments/meters with valid calibration certificates and necessary tools required by officers and inspectors of the statutory authorities for testing, visual inspections and checking of all the completed works shall be provided.

All necessary document /information of the Installations as required for the submission, inspection, certification and record by statutory authorities shall be provided. This shall include the provision of document /information of the Installations as required by the Building Contractor or other contractors for the consolidation on arrangement. Necessary applications to the statutory authorities for the inspection and testing be made well in advance.

Prior to the statutory inspection, all the required equipment/materials' lists, test certificates, test records, duly completed and signed forms and checklists, etc. as required by the statutory authorities shall be prepared and made ready for the examination by the Supervising Officer.

Any sub-standard, defective and outstanding works found during the statutory inspection shall be rectified or replaced before proceeding on arrangement of further.

The satisfactory completion of statutory inspection, testing and certification by the statutory authorities shall be one of the major considerations for certifying substantial completion of the Installations.

Specified forms as stipulated in the Buildings Energy Efficiency Ordinance (Cap. 610) signed by a Registered Energy Assessor for the Installations shall be submitted to the Energy Efficiency Office of the EMSD upon commencement and completion of the Works.

1.1.3.27 SAFE EXECUTION OF WORKS

All works, inspection, testing and commissioning of the Installations shall be carried out in a safe manner in order to protect the safety and health of persons.

1.1.3.28 FIXING SCREW AND BOLT

Machine screws and nuts shall be to ISO 885:2000. Hexagon bolts, screws and nuts shall be to BS EN ISO 4016:2011, BS EN ISO 4018:2011 and BS EN ISO 4034:2012. Bolts, nuts and washers shall be manufactured from non-ferrous material. Holes for bolts, screws and other fixings shall be drilled or stamped, and no larger than required for clearance of the bolt, screw, etc.

1.1.3.29 SHEET METAL WORK

Sheet metal boxes, meter chambers, etc. shall be manufactured from plain steel sheets. The thickness of steel sheet shall be as specified in this General Specification unless otherwise specified in the Particular Specification or Drawings, and subject to a minimum of 1.0 mm. Where necessary, suitable stiffeners shall be provided to give adequate rigidity.

Protection against corrosion shall be achieved by means of hot-dip galvanisation, anti-rust painting or enamel, or the use of stainless steel to Grade 304/316.

SUB-SECTION 1.1.4

BUILDING INFORMATION MODELLING

1.1.4.1 GENERAL

Building Information Modelling (BIM) shall be adopted as required by the Contract. BIM models shall conform to the requirements specified in this General Specification and the relevant Particular Specification.

1.1.4.2 INSTALLATION BIM MODELS

1.1.4.2.1 General Requirements

The modeling scope, preparation, coordination, storage, distribution and submission of BIM models for individual Installations and/or federated BIM models shall be in accordance with the BIM Project Executive Plan approved by the Supervising Officer.

The modelling requirements shall refer to the Particular Specification.

The BIM model shall be capable to generate equipment schedule.

1.1.4.2.2 BIM Model Coordination and Analysis

The Building Contractor shall responsible for the overall coordination, consolidation and development of federated BIM models as required in the Contract. The necessary design, installation details, cost information and installation schedule essential for the preparation of the federated BIM models and/or model analysis shall be provided to the Building Contractor. Coordination and model review processes as coordinated by the Building Contractor shall be participated.

Clash analysis shall include the checking of headroom requirements and working spaces for building services operations and maintenance activities. In particular, for major equipment which must provide services without any break, dynamic envelope model showing the estimated dimensions of the physical space sufficient for equipment delivery and maintenance is required as well as installation sequence. The Building Contractor shall liaise with the Supervising Officer or his representatives to determine the criteria level of acceptable clashes, e.g. sprinkler pipes pass through beams.

Clash or conflict identified in the BIM model review process which demonstrates considerable implication on the installation works on Site or off site shall be resolved prior to the installation /off site fabrication work.

1.1.4.3 AS-BUILT BIM MODELS

1.1.4.3.1 General

The modeling scope, preparation, coordination, storage, distribution and submission of BIM models for individual Installations and/or federated BIM models shall be in accordance with the BIM Project Executive Plan approved by the Supervising Officer.

The modelling requirements shall refer to the Particular Specification.

The BIM model shall be capable to generate equipment schedule.

1.1.4.3.2 Submission of As-built BIM Models

As-built BIM models shall be submitted to the Supervising Officer in accordance with the requirements set out in the Particular Specification.

Unless otherwise specified in the Contract, draft as-built BIM models shall be submitted to the Supervising Officer for comment within 28 days after the issuance of the certificate of completion of the Works. The Supervising Officer after checking the models shall provide comment within 42 days from the date of submission of the draft models. Re-submission after resolve of the comments received shall be arranged within 28 days from the date of receiving the Supervising Officer's comment. This process of submission and approval shall continue until the final approval of the Supervising Officer on these as-built models are obtained.

If Common Data Environment (CDE) or electronic document management system is required by the Contract, the draft and final approved as-built models shall be uploaded to the platform under a folder structure agreed by the Supervising Officer.

1.1.4.4 BUILDING ENERGY MODELS

1.1.4.4.1 General

Building energy models shall be provided and handover to the Employer if specified in the Particular Specification or other part of the Contract.

1.1.4.4.2 Modelling Requirements

The building energy models shall be in native format and representing the building configuration, building envelope, building services design, operating schedule and control methodology of the subject building. On top of the building energy model representing the subject building, a baseline building energy model shall also be provided and handover to the Employer.

The simulation software for building energy modelling shall meet the following criteria:

(a) Tested with industry standard methods: ANSI/ASHRAE Standard 140-2007, CIBSE AM11: 2015 Building performance modelling or equivalent.

(b) Capable to perform hourly simulation (i.e. 8,760 hours per year);

(c) Capable to model the hourly energy use accordingly to the hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat setpoints, and air-conditioning system operation;

(d) Capable to model 10 or more thermal zones;

(e) Capable to model and simulate the thermal behaviour of a building and the interaction of its building fabric, air-conditioning, lighting and other relevant energy consuming equipment and systems;

(f) Capable to perform design load calculations to determine the required air-conditioning equipment capacities and air and water flow rates for both the design case and baseline case building;

(g) Capable to model part-load performance curves for mechanical equipment;

(h) Capable to model capacity and efficiency correction curves for mechanical heating and cooling equipment; and

(i) Capable to model air-side economisers with integrated control.

The modelling requirements shall also refer to the BEAM Plus New Building of the HKGBC. The simulations for the building energy model of the subject building and the baseline building energy model shall be calculated according to the following criteria as minimum: -

- the same software;
- the same weather data;
- the same operating schedules;
- the same occupancy density;
- the same building design in terms of shape;
- the same outdoor and indoor design conditions;
- the same internal illuminance levels for space lightings; and
- the same thermal block based on similar internal load densities, occupancy, lighting, thermal and space temperature schedules.

Building energy modelling report covers the following content shall be provided as minimum: -

- Executive summary
- Project information

- Methodology of energy performance assessment
- Assumptions
- Model parameters
- Model configuration
- Simulation results and performance analysis

1.1.4.4.3 Software Licenses

Necessary software licenses for the building energy models shall be provided to the Supervising Officer in the Maintenance Period.

SUB-SECTION 1.1.5

DRAWINGS

1.1.5.1 DRAWINGS IN ELECTRONIC FORMAT

Drawings in electronic format shall be provided as required in the following clauses and as specified in the Contract.

Drawings shall conform to the latest version of CAD Standard for Works Projects (CSWP) as posted in the website of the Development Bureau and in accordance with the latest version of CAD Manual for the ArchSD Projects. Should any technical conflict between the CSWP and the CAD Manual arise, the CSWP shall take precedence. Drawings generated from BIM models may not need to follow the CSWP.

1.1.5.2 INSTALLATION DRAWINGS

1.1.5.2.1 Drawing Submission Schedule

A detailed installation drawing submission schedule and programme shall be submitted to the Supervising Officer. Reasonable time shall be allowed in the programme for vetting of the installation drawings by the Supervising Officer and for drawing resubmissions as necessary.

A comprehensive "Submission Schedule" of installation drawings and builder's work drawings shall be submitted to the Supervising Officer within 2 weeks after the acceptance of Tender, taking into account of the overall programme of the Installations including any Specialist Works and works by the utility undertakings. No equipment shall be delivered to the Site and no work shall be executed until the installation drawings have been approved by the Supervising Officer. The installation drawings and builder's work drawings shall be progressively submitted in accordance with the approved "Submission Schedule".

At least 6 hard copies and one electronic copy shall be provided unless otherwise specified in the Contract.

Unless otherwise indicated or instructed, detailed installation drawings and/or shop drawings (which may also be referred to as working drawings) demonstrating the works shall be submitted for acceptance by the Supervising Officer in adequate time before each section of the work proceeds. These drawings shall be fully dimensioned and shall be based on the basic intentions of the 'Drawings'.

Installation drawings and shop drawings in this context shall mean the drawings of items to be constructed at Site and at factory or workshop away from the Site.

If Common Data Environment (CDE) or electronic document management system is required by the Contract, the installation drawings

shall be uploaded to the platform under a folder structure agreed by the Supervising Officer.

1.1.5.2.2 Size of Installation Drawings

Drawings shall be of standard sizes from A0 to A4 or B1 size as stipulated in ISO 5457:1999+A 1:2010.

Installation drawings and/or shop drawings shall be prepared to such scales that will clearly show all necessary details.

1.1.5.2.3 Contents of Installation Drawings

In accordance with the provisions of this General Specification and as stated elsewhere in the contract documents, the installation drawings must incorporate details of the actual plant and equipment items as approved by the Supervising Officer.

All installation drawings shall be fully dimensioned and suitably scaled showing construction, sizes, weights, arrangements, operating clearances and performance characteristics.

(a) "Installation drawings" shall generally include, but not limited to, the following: -

- Symbols and notations same as and compatible with the Employer's own Contract Drawings' standard;
- Complete layout/assemblies including all necessary minor items and accessories;
- Service routings and levels relative to the structure and other services;
- Plant and equipment locations with dimensions and weights;
- Service joints, suppodetails together with their locations;
- Positions of all fixings, hangers and supports;
- Maintenance spaces for all withdrawable items, such as coils, heater elements, thermometers, thermostats, fan shafts and fan blowers, cleaning and replacement of tubes, removal of guards, etc.;
- Engineering calculation and data;
- Method of control and the control logic diagram;
- Location and type of interfacing with other services

- Positions & sizes of all test holes, test pockets, thermostat pockets, thermometer pockets, bends and fittings, clearances to allow for the removal of inserted equipment where applicable;

- Outline of insulation and clearances to allow for application thereof;

- Outline of valve and similar insulation boxes and the clearances to be allowed for their removal thereof;

- Lifting points and safe working weights of each item;

- Calculation and data such as for gaseous extinguishing system, drencher system and other Fire Service Installations as required;

- Method of control in ventilation/air-conditioning control system; and

- Location and type of interfacing with other services, such as for ventilation/air conditioning control system, fireman's lift control and audio/visual advisory system.

The drawings shall include all design accessories and shall be drawn to match the materials and equipment supplied. Drawings showing details in spatial zones shall be prepared subsequent to proper co-ordination with the Building Contractor and other trades on Site.

(b) Ductwork Fabrication and Installation Drawings

Installation drawings of the ductwork demonstrating the proposed final details of the manufacturing and erection methods of the ductwork shall be submitted to the Supervising Officer for technical appraisal and approval prior to the commencement of any ductwork manufacture.

Generally, the drawings shall be drawn to a scale of not less than 1:50 but subject to the Supervising Officer's approval a scale of 1:100 may be adopted where the installation is a simple one.

Ductwork drawings shall indicate the length of each ductwork section; the internal dimensions of the galvanised sheet steel or other materials to be used as specified; dimensions of bends and fittings; thickness of metal; sizes and positions of all stiffeners; angle flanges, etc. including the methods of fixing and bolting; location of all supports; outline of all insulation; position and sizes of all access doors; test points; location & fixings for all thermometers and other devices including withdrawal clearances; working pressures where applicable (e.g. for medium and high pressure systems), etc.

The details shown shall cover the provision of internal air flow equalising ductwork bends, splitters and any other air flow control devices such as dampers, control mechanisms, acoustic treatment measures, flexible joints, air diffusion devices proposed annotated with inlet or extracted airflow volumes and velocities.

(c) Pipework Installation Drawings

Installation drawings for the pipework installation shall be submitted to the Supervising Officer for technical appraisal prior to the commencement of any manufacture, fabrication, or installation. Generally, the drawings shall be drawn to a scale of not less than 1:50. Subject to the Supervising Officer's approval a scale of 1:100 may be adopted where the installation is a simple one.

The drawings shall indicate the location, with dimensions given, of all pipework in relation to the building structure and other pipework and equipment. The position of all valves, strainers, check valves, etc. shall be shown together with clearances necessary for removal of strainer baskets, internal parts of all valves, motors for motorised valves, solenoids, etc.

Positions and details of all hangers and supports shall be shown and the positions dimensioned.

Positions of thermostats, thermometers, test pockets and similar devices shall be shown and dimensioned including clearances required for their removal.

Details and outline of insulation and insulation boxes shall be shown including clearances required for removal of the boxes.

(d) Air Handling Plant Installation Drawings

Air handling unit plant installation drawings shall include details of all plant to be installed therein including fan shaft and runner with withdrawal clearances; cleaning spaces for coils and eliminators; filter arrangements; detail of specialist acoustic treatment where required in any Particular Specification and Drawings or where provided as part of a standard product; details of all air sealing; details of access doors and gaskets, hinges and catches/handles with manufacturers type and numbers for proprietary items; details of drains, drain traps, cleanouts, and construction method to avoid "cold bridges" etc. as well as provisions made for hoisting of fans, motors, etc. and the necessary clearance spaces for in-situ servicing or removal.

These drawings shall also show, in outline form only, any significant adjacent building structure and the clearances from and other equipment and/or known services no matter whether these

elements are provided under the work or others. All such known positions and/or clearances shall be dimensioned wherever possible.

(e) Control and Wiring Installation Drawings

Schematic diagrams showing the control layout with each item clearly identified with all interlocking and related facilities shall be submitted.

These drawings shall include logic sequence and wiring/pneumatic diagrams showing full details including terminal and wire numbers, colour code, etc. for all items of electrical/electronic equipment and port designations for all pneumatic installations. Interlocking, reset or similar facilities shall be clearly shown.

Installation drawings shall also be prepared and submitted for all physical wiring and pneumatic tubing systems detailing positions, enclosures, fixings, support, protection, sizes and number of cores/tubes for all runs.

The installation drawings shall show positions in relation to the building structure and other plant, equipment and/or installations. In the context, the plant, equipment and/or installations will mean to include the installed services under the work and those installed by others. For those services installed by others, sufficient details of relevant information from others shall be obtained in order to complete the drawings.

(f) Switchgear, Starter, Control/Instrumentation/Motor Control Installation Drawings

Shop drawings/installation drawings shall show the physical construction and layout, internally and externally, of all panels/cabinets/cubicles including the physical arrangement of all major and important components, bus-bars, phase separation barriers, interconnecting wiring, pneumatic piping, labels, etc.

Wiring diagrams and schematic diagrams shall show all internal & external wiring/piping including all interlocks and connections from the panels to external equipment.

Operation and control philosophy shall also be included in the submission. The drawings shall include proposed full wording of all labels to be installed in both English and Chinese characters.

(g) Special Plant Rooms Co-ordination Work

Planning and coordination with other services/building details shall be included where the work constitutes the major parts of the plant room (e.g. air conditioning works for chiller plant room).

Responsibility for the co-ordination of other services/building details within these specific areas shall be allowed in the Tender of the work. The responsibility shall include co-operation with whoever has the responsibility for the overall project construction stage co-ordination.

Where necessary, the foregoing plant room co-ordination requirement shall include the preparation of plant room co-ordination drawings which other contractors involved in the plant room are to comply with. The coordination shall include the cross checking of other contractors' plant room installation drawings before work thereon proceeds.

1.1.5.2.4 Builder's Work Drawings

Unless otherwise approved by the Supervising Officer, 6 copies of drawings showing details of all builder's work required shall be submitted to the Supervising Officer in accordance with the approved "Submission Schedule". Such drawings shall clearly indicate the details and positions of all associated builder's works.

1.1.5.2.5 Manufacturer's Shop Drawings

The manufacturer's shop drawings are drawings for equipment or plant to be manufactured by a specialist manufacturing supplier in their own workshops and places away from the Site.

The drawings shall show detailed construction, principal dimensions, weights and clearances for maintenance, etc. Immediately after placing of any order or at any event within 4 weeks unless otherwise approved in writing by the Supervising Officer, 4 copies of manufacturer's shop drawings indicating detailed construction, principal dimensions and weights, clearances for withdrawals and/or cleaning, etc. shall be forwarded to the Supervising Officer for comment. No work shall proceed on or off Site unless drawings requiring approval are so approved in writing by the Supervising Officer.

1.1.5.2.6 Drawings for Submission to Other Authority

Drawings as required by the statutory authorities shall be prepared and submitted. 4 sets of the preliminary installation drawings shall be submitted to the Supervising Officer who will then check, endorse and return in 2 sets for onward submission to the statutory authorities for perusal. The Installations shall only be commenced upon the approval by the statutory authorities and consent from the Supervising Officer. 6 sets of all such approved drawings shall then be submitted to the Supervising Officer.

1.1.5.2.7 Checking Drawings of Other Trades

The planning and execution of the work shall follow the design intent of the Contract Drawings and cross check with other trades in order to verify

the line, level, space and sequence in which the Installations are to be installed.

Reasonable adjustments to the proposed installation drawing layouts shall be made without extra charge as necessary to prevent conflicts with the work of other trades or for the proper sequence of and execution of the Installations if directed by the Supervising Officer. Where such modifications are of a nature and of such unforeseen complexity that they involve unreasonably extra work not covered by the Contract, they may be covered by variation order to be issued by the Supervising Officer wherever such a requirement is justified.

1.1.5.3 AS-BUILT DRAWINGS

1.1.5.3.1 Submission of As-built Drawings

As-built drawings, including the draft prints and revised draft prints shall be submitted to the Supervising Officer in accordance with the requirements set out in the Contract.

Unless otherwise specified in other part of the Contract, draft prints of as-built drawings shall be submitted to the Supervising Officer for comment within 28 days after the issuance of the certificate of completion of the Works. The Supervising Officer after checking the above draft prints shall return one set of the mark-up copies within 42 days from the date of submission of the draft prints. Re-submission after resolve of the comments received shall be arranged within 28 days from the date of receiving the Supervising Officer's comment. This process of submission and approval shall continue until the final approval of the Supervising Officer on these as-built drawings is obtained.

Unless otherwise specified, the final approved as-built drawings shall be in 1 set of hard copy and 3 sets of electronic copies. These shall be submitted within 21 days from the date of final approval. Each electronic copy shall be in the form of electronic removable storage media, labelled, with cross reference to a printed list of files explaining the contents and purpose of each file and supplied in sturdy plastic containers.

In addition to the above, one full set of as-built drawings in print shall be provided and stored in a metal container or other approved provision in the fire control centre or in a location agreed by the Supervising Officer. The container shall be properly labelled and shall be of appropriate size to contain the folded drawings.

If Common Data Environment (CDE) or electronic document management system is required by the Contract, the draft and final approved as-built drawings shall be uploaded to the platform under a folder structure agreed by the Supervising Officer.

1.1.5.3.2 Size of As-built Drawings

As-built drawings shall only be of standard sizes of A0, A1 or B1 size as stipulated in BS EN ISO 5457:1999+A1:2010. Smaller size (A2 to A4) is accepted for installation drawings.

As-built drawings shall be prepared to such scales that will clearly show all necessary details.

1.1.5.3.3 Content of As-built Drawings

All as-built drawings shall be verified for accurately represent the Installations before submitting them to the Supervising Officer. Unless otherwise specified in the Contract, the as-built drawings required to be provided for each Installations shall include, but not limited to the following:

(a) Building services layout plans such as positions of equipment, ducting arrangement, trunking arrangement, piping arrangement, etc;

(b) System schematic diagrams, control diagrams and wiring diagrams;

(c) Concealed work layout plan such as concealed conduit routing, etc.; and

(d) Installation details and assembly drawings.

As-built drawings shall complete with technical details such as design parameters for commissioning purposes. Any amendments noted on these drawings during the commissioning and test stage shall subsequently be transferred to the original as-built drawings once the amendments have been accepted by the Supervising Officer.

1.1.5.3.4 Framed Drawings

Glass-framed and non-fading prints of the following as-built drawings shall be provided and installed in the relevant major plant room and the fire control centre.

(a) Main schematic drawings for the Installations

(b) Valve and damper charts consisting of schematic diagrams showing the layouts and positions and identification of all valves and dampers with record of final settings/adjustment for regulating devices;

(c) Plant room record drawings showing all plant items, pipework, ductwork, etc. including all electrical and control schematics and diagrams; and

(d) Schematic wiring diagrams, tables or charts to indicate the type and composition of circuits, identification and location of item of

equipment of LVSB and MCC in each main switch room and MCC room.

Glazing shall be polished plate of not less than 6 mm thickness mounted in natural finish, extruded and anodised aluminium frames with the prints mounted on acid free mounting board and the whole backed with marine grade plywood not less than 8 mm thick.

SUB-SECTION 1.1.6

MANUALS

1.1.6.1 GENERAL

1.1.6.1.1 Types of Manuals

Three types of manuals with all changes made to the Installations during the course of the Contract suitably incorporated shall be provided to the Supervising Officer.

Operation and Maintenance (O&M) Manual is for use by the maintenance agent of the completed Installations. It shall contain detailed technical information covering both operation and maintenance aspects of the Installations.

User Manual seeks to give users of the completed Installations an overview of the essential information of the Installations. The contents of the manual should be concise for ease of comprehension by people with a non-technical background.

Energy Management Manual is to give operator and user an overview of energy efficiency and renewable energy system design features, and the essential information in operating the building and the systems in energy efficient manner.

1.1.6.1.2 Presentation

All manuals shall be written in English, unless otherwise specified. The text of descriptive parts shall be kept concise while at the same time ensure completeness. Diagrammatic materials shall also be supported by comprehensive descriptions.

The manuals shall comprise A4 size loose-leaf. The loose-leaf shall be of good quality paper that is sufficiently opaque to avoid "show-through". Unless otherwise specified in the Contract, the manuals shall be bound in durable loose-leaf 4 ring binders /multi-ring binders with hard cover. The manuals shall have labels or lettering on the front cover and spine. The Supervising Officer’s approval shall be obtained on this at the draft manual stage. The electronic copy of manuals including the technical literatures shall be in PDF format readable by Acrobat Reader Freeware.

1.1.6.1.3 Checking and Approval

The draft manuals shall be submitted to the Supervising Officer for checking and approval according to the requirements as specified in this General Specification and the Particular Specification.

The first draft of the manuals together with a list of recommended spare parts for one year’s operation and a list of special tools, both complete

with prices and contact of suppliers to the Supervising Officer for comment at least 42 working days prior to the testing and commissioning of the plant and equipment.

The Supervising Officer will check the drafts and return them with comment, if any, within 42 working days from the date of submission. Necessary amendments to the documents shall be made and the documents shall be resubmitted to the Supervising Officer within 21 days from the date of receipt of the comment. This process of submission and approval shall continue until the final approval of the Supervising Officer on these documents is obtained.

Unless otherwise specified, the final approved manuals shall be in 2 sets of hard copy and 2 sets of electronic copies. These shall be submitted within 21 days from the date of final approval. Each electronic copy shall be in the form of electronic removable storage media, labelled, with cross reference to a printed list of files explaining the contents and purpose of each file and supplied in sturdy plastic containers.

If Common Data Environment (CDE) or electronic document management system is required by the Contract, the draft final approved manuals shall be uploaded to the platform under a folder structure agreed by the Supervising Officer.

1.1.6.1.4 Intellectual Property Rights

The Government shall become the absolute and exclusive owner of the manuals and all intellectual property rights subsisting therein free from all encumbrances.

In the event that the beneficial ownership of any intellectual property rights subsisting in the above Manuals are vested in anyone other than the contractor of the work, the transferable, non-exclusive, royalty-free and irrevocable licence (carrying the right to grant sub-licences) to utilise the intellectual property rights in the manuals for the purposes contemplated in the Contract shall be procured and provided to the Employer. For the avoidance of doubt such purposes shall, but not limited to, include providing free copying of the materials in the manuals by any subsequent owner or user of the Installations, and/or any party responsible for the operation and maintenance of the Installations in connection with any subsequent alteration, extension, operation and maintenance of the Installations.

1.1.6.2 STRUCTURE AND CONTENTS OF MANUAL

1.1.6.2.1 O&M Manual

The target reader of the O&M Manual is operation and maintenance personnel. The detailed requirements, structure and contents of the O&M Manual shall be as specified in this General Specification or elsewhere in

the Contract. In general, they shall include, where applicable, the following information: -

(a) Project Information

Project title, site address, contract no., contract title, contract commencement date, substantial completion date and length of Maintenance Period.

(b) System Description

- Design intent of the Installations;
- Basis of design;
- Type(s) of system(s) and equipment installed, and their purposes;
- Locations of major plant rooms and pipe ducts;
- Brief description of the operation and functions of the systems and equipment;
- General operating conditions, expected performance and energy and resources consumption where applicable;
- Listing of set points which can be adjusted by the user to suit their operation needs;
- Technical information, design parameters and settings of key equipment, such as discrimination study of protective device of electrical installation.

(c) Equipment Schedule

- Schedule of all items of equipment and plant stating the location, name, model number, manufacturer's serial or reference numbers, duties and performance data.

(d) Spare Parts Lists

- Recommendations from manufacturers /suppliers for spare parts with item description, quantity, unit rates and agents and stocking levels for the equipment and plant of the system.

(e) Safety Precautions for Operation and Maintenance

Describe in this section the hazards and safety precautions of which the operation and maintenance staff need to be aware. These shall include the following: -

- Any known feature or operational characteristics of the equipment or systems installed which may produce a hazard;

- Any known hazards against which protection can be provided;

- Any mandatory requirements relating to safety;

- Any other safety precautions which should be observed; and

- Any other relevant warnings.

(f) Operation Instructions

Instructions for the safe and efficient operation, under both normal and emergency conditions, of the installed system which shall comprise: -

- an outline of the general operating mode;

- control data (location, effect, object, sequence, limits of capability, modes, set points);

- procedures and sequences for start-up, running and shut-down, under both normal and emergency conditions;

- interlocks between equipment/system;

- operating procedures for stand-by equipment;

- precautions necessary to overcome known hazards;

- the means by which any potentially hazardous equipment may be made safe;

- target figures for both energy consumption and energy costs; and

- forms for recording plant running status.

(g) List of Statutory Periodic Inspections and Tests

A schedule of periodic inspections and tests that owner and/or user of the Installations have to arrange to achieve compliance with the requirements stipulated in the relevant Laws of Hong Kong. The frequency of such inspections and tests shall be expressed in specific time intervals.

(h) Statutory Certificates

Certified True copy or Originals of submitted/endorsed/approved Statutory Inspection Certificate for various installations wherever applicable, including but not limited to: -

- Electrical Installations (e.g. Work Completion Certificate - Form WR1 or Form WR1a);

- Fire Service Installations (e.g. Fire Service Certificate - Form FS172, Form 314, Form 501, Form 251, Form 314a etc.);

- Installations work for Dangerous Goods Stores Licence Application;

- Lifts /Escalators Installations (e.g. test/examination report following the format given in the Appendices to the Code of Practice for Lift Works and Escalator Works);

- Others equipment such as surveyor's test certificates for high-pressure vessel, surveyor's load certificates for electrical operated roller shutters, lifting devices/appliances, etc.

(i) Drawing Lists

A complete list of as-built drawings and manufacturer's shop drawings identified with drawing number/reference;

(j) Photographs

A set of photographs with suitable captions to illustrate to the user the appearance and locations of devices which require their setting and operation.

(k) The certified copy of the final design report for Performance Based Fire Engineering System if applicable.

(l) Technical Literatures

A complete set of manufacturers' literatures for all the plant and equipment installed in the system. The contents of these literatures shall cover the following areas where applicable: -

- manufacturer's catalogues of equipment

- description, performance, technical details and characteristics of equipment with model numbers highlighted;

- factory/laboratory test reports, detailed drawings, circuit diagrams;

- methods and instruction of operation and control;

- cleaning and maintenance requirements;

- plants, materials and space required for maintenance; and

- protective measures and safety precautions for operation and maintenance.

(m) Maintenance Instructions

Instructions for the planned (preventive) and corrective maintenance of the installed equipment on each of the following as appropriate:

- nature of deterioration, and the defects to be looked for;

- isolation and return to service of plant and equipment;

- dismantling and reassembly;

- replacement of components and assemblies;

- dealing with hazards which may arise during maintenance;

- adjustments, calibration and testing; and

- special tools, test equipment and ancillary services.

(n) Maintenance Schedules

Proposed maintenance schedules for all the preventive maintenance tasks identified above. The schedules shall be based on both manufacturers' recommendations and other authoritative sources (e.g. statutory or mandatory requirements) and shall include: -

- routine servicing;
- inspections;
- tests and examinations;
- adjustments;
- calibration;
- lubrication; and
- overhaul.

The frequency of each task may be expressed as specific time intervals, running hours or number of completed operations as appropriate. Collectively, the schedules will form a complete

maintenance cycle, repeated throughout the whole working life of the Installations.

1.1.6.2.2 User Manual

The target reader of the User Manual is general users of the premise without technical background. The detailed requirements, structure and contents of the User Manual shall be as specified in this General Specification or elsewhere in the Contract. In general, they shall include, where applicable, the following information: -

(a) Project Information

Project title, site address, contract no., contract title, contract commencement date, substantial completion date and end date of Maintenance Period.

(b) System Description

- Type(s) of system(s) and equipment installed, and their purposes;

- Location of major plant rooms and pipe ducts;

- Brief description of the operation and functions of the systems and equipment; and

- Listing of set points which can be adjusted by the user to suit their operation needs.

(c) Schedule of Major Plant Rooms and Installed Equipment

- Schedule of major plant rooms and riser ducts including their locations; and

- Schedule of major equipment and plants including their locations and serving areas.

(d) Safety Precautions for Operation

State safety precautions and warnings signals that the users shall be aware of in the daily operation of the various systems and equipment in the installations including: -

(i) Mandatory requirements relating to safety;

(ii) Features or operational characteristics of the installed systems or equipment which may cause hazard and the related safety precautions;

(iii) Protective measures and safety precautions for operation; and

(iv) List of warning signals and the related meanings that the user shall be aware of and the actions to be taken.

(e) Operation Instructions

Instructions for the safe and efficient operation, under both normal and emergency conditions, of the installed system which shall comprise: -

- An outline of the operating mode;

- Step by step operation instructions for systems and equipment that are to be operated by the user, including at least procedures for start-up and shut-down;

- Means by which any potentially hazardous situation can be made safe; and

- Cleaning and basic maintenance procedures.

(f) List of Statutory Periodic Inspections and Tests

A schedule of periodic inspections and tests that owner and/or user of the Installations have to arrange to achieve compliance with the requirements stipulated in the relevant Laws of Hong Kong. The frequency of such inspections and tests shall be expressed in specific time intervals.

(g) Drawings

A set of selected as-built drawings which shall be able to illustrate to the user the general layout of the completed installations.

(h) Photographs

A set of photographs with suitable captions to illustrate to the user the appearance and locations of devices which require their setting and operation.

1.1.6.2.3 Energy Management Manual

The detailed requirements, structure and contents of the Energy Management Manual shall be as specified in this General Specification or elsewhere in the Contract. In general, they shall include, where applicable, the following information: -

(a) List of energy efficient features and renewable energy systems;

(b) Description of the final design intent and basis of design, including brief descriptions of each system in related to energy efficient features and renewable energy systems;

(c) Operating instructions and caveats about their function and maintenance relative to energy use;

(d) Final sequences of operations for all equipment;

(e) Coefficient of performance characteristics of chiller/ heat pump at its 100%, 75%, 50% and 25% rated cooling /heating capacity under different outdoor air (for air-cooled condenser type) temperature conditions (in between 17°C and 35°C at 3°C interval) or condensing water (for water-cooled condenser type) temperature conditions (in between 17°C and 32°C at 3°C interval), provided that the chilled water /condensing water flow rate and the chilled /heating water supply temperature are under its rated condition at constant.

(f) Coefficient of performance characteristics of chiller at its 100%, 75%, 50% and 25% rated cooling /heating capacity under different chilled water supply temperature setpoints (in between 7°C and 12°C at 1°C interval), provided that the condensing temperature is under its rated condition at constant.

(g) Characteristic curves of chilled water and condensing water pumps indicating the relationship between pressure, flow rate and power input;

(h) Saturation curve of cooling tower to demonstrate the outdoor relative humidity and outdoor temperature when plume abatement measures are required in different condition (i.e. the ratio of heat rejection load and fan speed in 1:1 and 1:2);

(i) Control setting and strategy of chiller sequencing control, chilled water reset and condenser flow rate reset control;

(j) Control logic flow chart showing temperature control, static pressure control and reset control in AHUs and PAUs;

(k) Summary table showing finalised sensitivity, time delay setting and set points of lighting control;

(l) Schedule of energy metering provisions, and their grouping configuration for consolidation under the building energy management system;

(m) Procedures for seasonal start-up and shutdown, manual and restart operation;

(n) Recommendations and brief method for appropriate metering, measurement and accounting of energy use;

(o) Specifications of re-calibration frequency of sensors and actuators by type and use;

(p) Recommendations for continuous commissioning or recommended frequency for re-commissioning by equipment type, with reference to tests conducted during initial commissioning;

(q) Recommendations regarding seasonal operational issues affecting energy use;

(r) List of all user-adjustable set points and reset schedules, with a discussion of the purpose of each and the range of reasonable adjustments with energy implications;

(s) Schedules of frequency of reviewing the various set points and reset schedules to ensure that they are still near optimum;

(t) List of time-of-day schedules and a frequency of reviewing them for relevancy and efficiency;

(u) Guidelines for establishing and tracking benchmarks for building energy use and primary plant equipment efficiencies;

(v) Guidelines for ensuring that future renovations and equipment upgrades will not result in decreased energy efficiency and will maintain the design intent;

(w) List of diagnostic tools, with a description of their use, that will assist facility staff of the building in operating equipment more efficiently; and

(x) Index of all commissioning documents with notation of their location.

SECTION 1.2

GENERAL INSPECTION, TESTING AND COMMISSIONING DURING CONSTRUCTION PERIOD

SUB-SECTION 1.2.1

GENERAL REQUIREMENTS

1.2.1.1 GENERAL

The inspection, testing and commissioning shall be carried out in accordance with the requirements specified in this General Specification and the following listed documents of latest version before the date of the first notice of tender invitation (hereinafter as the "Testing and Commissioning Procedures") as appropriate:

(a) Testing and Commissioning Procedure for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control System Installation in Government Buildings of the Hong Kong Special Administrative Region

(b) Testing and Commissioning Procedure for Broadcast Reception Installation in Government Buildings of the Hong Kong Special Administrative Region

(c) Testing and Commissioning Procedure for Burglar Alarm and Security Installation in Government Buildings of the Hong Kong Special Administrative Region

(d) Testing and Commissioning Procedure for Catering Equipment Installation in Government Buildings of the Hong Kong Special Administrative Region

(e) Testing and Commissioning Procedure for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region

(f) Testing and Commissioning Procedure for Emergency Generator Installation in Government Buildings of the Hong Kong Special Administrative Region

(g) Testing and Commissioning Procedure for Fire Service Installation in Government Buildings of the Hong Kong Special Administrative Region

(h) Testing and Commissioning Procedure for Lift, Escalator and Passenger Conveyor Installation in Government Buildings of the Hong Kong Special Administrative Region

(i) Testing and Commissioning Procedure for Liquefied Petroleum Gas Installation in Government Buildings of the Hong Kong Special Administrative Region

(j) Testing and Commissioning Procedure for Plumbing Installation in Government Buildings of the Hong Kong Special Administrative Region

(k) Testing and Commissioning Procedure for Drainage Installation in Government Buildings of the Hong Kong Special Administrative Region

(l) Testing and Commissioning Procedure for Steam Boiler and Calorifier Installation in Government Buildings of the Hong Kong Special Administrative Region

(m) Testing and Commissioning Procedure for Swimming Pool Water Treatment Installation in Government Buildings of the Hong Kong Special Administrative Region

Throughout the execution of the Installations, the compliance with the statutory and related requirements shall be ensured.

Supervising Officer shall be notified on any infringement which directly or indirectly detracts from the safe and satisfactory operation of the Installations whether or not such infringement relates to the works covered in the Installations or to those associated with others. All defects found during inspection, testing and commissioning shall be rectified or replaced to the satisfaction of the Supervising Officer.

1.2.1.2 METHODS AND PROCEDURES

Detailed inspection, testing and commissioning methods and procedures together with report formats for reporting the inspection, testing and commissioning results shall be submitted to the Supervising Officer for approval at least four months before commencement of the testing and commissioning works, or four months after the acceptance of his Tender, whichever is earlier.

For minor works under works order of minor works contract or quotation contract with short construction period, the submission of detailed inspection, testing and commissioning methods and procedures together with report formats shall be made at least four weeks before the commencement of any testing and commissioning works.

Submission for works to be tested and commissioned during the construction period shall be made in good times matching with the construction programme for approval. For tests that have to be done satisfactorily before subsequent construction work, such tests shall be completed to the approval of the Supervising Officer before new construction work is to be carried out.

Testing and commissioning methods and procedures shall follow the format in the relevant Testing and Commissioning Procedures and additional requirements in accordance with the manufacturers' recommendation and relevant standards.

1.2.1.3 NOTICES OF INSPECTION, TESTING AND COMMISSIONING WORKS

For items to be witnessed by the Supervising Officer or his Representative, advanced notice with details of date, time and list of items to be inspected or tested shall be provided unless otherwise specified: -

(a) Off-site Inspection and Test

An advanced notice of at least one week before commencement of the inspection or test shall be provided.

(b) On-site Inspection, Testing and Commissioning

An advanced notice of at least 3 days before commencement of inspection, testing or commissioning of any part or parts of the Installations shall be provided.

The Supervising Officer's Representative shall be informed of all site tests.

The planning of the testing and commissioning programme shall enable the Supervising Officer or his Representatives to witness all the tests. Unless otherwise approved by the Supervising Officer, inspection, testing and commissioning works in the absence of the Supervising Officer or the Supervising Officer's Representatives shall not be accepted as the approved test record.

1.2.1.4 LABOUR AND MATERIALS

Provision of all labour and both consumable and non-consumable materials for carrying out the inspection, testing and commissioning works shall be included in the work. Water and gas shall be properly drained and exhausted during and after the inspection, testing and commissioning works as required. Provisions and measures to avoid damage to the building, Installations, decorations and fixtures during the inspection, testing and commissioning works for any of the Installations shall be provided and implemented.

All necessary equipment, apparatus and tools for carrying out the inspection, testing and commissioning works shall be provided.

Competent and experienced commissioning personnel to carry out the inspection, testing and commissioning works shall be provided.

All consumable working medium such as diesel, fire extinguishing gases/media and lubricants and other materials expended or used during the test shall be replenished. The entire Installations including portable hand-operated approved appliances shall be in "as new" and functional condition at the conclusion of the tests.

Fire detectors shall be protected from dust and dirt by temporary protection or PVC wrapper or similar before put into operation, and shall be cleaned after any test.

1.2.1.5 INSPECTION, MEASURING AND TESTING EQUIPMENT

Calibrated equipment and instrument for inspection, testing and commissioning shall be provided. The period between calibration and testing shall not exceed the calibration period as recommended by the equipment/instrument manufacturer or 12 months whichever is shorter. If required, the calibration requirements for test instruments used for testing/measuring shall also comply with the Circular Letters issued by statutory authorities in connection with the subject matters.

1.2.1.6 READINESS FOR INSPECTION, TESTING AND COMMISSIONING

The completion of the works to be inspected, tested or commissioned, the associated builder's works, the associated Installations and all other prerequisites shall be checked to ensure that inspection, testing and commissioning can be preceded in a safe and satisfactory manner without obstruction.

1.2.1.7 "TYPE-TEST" CERTIFICATE

"Type-test" for materials and equipment, where specified, shall be carried out at the manufacturer's works, recognised institutions or accredited laboratories, or elsewhere as approved in order to demonstrate their compliance with the specified requirements. "Type-test" certificates together with the corresponding drawings, sketches, reports and any other necessary documents shall be submitted to the Supervising Officer for approval before delivery of the materials and equipment.

Unless otherwise specified and where appropriate, the acceptable "type-test" certificates include, but not limited to, the followings: -

(a) Fans: "type-test" certificates showing fan characteristic curves (ISO 5801:2017), "type-tests" Certificates for sound power levels (BS EN ISO 5136: 2009), fan dynamic balancing test Certificates completed with a method of statement from manufacturer on testing to Grade 2.5, 4 & 6.3 on appropriate fan types in accordance with ISO 21940-11:2016 and ISO 21940-14:2012.

(b) Pumps: "type-test" certificates for head, discharge, speed and power input (BS EN ISO 9906:2012 as appropriate).

(c) Electric motors: "type-test" certificates in accordance with BS EN 60034-1:2010 and/or IEC 60072-1:1991, IEC 60072-2:1990 & IEC 60072-3:1994.

(d) Low voltage starter switchgear and control gear assembly: "type-test" certificates for starter (e.g. auto-transformer) and control panels assembly as a whole in accordance with IEC 61439-1:2011.

(e) High voltage switchgear and motor control switchboard: "type-test" certificates for high voltage switchgear and switchboard in accordance with IEC 62271-100:2008+A1:2012+A2:2017.

(f) Other electrical equipment, such as air heaters (but excluding thermostatic control equipment): "type-test" certificates in accordance with BS EN 60335-1:2012+A13:2017, BS EN 60669-1:2018, BS 5733:2010+A1:2014 and BS EN 60670-22:2006.

(g) Refrigeration plant: "type-tests" Certificates for hydraulic and air pressure testing at works in accordance with BS EN 378-1:2016, BS EN 378-2:2016, BS EN 378-3:2016 and BS EN 378-4:2016

1.2.1.8 OFF-SITE TESTS / FACTORY TESTS

Factory tests and off-site tests as required shall be carried out at the manufacturer's works, laboratories by independent regulatory/testing bodies, independent accredited laboratories or elsewhere as approved. This shall include quality control tests and general inspection tests in factory recommended by the manufacturer or for compliance with relevant standards.

Where collection of test samples on the Site is required for the off-site tests, the sampling and analysis methodology, including but not limited to the proposed independent accredited laboratory and the procedures for collection and analysis of test samples and submission of test results, shall be submitted to the Supervising Officer for approval. Supervising Officer's Representative, who shall supervise the sampling, transport and delivery of the test samples shall be notified in advance on the date for collection of test samples. Collection of test samples shall be conducted by the independent accredited laboratory unless otherwise agreed by the Supervising Officer. The collected test samples shall be kept in sealed and locked containers inaccessible to unauthorised persons at all times. The test results in sealed envelope shall be submitted by the independent accredited laboratory to the Supervising Officer directly.

Where specified, performance tests shall be carried out in factory for each or some of the offered equipment before delivery. After the performance tests, factory test report/certificate certified by a qualified factory engineer shall be submitted in duplicate to the Supervising Officer for approval immediately after the tests and before the equipment is dispatched from the manufacturer's work place.

Factory tests shall be witnessed by an independent approved agency where specified. The Supervising Officer may require witnessing the tests and inspection of locally and/or overseas manufactured equipment during construction at the manufacturer's works.

Certificates of all manufacturer's tests carried out at the local and/or overseas manufacturer's factory/laboratory shall be submitted to the Supervising Officer for approval. This approval shall be obtained before the components or equipment are delivered from the manufacturer's works unless otherwise specified.

1.2.1.9 SITE TESTS

Site tests for all static systems shall be carried out during construction period for individual components and/or part of the installed works to ensure safe and proper operation of the complete installation according to the specified requirements. Such tests shall include integrity test of welds and pressure test on the hydraulic systems where

applicable. Any component or equipment set to operate at or below the test pressure shall be isolated or removed prior to applying the pressure test. Site tests for electrical works in the Installations shall comply with the COP for the Electricity (Wiring) Regulations unless otherwise specified. Registered or suitably qualified workers shall be deployed to conduct site tests, where applicable, for the Installations.

Works to be permanently covered up shall be subject to inspection and testing before covering up. If the Supervising Officer or his Representative discovers any work that has been covered up before inspection and testing, this work shall be uncovered for inspection and testing to the satisfaction of the Supervising Officer or his Representative. The cost involved in uncovering the work, inspecting, testing and re-concealing the work together with any consequential losses shall be at no cost to the Employer.

In particular, the following arrangements shall be included:

(a) "on-site" tests in respect of all static systems to ensure safe and proper operation as conforming to the design intent. Such tests shall include test of welds and pressure tests on the hydraulic systems.

(b) Re-charge and reinstate water distribution and circulation systems with clean water after hydraulic test. Any items of equipment set to operate at or below the test pressure shall be isolated prior to such test.

(c) Air leakage test for all ductwork.

SUB-SECTION 1.2.2

INSPECTION

1.2.2.1 INSPECTION OF MATERIALS AND EQUIPMENT DELIVERED TO SITE

Details of materials and equipment delivered to the Site including, but not limited to, brand name, model number, country of origin (if specified), their tested standards and record of Supervising Officer's approval, purchase order, delivery order, record of delivery, payment vouchers, ex-factory certificate and shipping voucher, and all other relevant documents as applicable shall be provided to the Supervising Officer for identification and verification of the materials and equipment delivered to the Site are in compliance with the approved submissions.

1.2.2.2 VISUAL INSPECTION AND CHECKING

Adequate provisions to facilitate visual inspections and checking of the work in progress to be carried out by the Supervising Officer or his Representative shall be arranged from time to time during the construction period. The inspection record shall be kept for checking from time to time. Any defective works or sub-standard works found during visual inspection and checking shall be rectified or replaced before proceeding with further tests.

Installations to be permanently covered up shall be subjected to inspection and tests before cover up. During the inspection, if the Supervising Officer discovers any work that has been covered up before inspection and testing, this work shall be uncovered for inspection and testing to the Supervising Officer's satisfaction. The cost involved in uncovering the work, inspection, testing and re-concealing the work together with any consequential losses such as the re-programme of work shall be at no cost to the Employer. Any defective works and installation of poor workmanship found during visual inspection shall be rectified or replaced before proceeding with further tests.

Visual inspection and checking shall include but not limited to the inspection and verification of the installed equipment being the approved brands and models and checking of any visible damages (such as scratches or dents, or painting problems) found on the equipment surface. Relevant documents including delivery orders, payment vouchers, confirmation from manufacturers, factory test records, etc., shall be provided to substantiate the equipment installed on Site being the approved brands and models if the identification of the manufacturer, model name, capacity and rating cannot be found or seen easily on Site.

1.2.2.3 HANDOVER INSPECTION

Detailed inspections for all components and equipment installed shall be carried out. All necessary checking including operational settings for all equipment and systems in accordance with the instructions and recommendations from the manufacturer and to the satisfaction of the Supervising Officer shall be made before the handover of the Installations.

If it is considered difficult or impossible to gain access to a part or parts of the complete installation for dismantling or maintenance purposes, demonstrations on dismantling and assembling those parts/components of the installation shall be carried out to confirm the provisions are adequate. All necessary modification work shall be carried out at no additional cost to the Employer to alleviate the difficulties associated with dismantling or maintenance access.

The Installations cannot be handed over until all the foregoing requirements where applicable have been carried out to the satisfaction of the Supervising Officer.

The following documents and data shall be provided before the handover inspection: -

(a) Test Certificates

Test records/certificates where applicable shall be provided: -

- Copies of manufacturer's works test records/certificates on the Installations;
- Copies of test records for all the Installations;
- Copies of electrical test records /certificates for works carried out on site;
- Copies of hydraulic and pressure test records/certificates for works carried out on site;
- Copies of works completion certificates for electrical works;
- Copies of boiler and/or refrigeration plant efficiency test/record certificate;
- Copies of Registered Surveyor's test/record certificates for pressure vessels;
- Copies of performance test/record certificate including water balancing, air balancing, room conditions, etc.;
- Copies of all noise test/survey records on every noise emitting plant and machineries, individual room/space and a statement of compliance with the statutory requirements under the current Noise Control Ordinance (Cap. 400); and
- Copies of test records /certificates issued by the statutory authorities.

(b) As-built Drawings

As-built drawings as required by the Contract shall be provided.

(c) Operation and Maintenance Manuals, User Manuals and Energy Management Manuals

O&M Manuals, User Manuals and Energy Management Manuals as required by the Contract shall be provided.

(d) Building Energy Models

Building energy models as required by the Contract shall be provided.

(e) Manufacturer's Name Plate

Every item of plant/equipment/apparatus supplied by manufacturer, if any, shall be fitted with a clearly engraved, stamped or cast manufacturer's name plate properly secured to the plant/equipment/apparatus and showing: -

- Manufacturer's Name;
- Serial and/or Model No.;
- Date of Supply;
- Rating/Capacity; and
- Test and Working Pressure (where applicable).

(f) Labels, Instructions and Warning Notices

Labels, instructions and warning notices shall be provided according to relevant clause(s) of this General Specification.

SUB-SECTION 1.2.3

TESTING AND COMMISSIONING

1.2.3.1 GENERAL

Proper testing and commissioning for the Installations with satisfactory results shall be conducted and completed before inviting the Supervising Officer or his Representative for witness the testing and commissioning works. Witness of the complete testing and commissioning by the Supervising Officer or his Representative shall be arranged. Unless otherwise approved by the Supervising Officer, testing and commissioning works in the absence of the Supervising Officer or his Representative shall not be accepted as the approved test record.

Any defects of alignment, adjustment, workmanship, materials and performance or other irregularities which become apparent during commissioning or testing shall be rectified. The relevant part of the commissioning or testing procedure shall be re-arranged and conducted to demonstrate satisfactory performance.

1.2.3.2 PROCEDURES, STANDARDS AND REQUIREMENTS

Relevant approved standards, procedures and guidelines shall be followed in the testing and commissioning works, including but not limited to: -

(a) Statutory obligations and requirements, specifications and standards specified in this General Specification;

(b) The Testing and Commissioning Procedures;

(c) Detailed inspection, testing and commissioning methods and procedures approved by the Supervising Officer;

(d) Equipment manufacturers' recommendations and specifications, if any; and

(e) Test requirements under various standards including British Standards, European Standards, ISO Standards, IEC Standards, National Fire Codes by NFPA, UL/FM's publications and other international standards on fire protection.

1.2.3.3 MASTER PROGRAMME FOR TESTING AND COMMISSIONING WORKS

A programme for testing and commissioning works shall be submitted within the first three months after acceptance of Tender. The programme shall indicate the tentative dates of all tests and commissioning works that will be carried out throughout the Conditions and all necessary submissions and approval relating to testing and commissioning. The testing and commissioning programme shall matches the master programme for construction and that all testing and commissioning works are complete

before the prescribed or extended date for completion of the Works. The programme shall also be updated as the Installations progress towards completion.

The programme shall detail the types of testing and commissioning works required, the breakdown of the programme into floor-by-floor and/or area-by-area basis, the tests that are required during construction and before completion of the Installations, the period of each test with float time allowed, the milestone dates for the key activities of works etc. Critical path programme shall be submitted. The programme shall be planned so as to minimise the overlapping of different tests arranged simultaneously in different locations of the Site.

A detailed checklist of all the Installations to be commissioned and tested shall be submitted at the same time. The checklist will be used for progress monitoring and shall be updated from time to time as the Installations progress towards completion.

1.2.3.4 TESTING AND COMMISSIONING ENGINEER / SPECIALIST

Competent and experienced testing and commissioning engineer/specialist responsible for overall planning, organising, coordinating, supervising and monitoring of the testing and commissioning works and also certifying all results and reports from the testing and commissioning works for the Installations shall be appointed. Information detailing the qualification and experience of the testing and commissioning engineer/specialist shall be submitted to the Supervising Officer for approval.

1.2.3.5 SAFETY, FUNCTIONAL AND PERFORMANCE TESTS

Complete safety, functional and performance tests on all installed equipment and systems, including the setting of controls, adjustments, commissioning and checking the operation of all protective and safety devices, in accordance with the manufacturers' recommendation, statutory requirements, and the approved procedures shall be conducted before the Installations will be accepted.

The testing and commissioning shall include, but not limited to, the following: -

- Factory tests and off-site tests;
- Visual inspection and checking;
- Setting to work including safety and quality tests;
- Commissioning, regulating, tuning and adjustment;
- Functional tests;
- Performance tests;
- Final mock-up tests; and
- Statutory tests and inspections.

Progressive testing and commissioning shall be organised to achieve practical overall completion and have the whole work ready to be handed over by a date to suit the Contract completion date or any other agreed programme date.

The completion of testing and commissioning of the Installations to the satisfaction of the Supervising Officer and the satisfactory completion of all associated statutory inspections by the statutory Authorities are the important considerations for certifying completion of the Installations. A detailed plan and programme for the testing and commissioning works shall be prepared at early stage of the Contract in order to ensure that all the testing and commissioning works will be completed within the construction period and before the completion date of the Installations.

Any defects of workmanship, materials and performance, maladjustments or other irregularities which become apparent during testing and commissioning shall be rectified at no additional cost to the Employer and the relevant parts of the testing and commissioning procedures shall be repeated.

During the inspection, testing and commissioning, demonstration shall be arranged to the satisfaction of the Supervising Officer on the dismantling and access arrangement for any part or component of the Installations for which, in the opinion of the Supervising Officer, have inadequate maintenance access. All necessary remedial work shall be carried out at no extra cost to the Employer to alleviate the difficulties associated with the dismantling or maintenance access when found.

1.2.3.5.1 Setting to Work, Safety and Quality Tests

Prior to the testing and commissioning works, the completion of the Installations and associated builder's work shall be checked to ensure that commissioning can be proceeded without obstruction.

Before any installation is subjected to commissioning and site testing, it shall be thoroughly cleaned both internally and externally.

The initial setting of the Installations shall include: -

(a) Preliminary checks to ensure that all systems and system components are in a satisfactory and safe condition before start up;

(b) Preliminary adjustment and setting of all plant and equipment consistent with eventual performance;

(c) Carrying out safety test, pressure test, hydraulic test and other tests required before energising the equipment and plant;

(d) Checking the proper functioning of the protective devices and safety valves in the Installations and carrying out all necessary safety testing;

(e) Energising and setting to work on all plants; and

(f) Initial regulation and demonstration that the Installations delivers the correct rate of flow at the conditions specified in the Contract.

Specialist plant or equipment shall be commissioned, certified and tested by the manufacturer's skilled commissioning engineer and/or technician.

Where the tests involved other Installations already in operation in other parts of the building outside the Site or Installations area, coordination with relevant parties shall be made, where necessary, on the temporary suspension of other system operation for the tests. All necessary temporary precautionary measures to fulfil the statutory safety requirements in such case shall be provided and the relevant statutory Authorities shall be informed on the arrangement.

1.2.3.5.2 Commissioning, Regulations, Tuning and Adjustment

The Installations shall be regulated, balanced, tuned, commissioned and adjusted as appropriate to deliver the conditions and requirements as specified in the Contract until all the requirements are met and accepted by the Supervising Officer.

1.2.3.5.3 Functional Tests

The functioning of the system and equipment complying with the operational and functional intent and the requirements in the Contract shall be demonstrated to the satisfaction of the Supervising Officer.

Necessary measures to ensure that all water discharge in the test is properly drained to nearby drain points shall be provided. All the smoke and gas generated shall also be vented outside the building after the test.

1.2.3.5.4 Performance Tests

Tests shall be carried out to prove the performance of the Installations, system and equipment in term of operating sequence, control, flow, pressure, electrical current, sound level, and other technical aspects complying with the requirements in the Contract, relevant standards and the statutory requirements. The Installations shall be regulated, balanced, tuned, adjusted and modified as necessary till the performance requirements are met. The final setting and operation parameters of all equipment shall be recorded.

Where necessary or as required, full load test by simulation method or other approved method to prove the performance of the Installations at full load condition shall be provided.

1.2.3.6 DOCUMENTATION AND DELIVERABLES

All commissioning information and testing results at the witness of the Supervising Officer or his Representatives shall be recorded. Testing and commissioning shall be properly checked and certified by the Testing and Commissioning Engineer /Specialist and signed by the Supervising Officer or his representative who has witnessed the testing or commissioning before submission to the Supervising Officer.

Immediately after each test, the Testing and Commissioning Engineer /Specialist shall sign the test/data record sheet, and obtain the endorsement of the Supervising Officer's representative who has witnessed the test on site, irrespective of whether the test is successful or not, and submit a copy of the test/data record sheet to the Supervising Officer.

Commissioning and testing report shall be submitted to the Supervising Officer within 14 days after completion of the commissioning and testing of the Installations. The report shall be in accordance with the requirements approved by the Supervising Officer.

SECTION 1.3

GENERAL TRAINING, INSPECTION, ATTENDANCE. OPERATION AND MAINTENANCE DURING MAINTENANCE PERIOD

SUB-SECTION 1.3.1

GENERAL REQUIREMENTS

1.3.1.1 GENERAL

Training, inspection, attendance and operation and maintenance services as described in this Section for all Installations shall be provided during the Maintenance Period. Specific requirements as stipulated in various Parts of this General Specification and the Particular Specification shall also be followed for particular Installations.

Replacements for any equipment or parts thereof, which may, in the opinion of the Supervising Officer, become unserviceable, especially where the causes are attributable to faulty materials, workmanship, or inadequate performance, shall be supplied and installed without additional cost to the Employer.

All works shall be carried out in compliance with the statutory regulations to safeguard persons, including workers, users and any persons in the vicinity of the installation, against the risk of any accident including fire accident associated with the works.

The interruption of electricity supply and functioning of the Installations during execution of works shall be kept to the minimum. Such interruption shall only be allowed with the prior approval of the Supervising Officer or his Representative.

All burnt out or defective lamps or luminaires for failure or deficiency in performance shall be replaced at no cost to the Employer if the failure of the Installations is still within the manufacturer's guaranteed life period. The cost of lamps will be permitted to charge for only if they fail beyond the guaranteed life period.

Necessary arrangements to avoid damage to property or installations provided by others during the course of the Installations shall be made. All losses and claims for injury or damage to any person or property whatsoever which may arise out of or in consequence of the execution of the repair and maintenance of the Installations shall be reimbursed to the Employer.

No replacement of plant or parts of plant shall be carried out at any time unless the Supervising Officer has been notified and approval given.

1.3.1.2 COMPLETION OF OUTSTANDING AND DEFECTIVE WORKS

After receiving the list of defects and outstanding works issued with the certificate of completion of the Works, the rectification of defects and outstanding works shall be completed to the satisfaction of the Supervising Officer within the agreed time frame during the Maintenance Period. Any defects identified within the Maintenance Period shall be rectified as soon as practicable.

Periodic report on the progress of completion for outstanding works and defect rectification works shall be submitted to the Supervising Officer. Inspection with the Supervising Officer's Representatives to verify satisfactory completion of the outstanding works and defect rectification shall be arranged.

1.3.1.3 REPAIR AND MAINTENANCE RECORDS

Log book as required by statutory requirements shall be provided and maintained.

Other than the physical log book as required under statutory requirement, electronic log book system(s) as agreed with the Supervising Officer or his Representative shall be provided for each Installations during the Maintenance Period. Every attendance, inspection, repair, maintenance services and details of work done for the Installations shall be recorded into the electronic log book so as to form a comprehensive record. The electronic log book may be in either English or Chinese.

The electronic log book shall features acknowledgement function for each item of works. Digital acknowledgement from the representative of the occupant for each entry in the logbook to acknowledge and accepting the visit, attendance, repair and maintenance work by the occupant shall be obtained.

The electronic log book shall allow the upload of photos for specific log item. Record of attendance shall be by means of scanning identification devices installed in the specific locations (e.g. Radio Frequency Identification tag or QR code).

The electronic log book shall be accessible from Internet with access management control and encryption function for data security. Anti-virus software with updated security patches shall be maintained. The stored data shall be backup periodically. Full record in the electronic log book system shall be exported to files in open format (example pdf file) for handover to the Supervising Officer upon the end of Maintenance Period.

The detailed proposal of the electronic log book system shall be submitted to the Supervising Officer for approval.

For faults due to equipment failures, vandalism, major repair, or repeated breakdowns, in addition to record the event in the electronic logbook, a report shall be submitted to the Supervising Officer within 3 days of the faults. The report shall include the details of findings in the investigation, cause of breakdown, the time and date that the fault reported, the repair team arrival and the repair carried out, the remedial actions taken, and the time and date that normal service is resumed, suggested precaution and/or action required to prevent recurrence of similar incident. A list of equipment replaced shall also be attached to the report. The maintenance works records must be kept for a period of not less than 3 years counting from the issue of maintenance certificate.

Furthermore, a monthly fault call and emergency report should be prepared from a database, which is set up for recording the history of all fault logs, for performance evaluation. This fault report should be detailed enough for analysis to prevent "repeated faults", and trend analysis of breakdown.

SUB-SECTION 1.3.2

TRAINING TO USERS AND OPERATION AND MAINTENANCE AGENTS

1.3.2.1 GENERAL

Training for the operation and maintenance of system and equipment under each Installations shall be provided and arranged. The training shall include all training facilities, material handouts, lecture, briefing, demonstration and all necessary provisions. Training proposal shall be submitted for the Supervising Officer's approval at least 3 months prior to the prescribed or extended date for the completion of Works.

Training proposal shall include the training details, schedules, syllabus and duration of the training activities, qualifications of the instructor and the qualification requirements for the trainee(s). The training schedule shall ensure that the Employer's operation and maintenance staff can acquire full knowledge and operation, breakdown and routine maintenance, diagnosis and hence operate and maintain reasonably effectively and efficiently the system/equipment upon the handover of Installations. System design, operation and maintenance of the plant, use of special tools and equipment and emergency changeover operation shall be covered in the training.

Equipment schedule with full details on equipment name, quantity, installation location, brand name, manufacturer name, supplier name, supplier contact information, equipment cost, recommended serviceable life, cycle of major overhaul, etc. shall be provided before the training activities.

Whenever possible, the training courses shall be held before or during the commissioning period and shall be in Hong Kong.

Training courses shall be conducted in English and Cantonese and shall be held in Hong Kong.

1.3.2.2 OTHER TRAINING REQUIREMENTS

The training course shall contain, but not limited to, the following: -

(i) General description of the system and its associated equipment as a whole;

(ii) Start-up and shut-down procedures;

(iii) Safety precautions during start-up, operation, shut-down and maintenance;

(iv) A detailed description of the functions of all switches and indicators on control console;

(v) Trouble shooting procedures;

(vi) Emergency changeover operation and procedures;

(vii) Preventive and corrective maintenance requirements to ensure proper operation of a system or equipment under the maintenance schedule;

(viii) Identification of all the operating parameters which affects the performance of the plant;

(ix) Adjustment of the operating parameters to achieve optimum operating conditions;

(x) Check-list of all the periodic inspection and servicing of the plant;

(xi) Illustration of the construction of major components of the plant by sectional views;

(xii) Dismantling and reassembling procedures during a major repair;

(xiii) Critical dimensions such as bearing clearance, wearing ring clearance, thrust clearance, torque table for bolts and nuts, etc.;

(xiv) The use of special tools and equipment;

(xv) Calibration for testing equipment, measurement, record and performance assessment; and

(xvi) Any other items as found necessary.

SUB-SECTION 1.3.3

GENERAL INSPECTION, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

1.3.3.1 RESPONSE AND ATTENDANCE TO EMERGENCY AND FAULT CALLS

Emergency, fault and complaint calls arising from defective work materials and/or system operation shall be attended at any time or as specified in accordance with the following categories during the Maintenance Period. Defects leading to fault or breakdown of the equipment and/or system shall be rectified within the time as specified in contract documents. The costs for the attendance, labour, overtime work, repair service, materials and spare parts for repair, submission of fault/breakdown reports, etc. are deemed to have been allowed for in the Tender.

(a) VERY URGENT for cases involving any life safety issue /incident, power supply interruption more than one final sub-circuit, breakdown of central chiller/heating plant causing insufficient supply capacity, pipe burst, breakdown of installations causing interruption of services at large, or other situations the Supervising Officer or his representative determine, the call shall be immediately response and attend the faults within 30 minutes.

(b) URGENT for cases involving power supply interruption not more than one final sub-circuit, clogging of drain pipe, drainage overflow, minor water leakage, breakdown of central chiller/heating plant not causing insufficient supply capacity, breakdown of installations not causing interruption of services at large, or other situations the Supervising Officer or his representative determine, the call shall be immediately response and attend the faults within 1 hour.

(c) NON URGENT for cases that is not as serious as being included in (a) and (b) above, such as minor pipe cracking, malfunction of valve and strainer clog, etc., the call shall be immediately response and attend the faults within 4 hours.

The breakdown calls shall be immediately answered during the day or night including public holidays, and attend to the faults both inside and outside the normal working hours in the shortest possible time and using the quickest means of transport.

The Supervising Officer or his representative shall be immediately informed upon the failing to attend the faults within the specified period. Justification for the incapability to comply with the requirement of response shall be provided.

If there is a failture to respond or attendance to the emergency /fault call, the Supervising Officer may seek alternative service to remedy the emergency issue /fault. Any costs so incurred in connection with the alternative service, irrespective of whether it is within the liability under the Contract, shall be deducted from monies retained under the Contract.

After each service, an investigation report shall be provided to the Supervising Officer regarding the cause of the fault and the repair work carried out. Investigation report and proposal for improvement/ modification shall be provided.

Any necessary repairs shall be carried out with the most practicably expeditious means to ensure minimum interruption to the operation of the Installations.

Necessary repair for resuming the breakdown installation shall be completed promptly. In case immediate permanent repair is not possible due to safety related reason, the following "time for repair" targets counted from the receipt of breakdown or fault call shall be complied with: -

(a) Complete temporary repair for resumption of the suspended or breakdown services to a safe operating condition within 24 hours; and

(b) Complete permanent rectification works within 3 working days unless long component and parts delivery time is required.

1.3.3.2 MAINTENANCE SCHEDULE

Maintenance schedule for the necessary works in accordance to the requirements of this General Specification shall be submitted for the approval of the Supervising Officer before the commencement of the Maintenance Period.

Upon the approval of the maintenance schedule and before the commencement of the Maintenance Period, a comprehensive maintenance schedule for all Installations shall be prepared and the dates for routine and periodic inspection, servicing and maintenance of the Installations shall be indicated.

1.3.3.3 INSPECTION DURING MAINTENANCE PERIOD

In addition to the routine servicing and maintenance, further inspections for the Installations shall be made to check and, if necessary, re-adjust the equipment/systems to meet the actual operation conditions and to test the installations to meet statutory requirements including the submission of test reports and certificates.

1.3.3.4 JOINT INSPECTION AT THE END OF MAINTENANCE PERIOD

Inspections to the Installations at the expiry of the Maintenance Period shall be arranged in order to facilitate the acceptance and handing over of the Installations to the Employer’s operation and maintenance agents. Site checking shall be conducted and necessary adjustments to the equipment/systems shall be made one month before expiry of the Maintenance Period to ensure that the Installations are in good working order and in safe, satisfactory and energy efficient operation conditions for handover.

1.3.3.5 SPARE PARTS AND SPECIAL TOOLS

Spare parts and special tools required for the operation, servicing, maintenance and repair of the Installations shall be supplied and provided during the Maintenance Period. Adequate stocks shall be kept throughout the Maintenance Period.

Before the certified completion date of the Installations, a list of spare part and special tools for the Installations as recommended by the equipment manufacturers or as required shall be submitted to the Supervising Officer. The list shall include the itemised spare parts and special tools, application areas, manufacturers, model/part numbers, supplier contact, recommended stock keeping quantities and unit prices. Necessary diagrams and catalogues shall be included when requested by the Supervising Officer.

Unless specified in detail, the criteria to judge the need for spare parts to be included in the list shall be any part or component of the plant or equipment that is subject to frictional wear, vibration or temperature fatigue, rupturable to safety (or otherwise), corrosion, erosion, unacceptable deposits and/or saturation by contaminants (such as for filters), normal fair wear and tear and is likely to fail or reach an unacceptably low performance level within a period of three years or less from its commencement of operation.

The list shall include, but not limited to, at least the following items where they are part of the Installations: -

- springs, valves, valve rings, valve plates, etc.;
- bearings or bearing bushes;
- electric carbon brushes;
- electrical main and arcing contacts;
- electronic devices of CCMS and automatic control system;
- driving belts in matched sets;
- standard and special replaceable type air or liquid filter media;
- gaskets and jointing;
- seals, gland packings, etc.;
- rupturable safety devices;
- replaceable heat exchanger tubes;
- sight glasses;
- plug in relays;
- indicator light lamps;
- non-standard fuse cartridges;
- overload heaters/coils;
- flexible hoses and similar;
- unit to house an assembly of generator cells and sundry items;
- complete cell set for electro-chlorinator; and
- ultra-violet lamp.

Any of the above spare parts and/or disposable items which are required to replace defective or prematurely worn out parts that arise during the Maintenance Period shall be replaced at no cost to the Employer before the maintenance certificate is issued. The above items shall not be exhaustive. Other parts and components for normal operation of the Installations shall also be replaced at no cost if they are out of order.

PART 2 – MODULAR INTEGRATED CONSTRUCTION

SECTION 2.1

GENERAL REQUIREMENTS

SUB-SECTION 2.1.1

SCOPE OF WORKS

2.1.1.1 DEMARCATION OF WORK

Modular Integrated Construction (MiC) and MultiTrade Integrated Mechanical, Electrical and Plumbing (MiMEP) shall be applied when specified in the Contract. The latest edition of the General Specification for Buildings issued by the Architectural Services Department of the HKSAR Government shall be referred and followed.

The Building Contractor shall be responsible for the overall planning, design and coordination on the implementation of MiC and MiMEP. The demarcation of works between the Building Contractor and Nominated Sub-contractor(s) /Specialist Sub-contractors in carrying out the building MiC and MiMEP, including the design responsibilities, execution of works, quality assurance, inspection, testing and commissioning works, shall be proposed by the Building Contractor.

For Direct Contract without Building Contractor, the requirements of this General Specification shall also be applied for MiMEP.

MiC Building Services Designer shall be engaged to supervise and certify the MiMEP work as appropriate.

2.1.1.2 MIC BUILDING SERVICES DESIGNER

Where specified in the Contract with a MiC Building Services Designer to carry out the design and checking of the building services works for MiC and MiMEP, the MiC Building Services Designer shall be a Registered Professional Engineer in Hong Kong under the Engineers Registration Ordinance (Cap. 409) in Building Services, Mechanical or Electrical discipline and possess minimum 5 years post Registered Professional Engineer experience in the design, supervision and coordination of construction projects.

The MiC Building Services Designer shall coordinate with the MiC Architectural Designer and MiC Structural Designer to ensure that the designs of off-site MiC modules are well-integrated and fully complied with the requirements as specified in this General Specification and the General Specification for Buildings to the acceptance of the Supervising Officer (SO).

All drawings and design calculations, for both permanent and temporary works of the proposed MiC and MiMEP modules shall be prepared under the direct supervision of and certified by the MiC Building Services Designer with the endorsement from a Registered Structural Engineer (RSE).

The MiC Building Services Designer shall provide adequate off-site supervision at the prefabrication factory to check that the module production works are constructed to the approved design, required standards and quality. The supervision provided by the MiC Building Services Designer shall also cover the on-site construction works related to the assembly of modules.

The MiC Building Services Designer shall conduct audit design checking as specified in the General Specification for Buildings.

2.1.1.3 FABRICATION PROPOSAL

The detailed scopes of work including the domestic products for off-site MiC and MiMEP fabrication /installation shall be submitted to the Supervising Officer for approval before fabrication. The information to be submitted shall include, but not limited to, the following:

(a) The scope of the installation /system(s) being constructed under MiC and MiMEP approach respectively;

(b) The detailed demarcation of the building services components of the MiC units and MiMEP modules shall be illustrated in coloured drawing plans or/and Building Information Modelling (BIM) models to demarcate whether the works to be fabricated/assembled/installed in: -

- factory outside Hong Kong;
- off-site prefabrication yard /factory; and
- in-situ.

(c) Construction details to be integrated as a part of the MiC / MiMEP modules, in particular the interfacing details with in-situ installation;

(d) Maintenance facilities and access after the MiC / MiMEP modules are put in place on site;

(e) Method statement of the assembly work covering from the fabrication work process inside MiC / MiMEP factory to on-site installation, including precautionary site survey check of in-situ installation for interfacing with MiC / MiMEP modules, services duct / pipework alignment tweak, etc.;

(f) Testing and commissioning procedure to be conducted at factory;

(g) Factory production time schedule for MiC / MiMEP modules;

(h) Temporary protective measures for components of MiC / MiMEP modules in the course of transportation for delivery to the Site;

(i) Delivery and logistic proposal for access route to the installation locations within building structure and plant rooms;

(j) The estimated quantities of various building services components assembled under the MiC and MiMEP approach respectively against the

overall Installations, including proportion of areas for individual installation/system, estimated cost and area incurred;

(k) The supply sources of the building services components for assembly and installation in the MiC units and MiMEP modules outside Hong Kong; and

(l) Where household electrical product, prescribed product or domestic gas appliance is involved to be pre-installed off-site outside Hong Kong, the supply sources of the prescribed products and gas appliances under the Electrical Products (Safety) Regulation (Cap. 406G), the Energy Efficiency (Labelling of Products) Ordinance (Cap.598) or the Gas Safety (Miscellaneous) Regulation (Cap. 51F) respectively for installation in the MiC units and MiMEP modules.

The Contractor shall stocktake and summarise the as-built quantities of various building services components assembled under the MiC and MiMEP approach against the overall Installations, including proportion of areas and costs for individual installation/system, the estimated cost per unit area incurred. The updated figures shall be provided upon request and the final figures shall be provided within 6 months after the certified completion of the Contract.

2.1.1.4 STATUTORY REQUIREMENTS, STANDARDS AND GUIDELINES

On top of the statutory requirements, standards and guidelines stipulated in the General Specification for Buildings, the MiC and MiMEP modules shall also comply with, but not limited to, the following:

(a) FSD Circular Letter No. 3/2019 Guidance Notes on Submission, Approval and Acceptance Inspection of Fire Service Installations and Equipment in Modular Integrated Construction Building Projects issued by the Fire Services Department (FSD);

(b) Circular Letter No. 2/2019 Procedures for Applications for Water Supply in New Building Projects adopting “Modular Integrated Construction” Method issued by the Water Supplies Department (WSD);

(c) Guidance Note on Fixed Electrical Installations with Modular Integrated Construction Method issued by the Electrical and Mechanical Services Department;

(d) Guidance Note on Household Electrical Products with Modular Integrated Construction Method issued by the Electrical and Mechanical Services Department (EMSD);

(e) Guidance Note on Gas Supply Installations issued by the Electrical and Mechanical Services Department (EMSD);

(f) Guidance Note on Supply of Energy Label Prescribed Products at MiC Projects issued by the Electrical and Mechanical Services Department (EMSD);

(g) Guidelines on the Statutory Requirements for Modular Integrated Construction Projects issued by the Construction Industry Council (CIC);

(h) Guidelines on Application of Construction Noise Permit for using Modular Integrated Construction (MiC) Method" by the Environmental Protection Department (EPD);

(i) Code of Practice for the Electricity (Wiring) Regulations 2020 Edition Section 26T Installation for Modular Integrated Construction

(j) Road Traffic (Traffic Control) Regulations; and

(k) Any other statutory requirements and guidelines in relating to the MiC construction method.

SUB-SECTION 2.1.2

DESIGN REQUIREMENTS

2.1.2.1 DESIGN CONSIDERATIONS

2.1.2.1.1 Layout and Configurations

Layout and configuration shall be well planned and coordinated in an effective modular design to ease on-site installation with minimisation of ductwork / pipework joints as far as practicable. Building services components shall be strategically located that are free from the danger of water damage and/or flooding. The configuration and geometry of building services components shall be simplified to avoid complicated routing, excessive bends and joints.

For multi-layer MiMEP, such as the ceiling mounted multi-trade horizontal services modules etc., the layer shall be designed and laid based on the frequency of access required during the operation and maintenance.

MiMEP modules shall be standardised as far as practicable to maximise the benefits of pre-fabrication.

The volumetric size and geometry of individual module shall be optimized to suit the particular site environment for proper transportation, hoisting, delivery and assembly on site.

The provisions in the construction site, including loading and unloading area, lifting facilities, delivery route, preparation work and associated builder's work shall be considered.

2.1.2.1.2 Joints

Tolerance of gradient and necessary extended short length of services for connections shall be allowed between MiC units and MiMEP modules at joints. Integrity and performance of the Installations shall not be compromised due to connections and joints.

2.1.2.1.3 Access for Inspection, Operation and Maintenance

Adequate access to the building services components for frequent inspection, operation, maintenance and future replacement should be allowed after the assembly of units /modules. To facilitate future operation and maintenance, temporary support, in the course of transportation for delivery to the site, shall be removed as soon as the MiC units and MiMEP modules are put in place on site.

2.1.2.1.4 Supporting Frame and Structure

For standalone MiMEP modules, an integrated supporting frame / hanger system shall be provided for the composite fixing of multi-services trades within each module. The steel frame / hanger shall be of robust and adjustable framing design featured with flexible fixing and bracketry facilities for mounting of different services duct / pipe in position. The flexible fixing facilities shall be able to accommodate certain degree of services fixing adjustment in order to suit the alignment of module interfacing with on-site installation or among modules themselves.

Lifting lugs shall be incorporated in the design of the modules to facilitate transportation and delivery. The design of steel frame and hangers for the sole purpose of maintaining structural integrity during transportation and delivery should be able to taken down after the assembly module is put in place on site in order to allow more flexibility in access to maintenance.

The design of the supporting frame and hanger system shall allow the alteration, take down and re-fix of the building services components without affecting the structural integrity of the overall framing of the individual building services module. Clear marking shall be shown for critical structural support components that shall not be dismantled during the alteration works.

2.1.2.2 DESIGN PROPOSAL

Design proposal certified by the MiC Building Services Designer for the MiC /MiMEP work for structural elements when involved shall be submitted to the Supervising Officer for approval before fabrication. The design proposal shall include, but not limited to: -

(a) Layout and configurations of individual MiC /MiMEP modules;

(b) Design calculations for the structural integrity of MiMEP for both permanent and temporary works;

(c) Use of materials and equipment;

(d) Details of jointing and interface between MiC /MiMEP modules;

(e) Details of supporting frame /hanger system and design calculation;

(f) Provisions of anti-vibration accessories and design calculation;

(g) Positions of covered up and exposed components;

(h) Provision of access points to facilitate inspection and repair/replacement of building services connections, drainage pipes and joints; and

(i) Associated site preparation and builder's work for the setting out and assembly of the Installation on site.

SUB-SECTION 2.1.3

QUALITY CONTROL AND SUPERVISION

2.1.3.1 GENERAL

The quality control and supervision for MiMEP shall follow the requirements stipulated in this Sub-section of this General Specification. The quality control and supervision for MiC shall follow the requirements stipulated in the General Specification for Buildings.

Each MiMEP module shall be assigned with a unique code for identification in the design, fabrication and assembly process. Individual module shall be labelled for the identification. Details such as module code etc. shall be included in the label to ensure all modules are properly positioned as designed. Radio-frequency identification (RFID) tags, QR codes or other equivalent identification methodology agreed with the Supervision Officer shall be used to facilitate tracking of fabrication, delivery and installation of module to ensure traceability. Record contained in the code for identification should be encrypted and non-editable once it is entered into the system.

Inspection report, including the identification of various parties responsible for conducting the quality assurance supervision, details of the inspection, auditing and testing of the off-site installation works shall be maintained and ready for examination when requested.

Paper record and/ or digital records (by adopting system such as Digital Works Supervision System (DWSS)), including photographs and videos during inspection and testing in the off-site factory and on-site assembly process shall be maintained. The record shall be ready for examination by the Supervising Officer, Independent Inspection Agent (IIA) and the representatives of the statutory authorities when requested.

The Supervising Officer and his representatives, if consider necessary, will pay visit(s) to the prefabrication factory to inspect the fabrication processes or mock-up production; and/or to check the quality control and supervision of the MiMEP production.

The Supervising Officer and his representatives, will reserve the right to request for a sampling test/inspection of up to 1% of the MiMEP modules/items/materials delivered to site before installation to verify the compliance with the Contract requirements.

2.1.3.2 QUALITY ASSURANCE PLAN

Quality assurance plan addressing the fabrication, assembly, installation, inspection, testing and commissioning process of MiMEP modules shall be submitted to the Supervising Officer for approval prior to the commencement of the MiMEP modules fabrication in the factory. The information to be submitted shall include, but not limited to, the following:

(a) The organization chart indicating the roles and responsibilities of various parties for the quality control and supervision;

(b) Structural drawings and design calculation endorsed by the Registered Structural Engineer (RSE) on permanent and temporary works of the MiMEP modules, including but not limited to the mounting and the supporting frames for suspending the MiMEP modules and the related structural plans for the supporting frames;

(c) Inspection schedule of building services components on-site;

(d) Inspection, examination and acceptance process in accordance with the requirements in the Quality Site Supervision Plan (QSSP) or Inspection, Test Plan (ITP), as appropriate, with all critical activities identified and included, as appropriate;

(e) The inspection recording mechanism for ready examination by the Supervising Officer;

(f) Quality control tests of materials on-site; and

(g) Calibration of laboratory equipment for quality control test.

2.1.3.3 INSPECTION PRIOR TO ON-SITE ASSEMBLY

On-site verification shall be carried out to ensure the builder's works (e.g. wall/floor openings, surface for fixing of modules' frame, delivery route, provision for hoisting/lifting facilities, etc.) are provided before delivering the MiMEP modules.

Before the on-site assembling process, necessary inspection and checking shall be arranged, especially if there is concern over possible deformation damage or the like during transit and difficulty in replacing /repairing the components after assembly on-site. Any deficiency of MiMEP modules identified shall be investigated and reviewed with improvement and control measures as appropriate. A joint inspection shall also be arranged with relevant parties to monitor the on-site assembling process.

Contractor's Supervisory Team shall be available to carry out full inspection and check for all off-site installation works, as well as onsite assembly.

2.1.3.4 PROVISIONS FOR INSPECTION

The Supervising Officer may deploy an Independent Inspection Agent (IIA) to carry out inspection of the factory production process outside Hong Kong. A schedule of MiMEP inspections shall be prepared and submitted at early stage of the Contract period to facilitate the arrangement of IIA services by the Supervising Officer. Advance notice shall be given to the Supervising Officer of not less than 48 hours to allow the deployment of the IIA.

Temporary office accommodation in the factory shall be provided to facilitate the IIA to execute the inspection duties. Any works/tests that have been carried out without adequate advance notice shall deem to be rejected unless demonstrated to the satisfaction of the Supervising Officer.

Access and attendance shall be provided during the off-site inspection period by the Supervising Officer or the IIA. As and when necessary, the Supervising Officer or IIA may carry out routine supervision and inspections of the MiMEP modules. The Supervising Officer or IIA may require samples of material, workmanship, installation and the like to be provided for review. The Supervising Officer or IIA may call for meetings on quality matters and attendance will be required.

SECTION 2.2

TECHNICAL REQUIREMENTS

SUB-SECTION 2.2.1

MODULAR INTEGRATED CONSTRUCTION UNIT

2.2.1.1 BUILDING SERVICES WORKS

The building services components including the concealed cable containment facilities, exposed services, associated supporting framework /hanger and associated builder's works shall be pre-fabricated on the MiC units off-site as far as practicable, unless prior approval by the Supervising Officer.

Electrical cabling works of a completed circuit /sub-circuit within individual MiC unit shall be pre-installed off-site as far as practicable. Interconnection of cables between MiC units shall be conducted on-site. Interconnection of cabling facilities between MiC units shall be by means of either surface cable containment, or by means of concealed cable containment /conduit with proper concrete recess reserved in MiC units. Connection of cables, shall comply with the Code of Practice for the Electricity (Wiring) Regulations Section 26T and the Guidance Note on Fixed Electrical Installations with Modular Integrated Construction to ensure the complete continuity with acceptable connection methodology. Pre-installed electrical wirings shall be neatly grouped and terminated in cable terminals for easy identification.

Cabling facilities of Fire Services Installation (FSI) between MiC units shall be allowed for on-site installations of power and control cables. Cable joints should not be used for fire resisting cables serving FSI. All materials and equipment selected and installed shall be accompanied with product listing certificates /records /letters issued by the respective product certification bodies accepted /approved in accordance with FSD Circular Letter No. 3/2020.

Fixings for services adjacent and near the boundary /edge of the MiC units shall be detachable and re-fixed for minor re-positioning in order to allow flexibility and tolerance for jointing assembly of the services between MiC units. Flexible pipe jointing and/or extended short length of services, where required, shall be designed and installed for service connection.

All the gas installation works conducted in Hong Kong, including the installation of gas pipes/fittings/gas appliances and assembling of pre-laid gas pipes shall be carried out by Registered Gas Installer(s) registered to the appropriate class and employed by Registered Gas Contractor(s).

Adequate protection measure shall be provided for all cable containment, including conduit, pipe, duct and trunking, in order to prevent the water from entering.

2.2.1.2 PRODUCTS AND APPLIANCES TO BE INSTALLED

Household electrical products installed with the MiC units shall comply with the applicable safety requirements of the Electrical Products (Safety) Regulation (Cap. 406G), and the products should have been issued with valid certificates of safety compliance, as detailed in the Guidance Notes for the Electrical Products (Safety) Regulation issued by the EMSD.

Pre-installed domestic gas appliances (DGAs) in the MiC units shall be of brands and models approved by the Gas Authority under the "Approval Scheme for Domestic Gas Appliances" and bear the GU Mark as stipulated in Regulation 3B of Gas Safety (Miscellaneous) Regulations, Cap. 51F. Alternatively, the Contractor may apply for the Gas Authority's approval to import the DGA.

The prescribed products installed in the MiC units shall comply the Energy Efficiency (Labelling of Products) Ordinance (Cap.598). The Contractor shall ensure that the prescribed products being installed in the MiC units are listed model having reference number assigned in the supplier's name by the EMSD and bear an energy label that comprises with the specified requirement.

Prescribed products may be purchased from a Hong Kong importer (i.e. the specified person to whom a reference number for the prescribed product under the Energy Efficiency (Labelling of Products) Ordinance (Cap.598) has been assigned) for installation at the MiC units. The prescribed product should be a listed product model, and bear an energy label.

Prescribed products may be purchased from Mainland /overseas supplier or manufacturer for installation in the MiC units subject to the approval by the Supervising Officer. Irrespective of whether the product model is a listed model or a non-listed model under the Energy Efficiency (Labelling of Products) Ordinance (Cap.598), the importer of the product model shall be engaged to provide support for the import of the MiC units installed with the prescribed products.

2.2.1.3 BUILDING WORKS

For works falling within the scope of building works under the Buildings Ordinance, the Building Contractor shall design and propose the construction details and installation methodology of fire resisting construction components, drainage works and provision of access points for inspection /maintenance /repair of building services elements as an integral part of individual MiC systems /components /prototype with reference to the pre-acceptance arrangement for granting in-principle acceptance in according to PNAP No. ADV-36 on Modular Integrated Construction.

SUB-SECTION 2.2.2

MULTITRADE INTEGRATED MECHANICAL, ELECTRICAL AND PLUMBING MODULES

2.2.2.1 GENERAL

The components mentioned in this Sub-section shall be constructed through MiMEP approach unless otherwise approved by the Supervising Officer. Technical proposal for particular MiMEP module types that are not included in this General Specification but specified in the Contract shall be submitted to SO for approval.

2.2.2.2 CHILLED WATER PLANT AND PIPEWORK MODULE

Chilled water plant and pipework system shall be constructed in sectional modules and assembled to form a complete system. The sectional modules may comprise chiller units, pipe headers, straight pipes, bends, thermal insulation, cladding, valves, fittings, pump set module, associated electrical and control accessories, metering accessories, steel frame, hanger fixing, provision of vibration isolation accessories and maintenance platform, where applicable.

The supporting framework of the modules shall have adequate structural integrity to support the modules and the associated components, the loading of the circulating water under operation, the maintenance load and allowance for alteration and addition works. For modules accommodating chiller or other equipment, the supporting framework of the modules shall also further cater for the wind load imposed to the equipment for outdoor installations.

The design of chilled water pipework modules shall cater for the situation that air-conditioning plant components could be isolated for servicing without the need to complete drain-off of the entire pipework of the chilled water plant. Isolating valves and drain valves shall be provided to modules as appropriate.

Mechanical coupling or flange, joint and fitting shall be used as far as practicable, and in compliance with relevant clauses in Part 6 of this General Specification. All mechanical grooved couplings, grooved fittings, grooved valves, lubricant for coupling installation and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

Welding of pipework shall be minimised as far as practicable on site.

The module support framework shall be constructed of welded or bolted galvanized steel sections. The footing design of the module shall be suitable for on-site fixing with anchor bolts to the designated pedestals in the building structure. The framework shall be marked with alignment reference for easy checking of the alignment with adjacent modules.

Provisions for fine movement of the module in adjustment to the correct horizontal and vertical alignments with adjacent module(s). The anti-vibration mounting for air-cooled

chiller unit(s) shall be designed for the rotating frequency of the chiller fan and also for the lateral movement due to wind acting on the chiller.

2.2.2.3 COOLING TOWER PLANT AND CONDENSING WATER PIPEWORK MODULE

Cooling tower and condensing water pipework system shall be constructed in sectional modules and assembled to form a complete system for the proper operation of the condensing water system. The sectional modules may comprise cooling tower units, pipe headers, straight pipes, bends, cladding, valves, fittings, pump set modules, associated electrical and control accessories, metering accessories, steel frame, hanger fixing, provision of vibration isolation accessories and maintenance platform where applicable.

The supporting framework of the modules shall have adequate structural integrity to support the modules and the associated components, the loading of the circulating water, the maintenance load and allowance for alteration and addition works. For modules accommodating cooling tower or other equipment, the supporting framework of the modules shall also further cater for the wind load imposed to the equipment.

The design of cooling tower and condensing water pipework modules shall cater to the situation that cooling tower system could be isolated for servicing without the need to complete drain-off of entire pipework of the condensing water system. Isolating valves and drain valves shall be provided to modules as appropriate.

Mechanical coupling or joint shall be used as far as practicable, and in compliance with relevant clauses in Part 6 of this General Specification. All mechanical grooved couplings, grooved fittings, grooved valves, lubricant for coupling installation and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

Welding of pipework shall be minimized as far as practicable on site unless prior approval by the Supervising Officer.

The module support framework shall be constructed of welded or bolted galvanized steel sections. The footing design of the module shall be suitable for on-site fixing with anchor bolts to the designated pedestals in the building structure. The framework shall be marked with alignment reference for easy checking of the alignment with adjacent modules.

Provisions for fine movement of the module in adjustment to the correct horizontal and vertical alignments with adjacent module(s).

2.2.2.4 MODULAR WATER PUMP SET

Modular water pump set shall be constructed as a self-contained packaged module comprises of pump, motor, header pipes, sectional pipework, valves, fittings, thermal insulation, cladding, power supply connection to the pump motor from the motor control panel, control and metering accessories, skid plate and the mounting framework, as appropriate.

Chilled water pump, where specified in the Contract for modular water pump set, shall either be constructed as a self-contained packaged module or sectional pump module with prefabricated components, subject to the consideration of the weight, practicability for transportation and delivery.

The concrete inertia block, or floating plinth for pump skid, and anti-vibration provisions shall be integrated into the water pump set module as far as practicable subject to the consideration of the volume, weight, practicability for transportation and delivery of the modules.

The skid base shall be constructed of epoxy coated carbon steel or galvanized steel. Locking of the skid base to the concrete inertia block shall be by locking bolts embedded in the inertia block and passing through holes accurately pre-drilled in the skid base.

The skid base shall be fixed with necessary framework of the same construction material for the suitable mounting/support of piping, electrical and piping accessories etc. Footings of framework supporting pipework sections downstream of the anti-vibration flexible connectors shall be designed for direct mounting onto the floor slab of the pump room to avoid vibration transmission from the running pump(s) to downstream pipework.

Suitable mechanical or flange joints shall be allowed for the interface connections between the pump set module and the in-situ water pipes at the plant room. Other pipe joint arrangement can be proposed for the approval by the Supervising Officer.

Centralized dashboard shall be provided, if specified in the Particular Specification, to accommodate the meter displays, pressure switches or monitoring devices of metering /sensing devices /probe for easy housekeeping and maintenance. The metering or sensing elements mounted in the pipework shall be wired back to the corresponding devices in the dashboard. Identification tags shall be provided to clearly indicate each device mounted in the dashboard.

2.2.2.5 INTEGRATED AIR HANDLING UNIT AND PRIMARY AIR HANDLING UNIT

The Integrated Air Handling Unit (AHU) /Primary Air Handling Unit (PAU) shall be factory-assembled, integrated with a pre-wired control module and water pipe connection to facilitate plug-and-play installation upon delivery on site.

The packaged module shall comprises of the casing & frame, fan, motor, chilled water /hot water pipework connected to the coils, cladding, valves, fittings, air treatment facilities, built-in with direct digital control (DDC) panels, sensors, associated electrical and control accessories, metering accessories and water pipe connection terminals and provision of vibration isolation accessories and maintenance platform, where applicable. Supporting base frame and lifting lugs shall be provided for transportation, delivery and services connection on site.

The framework of the integrated AHU/PAU shall be constructed with corrosion-resistant material of inherent strength for mounting the specified components as a whole package. Tampered glass viewing panel(s) shall be provided at the outer framework for inspection of the major internal components of the AHU/PAU.

The power supply and control system of the integrated AHU/PAU, where applicable, shall be pre-assembled and pre-tested in the off-site factory to ensure proper wiring connection and installation.

2.2.2.6 ELECTRICAL SERVICES IN ELECTRICAL ROOMS

The electrical services in Electrical and/or Extra Low Voltage (ELV) Rooms comprising MCCB/MCB distribution boards, electrical /ELV panels, metering devices, cable containments, connection boxes and other accessories shall be installed on purposely-built bracketry framework to form standalone module for delivery to and assembly on-site.

Electrical cabling works of a completed circuit /sub-circuit within the individual module shall be pre-installed off-site. Interconnection of cables between modules and other electrical installation shall be conducted on-site. Joint of cables, if unavoidable, shall ensure the complete continuity with acceptable connection methodology. The wires at a termination box shall be distinctively labelled to facilitate wire checking. Pre-installed electrical wirings shall be neatly grouped and terminated in cable terminals for easy identification.

2.2.2.7 PANELISED ELECTRICAL MODULE

The Contractor shall submit schematic and layout drawings showing circuitry numbers, cable size, connection coupler locations, mounting heights of components etc. to Supervising Officer for agreement prior to material ordering and installation.

The size and length of modular cables and connection components should be well selected based on the technical calculations and on-site coordination. If damage of cable or connection component was found during on-site installation, the material should be replaced.

The Contractor shall follow the installation instructions of the cable connector during on-site installation. The Contractor shall be responsible to check and inspect if the cable connectors are firmly and properly connected.

The cables should be accommodated in cable containment, i.e. cable trays or trunking. The Contractor may consider using proprietary fixings to anchor cables to building structure if there is site constraint. The locations and fixing method shall be approved by Supervising Officer prior to installation.

2.2.2.8 HOSE REEL CABINET

Hose reel cabinet shall be construction in module with one or two chamber as required.

For module with two chambers, the top chamber shall house the hose reel, hose reel guide, pipework, manual call point, alarm bell, visual fire alarm, monitor and control modules, power supply /control cables of completed circuit within module, cable containments, emergency luminaire and operation instruction as required by design. The

bottom chamber shall accommodate two sand buckets and one portable fire extinguisher. Each chamber shall be provided with hinge door completed with magnetic door catches and pull handle.

For exposed type hose reel module, extended framework above the top chamber may be used for mounting of visual alarm unit and emergency luminaire subject to the approval of the Supervising Officer.

Where alarm bells are mounted inside the module, suitable means should be allowed to ensure the installation and the sound level of the alarm bells meeting the FSD's requirements.

The module shall be constructed of welded galvanized steel framework with cover plates fixed properly on the framework. Openings for connection of pipework and cables shall be provided.

The layout and arrangement of all components inside the cabinet shall be approved by the Supervising Officer before commencement of off-site fabrication work.

2.2.2.9 SPRINKLER CONTROL VALVE SET

Sprinkler control valve set module shall comprise the completed sprinkler control valve set, cable containment, monitoring and control devices, wirings of completed circuits within the module, identification plates, tagging, earth bonding, associated components and steel framework for direct mounting to the building structure.

All pipework, components and devices shall be assembled and properly fixed to the framework and completed with hangers, brackets, saddles, guide etc. Pipework supports shall be welded, screwed or bolted to the framework. The framework shall be designed with pre-drilled holes for onsite direct fixing to building structures. Provisions shall be allowed to facilitate the transportation, delivery, assembly and services connection on site.

Exposed framework and pipework shall be factory painted, except the colour bands, according to the painting finish specified by the Supervising Officer.

The framework shall be designed and constructed without any obstruction to operation and maintenance of all components and devices inside the module.

Riser-mounted air compressor and associated components shall be assembled and integrated in the module for dry pipe sprinkler system, pre-action and recycle sprinkler system.

2.2.2.10 SPRINKLER SUBSIDIARY STOP VALVE SET

Sprinkler subsidiary stop valve set module shall be completed with pipework, subsidiary stop valve, flow alarm switch, gate valves, monitor modules, signal cables, earth bonding, associated accessories and steel framework as an integrated assembly.

Provisions shall be allowed to facilitate the transportation, delivery, assembly and services connection on site.

Exposed framework and pipework shall be factory painted, except the colour bands, according to the painting finish specified by the Supervising Officer.

The framework shall be designed and constructed without any obstruction to operation and maintenance of all components and devices inside the module.

2.2.2.11 CEILING MOUNTED MULTITRADE HORIZONTAL SERVICES MODULE

Ceiling mounted multi-trade services in typical floor, corridor and plant room shall be constructed through MiMEP approach. The multi-trade horizontal services module shall be pre-fabricated in sections for assembly on site to form a completed system.

A 10% additional loading capacity for the integrated supporting frame / rack should be allowed for the addition and alteration works for the building services components.

Jointing details, material /equipment and assembly methodology shall be submitted to the Supervising Officer for approval.

Individual module section should not pass through fire compartmentation wall unless appropriate fire rated connection unit is facilitated between services modules passing through the compartmentation wall.

Integrated support frame and hanger shall be provided for composite fixing of the multi trade services for each module. The frame shall be of robust with flexible fixing and bracketry facilities for mounting of different services. The flexible fixing facilities shall be able to accommodate certain degree of services fixing adjustment in order to suit the alignment of module interfacing with on-site installation or among modules themselves.

The design of the supporting frame and hanger system shall allow taking down and re-fixing of the building services components without affecting the structural integrity of the overall framing of the module. Clear marking shall be shown for critical structural support components that shall not be dismantle during the alteration works.

2.2.2.12 BUILDING SERVICES RISER MODULE

Typical building services riser module in a standardized configuration shall be pre-fabricated in sectional modules.

Building services riser module shall be assembled and installed on-site prior to, and/or independent of, the erection of block walls of the riser shaft construction. Alternatively, the riser module may be delivered into the riser shaft through designated openings. As such, lifting lugs and bracketry shall be incorporated in the design of the modules.

Town gas / Liquefied Petroleum Gas pipe shall not be allowed in the riser module unless the statutory requirements under Regulation 17 of Cap. 51B and Regulation 17(5) of Cap.51C are fully complied with.

PART 3 – RENEWABLE ENERGY SYSTEMS

SECTION 3.1

TECHNICAL REQUIREMENTS

SUB-SECTION 3.1.1

PHOTOVOLTAIC SYSTEM

3.1.1.1 GENERAL REQUIREMENTS

The photovoltaic (PV) system shall include array of rack type modular PV panels and/or building integrated photovoltaic (BIPV) panels, and balance of system (BOS) including where applicable, combiner boxes, charge controllers and storage batteries (for off-grid system only), inverters, mounting structures, wiring, switchgear and fuses, surge arrestors, earth-fault protection devices and other components as necessary to complete the installation.

All materials and equipment of the PV system shall be products of manufacturers certified under the latest edition of ISO 9001 quality assurance standard. The PV system shall have test certificates to prove the performance claimed.

The PV system shall be connected through the local electrical distribution system in the building. For grid-connected application, proposal to the power supply company for their agreement of power grid connection of the solar power system to the power supply network; and provide all necessary equipment and facilities as required by the power supply company and make arrangement on necessary test.

The following shall be submitted prior to commencement of site works:

(a) Type test certificates to prove the power (kW) generated under Standard Testing Condition (STC) for the offered model of PV and/or BIPV panel;

(b) Estimate annual energy yield (kWh) under Hong Kong weather condition with the consideration of the proposed installation arrangement and surrounding environment such as shading effect to the system;

(c) Number, area and mounting angle of PV and/or BIPV panels; and

(d) Requirement of electrical and builders' work for the PV system.

For BIPV installation, PV panels shall integrate with the architectural features. The BIPV shall fulfil the requirements set out in Buildings Ordinance, Code of Practice for Fire Safety in Buildings and PNAP APP-37. The submissions and installation shall be in according to the recommendation from the manufacturer.

3.1.1.2 COMPLIANCE WITH STANDARDS AND REGULATIONS

On top of the requirements stipulated in Part 1 of this General Specification, the Works shall also comply with the latest edition of the following standards and specifications, where applicable, including all amendments prior to the closing date of the tender:

(a) IEC 61215-1: 2016 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements;

(b) IEC 61215-1-1: 2016 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval – Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules;

(c) IEC 61215-1-2: 2016 - Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-2: Special requirements for testing of thin-film Cadmium Telluride (CdTe) based photovoltaic (PV) modules;

(d) IEC 61215-1-3: 2016 - Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-3: Special requirements for testing of thin-film amorphous silicon based photovoltaic (PV) modules;

(e) IEC 61215-1-4: 2016 - Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-4: Special requirements for testing of thin-film Cu(In,Ga)(S,Se)2 based photovoltaic (PV) modules;

(f) IEC 61730-1: 2016 - Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction;

(g) IEC 61730-2: 2016 - Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing;

(h) IEC 61427-1: 2013 - Secondary cells and batteries for renewable energy storage - General requirements and methods of test - Part 1: Photovoltaic off-grid application

(i) IEC 61427-2: 2015 - Secondary cells and batteries for renewable energy storage - General requirements and methods of test - Part 2: On-grid applications

(j) IEC 62109-1: 2010 - Safety of power converters for use in photovoltaic power systems- Part 1: General requirements

(k) IEC 62109-2: 2011 - Safety of power converters for use in photovoltaic power systems- Part 2: Particular requirements for inverters

(l) IEC 62109-3: 2020 – Safety of power converters for use in photovoltaic power systems- Part 3: Particular requirements for electronic devices in combination with photovoltaic elements; and

(m) ISO 9050: 2003 - Glass in building — Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors.

3.1.1.3 PHOTOVOLTAIC PANELS

Relevant type test certificates for the offered PV and/or BIPV panels shall be submitted. Type test certificates shall be provided by organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS. Product warranty for 10 years for material and workmanship and performance guarantee that guaranteed linear degradation to 80% for 25 years.

The PV and/or BIPV panels shall be manufactured to minimise glare to the neighborhood building. The panels shall be oriented and positioned to avoid potential glare disturbance to the adjacent visually sensitive receiver and optimise the solar energy gain as far as technically and aesthetically feasible. The front cover material of the PV module is recommended to have anti-reflective coating with ≤ 4% of reflectance complying ISO 9050 or equivalent international standard. The possible and anticipated shading effect on the PV and/or BIPV panels from existing nearby building structure shall be fully studied. Computational software shall be adopted to calculate the annual energy generation and to analyse the potential glare of the PV system to the neighborhood building. Any inevitable shading effect shall be submitted before confirming the location of array of PV panel installation.

Sizes of each type of PV, mounting details, orientation and spacing shall be submitted. The PV panels shall be installed with adequate maintenance space for checking, cleaning and replacement without the need to dismantle the adjacent PV panels.

The PV and/or BIPV module on mounting to the building element or structure with design to be carried out by a registered structural engineer with due consideration of wind load, safety, and proper access for maintenance.

All structural supports for installation of the PV and/or BIPV panels shall be provided.

If bifacial PV module is adopted, minimum bifaciality/ bifacial factor of 70% shall be met. The bifacial output-rearside power gain and module efficiency shall be stated separately.

The maximum temperature coefficient of the maximum output power shall not exceed -0.40%/°C.

3.1.1.4 ELECTRICAL REQUIREMENTS

Electrical wirings shall be PVC insulated to IEC 60227: 2007-1 or PVC insulated and sheathed with armour to IEC 60502-1:2004+AMD1:2009. The PVC insulated wirings shall be installed in G.I. conduits. The armour cable shall be installed on metal cable tray. The IP rating of enclosures for housing the electrical installation at outdoor shall

be to IP54 minimum. For BIPV panels installation, the wiring shall be of low smoke zero halogen type and to be integrated in the building structure.

Exposed flexible cables inter-connecting between adjacent PV panels shall be double insulated with sheathed. The sheath shall be UV-resistant and tested to ISO 4892-2: 2013 method A.

All wirings shall be neatly grouped and terminated in terminal blocks which shall be suitably labeled.

Where interfacing to CCMS is required for monitoring of system points of the PV system, the CCMS works to provide all necessary software and hardware interface for the effective communication with the CCMS for monitoring the points shall be coordinated.

Where energy harvesting information from PV system shall be displayed, all hardware and software to record and display the total energy generated by the PV system shall be included. Besides, it shall include meters to measure the sun irradiation for calculating the overall solar conversion efficiency.

3.1.1.5 POWER INVERTER

The power inverter(s) shall be provided and consisted of a power management system utilising power electronics to convert the D.C. output from the array of solar panels to either 380V, 3-phase or 220V, 1-phase A.C. output. The number and arrangement of power inverter(s) shall be selected to achieve the highest efficiency for the conversion of the D.C. power from PV array.

The power inverter shall have the following features:

(a) A Liquid Crystal Display (LCD) panel to display the following data or information: -

- Supply frequency;
- Output voltage of each phase and three-phase;
- Output current of each phase and three-phase;
- Accumulated output (kWh);
- Instantaneous power output (kW); and
- Inverter fault/overload alarm.

(b) Logging of data at the preset interval;

(c) Built-in memory capacity – Store at least 3 parameters at 30-minute intervals for 1 year. Provide all necessary hardware and software for download of stored data;

(d) Adopt the Maximum Power Point Tracking (MPPT) method to harvest maximum power from the PV modules

(e) Automatic start up with sufficient solar power;

(f) Automatic dormancy to reduce energy consumption under idle condition;

(g) Automatic shutdown immediately when a mains A.C. supply failure is detected;

(h) Automatic restart the equipment sequentially after recovery of mains A.C. supply and the PV system;

(i) Allow input voltage of maximum 1000Vdc, continuous power of not less than 5000VA and efficiency of not less than 97%;

(j) Capable to automatic protect the sources against overload;

(k) PV inverters shall comply with IEC 62109/BS EN 62109, UL 1741 or equivalent; and

(l) The degree of protection of PV inverter shall be IP54 or higher of the standard IEC 60529, subject to the installation location and condition .

3.1.1.6 ISOLATING TRANSFORMERS

The isolating transformers shall be provided and complied with IEC 61558 or equivalent international standard; three phase with input voltage and output voltage of 380 V at 50 Hz. The isolating transformer shall have the following features:

(a) Powered device galvanically isolated from power source;

(b) Insulation class not lower than Class F; and

(c) Protection rating not lower than IP 23.

3.1.1.7 BATTERIES

For off grid (standalone) PV system, gel type valve-regulated lead-acid (VRLA) battery suitable for deep cycle discharge shall be provided. The battery shall be complied with IEC 61427-1: 2013. Calculation of battery capacity in Ampere-hour (AH) shall be submitted.

For off grid (standalone) PV system, battery charger suitable for charging the deep cycle discharge VRLA battery shall be provided. The charger shall be a microprocessor based power management system utilising power electronics to convert the D.C. power from the PV array for energy storage in the battery. The charger shall optimise the voltage and current produced by the PV array, and shall regulate the charge into the battery. The number and arrangement of charger(s) shall be selected to achieve the highest efficiency for the conversion of the D.C. power from PV array.

The charger shall have the following features: -

(a) Charging status indications;

(b) Battery status indications;

(c) Overcharge and over-discharge protection;

(d) Back current blocking to PV panel when voltage of battery is higher than PV panels;

(e) Adopting the Maximum Power Point Tracking (MPPT) method to harvest maximum power from the PV modules;

(f) Temperature sensor at the corresponding terminal of the battery set for charging level compensation; and

(g) An LCD panel to display the following data or information:

- Battery voltage;
- PV system input voltage; and
- PV system input current.

3.1.1.8 INTERFACING WORKS

Electrical wiring to connect with the inverter from/to the three-phase distribution board and the single-phase distribution board or isolator shall be provided. Trunking and conduit run drawings for PV system related electrical works shall be submitted. All wirings shall be grouped and installed together in a neat and tidy manner. Each connection shall be terminated in an approved type of terminal block, which shall also be suitably labeled.

All necessary software and hardware interface for the effective communication with the Central Control and Monitoring System (CCMS) or other central monitoring system for monitoring the points as indicated shall be provided.

The following information from PV or BIPV installation shall be interfaced with and shown in the CCMS or other central monitoring system: -

(a) Schematic wiring diagram for PV system including PV module, power inverter(s) and all equipment;

(b) System ON/OFF/STANDBY/FAULT;

(c) System mains A.C. output voltage of each phase and three-phase;

(d) System mains A.C. output current of each phase and three-phase;

(e) Mains A.C. supply frequency;

(f) Accumulated maximum input and output power (kWh) each day output;

(g) Instantaneous power output (kW);

(h) Power inverter: (for each power inverter);

(i) Inverter status: ON/OFF/STANDBY/FAULT;

(j) Inverter input and output current and voltage;

(k) Inverter high and low current and voltage alarm;

(l) Inverter input and output power;

(m) Inverter on line/off line indication ;

(n) Automatic changeover status: Normal/Fault;

(o) Inverter failure alarm;

(p) Environmental data, including: -

- Solar irradiance (at least 2 set each on the roof surface and at the inclined angle to the PV panel installation);
- Wind speed;
- Ambient Temperature; and
- Ambient Temperature adjacent to PV panel; and

(q) Performance Evaluation, including: -

- DC to AC conversion efficiency (each inverter and overall system); and
- System output against rated peak output efficiency.

3.1.1.9 SYSTEM AND INSTALLATION REQUIREMENTS

The peak solar power generated by the PV System shall be tested under Standard Testing Condition (STC) - the testing conditions to measure photovoltaic cells or modules nominal output power. The irradiance level shall be of 1,000 W/m² with the reference air mass coefficient of solar spectral irradiance distribution of AM1.5 and cell or module junction temperature of 25°C. Measurement of the output power shall be taken at the point after all necessary rectification, conversion from D.C. to A.C. to the designated MCCB/ MCB board. The performance ratio of the PV System shall be not less than 0.7.

Useful power output on computer modelling or equivalent to demonstrate the fulfilment of the contract requirements shall be verified.

The PV or BIPV panel shall be capable to function at locations where the ambient temperature ranging from 0°C – 40°C and relative humidity up to 95% in indoor and 99% in outdoor.

The modular PV panels and their mounting angle and/or direction shall maximise the possible solar energy gain. Calculation shall be submitted for approval.

Silicon monocrystalline, silicon polycrystalline or thin-film amorphous silicon with the respective minimum module efficiency 20%, 15%, 8%. The module efficiency is calculated by formula below: -

$$module\ efficiency = \frac{power\ output\ of\ PV\ module\ at\ STC\ (W)\ x\ 100\%}{area\ of\ PV\ module\ (\mathrm{m}^2)\ x\ 1000W\ at\ STC}$$

Checking the building frame to decide the exact position of support and the type of anchorage devices on site. Make necessary modifications to the anchor ties and fixing bolts to suit different site conditions.

All the structural calculations for demonstration of the proposed structural adequacy shall be endorsed by a Registered Structural Engineer and to be submitted to the Supervising Officer for approval prior to carrying out the installation. The structural design shall be in compliance with the prevailing edition of Code of Practice on Wind Effects Hong Kong issued by the Building Authority.

3.1.1.10 ENERGY MANAGEMENT AND MONITORING SYSTEM

The PV system shall be provided with a data logging system for automatic generation of the following information: -

(a) Monthly mean in-plane solar irradiation (MJ/sq.m/month);

(b) Monthly mean solar energy absorbed by system (MJ/month); and

(c) Monthly power generation (kWh/month).

The data logging system shall be able to record all data generated from the PV system.

Independently calibrated microclimate stations including one or few pyranometers such as temperature sensor, anemometer, rain sensor, solar irradiance, UV sensor, etc. shall be provided and installed to record insolation data. Recorded weather data could be used to estimate how much electricity generated from the PV system for comparison with the actual electricity generation for verification of the system performance in future.

SUB-SECTION 3.1.2

POLE MOUNTED SOLAR-POWERED LIGHTING

3.1.2.1 GENERAL REQUIREMENTS

The solar LED luminaire shall consist of, but not limited to, PV panel, batteries, energy management system, LED luminaire, structural mounting brackets and other components as necessary to complete the installation. The components of solar LED luminaire shall be neatly integrated so that the overall appearance of solar LED luminaire shall be aesthetic pleasing. The solar LED luminaire shall operate independently without mains a.c. power supply(for standalone power LED lighting) / with main AC power back up supply(for on grid solar power LED lighting). The solar LED luminaire shall be mounted on a pole where the PV panel shall integrated into the top of the pole to maximise the receipt of solar energy for charging the batteries during daylight. The batteries shall discharge and provide energy to the LED luminaire for illuminating the areas under the pole as when required. The LED luminaire shall be switched on/off automatically according to the daylight level received by the daylight sensor.

3.1.2.2 PHOTOVOLTAIC PANELS

The PV panel shall fully comply with the requirements in Sub-section 3.1.1 of this General Specification. For any alternative material and technology to be adopted, the efficiency and performance as required in Sub-section 3.1.1 shall be complied with.

Calculations on the selection of the rating of PV panel shall be submitted. The batteries shall be charged to a capacity during daytime that is at least 10% more than the power consumption by the LED luminaire at full intensity during nighttime assuming the receiving daylight at STC conditions is 4 hours during daytime.

The mounting bracket of PV panel shall be rigidly fixed at an optimum tilt angle on the pole but the orientation of the PV panel shall be flexibly adjusted to maximise the solar energy gain. Mounting method of the PV panel shall be submitted.

Components of the LED luminaire shall comply with relevant Sections of this General Specification.

3.1.2.3 BATTERIES

The batteries shall be gel type maintenance free valve regulated lead acid (VRLA) type for deep cycle discharge. The batteries shall comply with IEC 61427-1: 2013 and other relevant international standard requirements for safety and performance.

Calculation of battery capacity shall be submitted in Ampere-hour (AH) meeting the following requirements: -

(a) The batteries at full capacity shall be able to energise the LED luminaire at full intensity for 12 hours at nighttime and minimum 4 nights without receiving solar irradiance at daytime; and

(b) The remaining capacity after discharge shall be not less than 20% of full capacity.

3.1.2.4 ENERGY MANAGEMENT SYSTEM

An energy management system shall be an intelligent system to regulate power between batteries, PV panel and LED luminaire. The system shall have the following features: -

(a) To monitor the state of charge of batteries and regulate energy delivery to the LED luminaire in order to prevent the batteries from being damaged by over discharging.

(b) To manage solar energy collection from the PV panel and charge the batteries and also protect the batteries from overcharging.

(c) To switch on the lighting to provide a constant level of illumination after dusk or below the preset daylight level by the daylight sensor of the LED luminaire or other means. At dawn, the lighting shall be automatically switched off.

(d) Motion Sensor Capability – When motion is detected by a built-in passive infra-red detector, the lighting shall automatically ramp up to full intensity and then it will ramp down to a lower preset illuminance level after a configurable delay time which can be set between 30 seconds and 5 minutes.

(e) To prevent the batteries from being over-discharged. The system shall automatically shut off the batteries from discharging when it detects the battery capacity is less than 20%. The batteries shall not supply energy to the LED luminaire until the batteries are recharged to a capacity as recommended by the Supplier.

(f) To indicate the status of batteries including battery fault.

(g) To indicate battery capacity less than 20%. This feature can be an indicator that will automatically blink at a pre-determined interval or otherwise which can be easily visualised.

3.1.2.5 INSTALLATION REQUIREMENTS

Calculation shall be submitted to substantiate that the whole solar LED luminaire including foundation, mounting brackets, pole, etc are structurally sound under typhoon conditions. All the structural calculations shall be endorsed by a Registered Structural Engineer and shall be submitted prior to carrying out the installation.

Outdoor luminaires shall be able to withstand wind speed under typhoon conditions. Metal work shall be protected against corrosion, and parts which have to be removed for access to the interior shall be provided with proper gaskets to restrict the entrance of

moisture and dirt. Mounting brackets shall be heavily galvanised and stainless steel or galvanised bolts and nuts shall be used.

The adjustment bolts and nuts of a luminaire which is mounted on high level shall be captive to prevent accidental loss during servicing. Safety chains shall be provided to hold the luminaire from falling. A luminaire installed in a location within hand reach shall be of robust construct, fitted with an impact-resistant transparent or diffusing front panel, and shall have secret key fixings for the panel to the body of the luminaire. Where necessary, wire guards shall be fitted over the front panel to give extra protection.

SUB-SECTION 3.1.3

SOLAR HOT WATER SYSTEM

3.1.3.1 GENERAL REQUIREMENTS

3.1.3.1.1 The solar water heating installation shall include solar collector system, heat transfer fluid, water treatment system, hot water storage calorifier(s), water/heat transfer fluid circulation pumps, heat exchanger(s), feed and expansion tanks, automatic control and performance monitoring system, water pipework, valves, thermal insulation, brackets/supports, access walkways, maintenance platforms, and ancillary equipment, etc. All the components and parts shall be compatible with each other to provide the best performance of the installation.

3.1.3.1.2 Individual components forming part of the solar water heating installation shall, in addition to this section, comply with the appropriate sections of this General Specification. Information on the make and type of each unit shall be submitted together with the test certificate of solar collector panels complying with BS EN ISO 9806:2017 or equivalent.

3.1.3.1.3 The solar collector or solar collector panel shall be either evacuated-tube or flat-plate type. Thermal insulation of appropriate thickness shall be provided under and around the side of the absorber plate, to prevent heat loss from the solar collector panels. The solar collector panels shall have an impact resistance and cyclone resistant.

3.1.3.1.4 The installation details shall be in accordance with the manufacturer's instruction and manual. The plant shall be so selected and installed with sufficient space allowed for maintenance and servicing. All mounting brackets and fixing supports shall be hot-dip galvanised steel unless otherwise specified on the drawings or in the particular specification. Exposed metals shall be treated to prevent corrosion and painted in accordance with the requirements of this General Specification.

3.1.3.1.5 Hot-dip galvanised steel maintenance platform, catwalk and cat ladder shall be provided for future maintenance access of the solar collectors.

3.1.3.1.6 The feed and expansion tank shall be mounted at the highest point of the solar water heating installation. All water pipework shall be completed with flexible closed-cell elastomeric insulation of sufficient thickness and with coating for UV protection or other protection methods as specified the drawings or in the Particular Specification.

3.1.3.1.7 The configuration of the solar water heating installation shall allow any solar collector panel to be replaced without the need to dismantle any roof structural members or adjacent panels.

3.1.3.1.8 The solar collector panels shall be installed on the appropriate supporting framework with sufficient maintenance access facilities as recommended

by the manufacturer. The solar collector panels shall be mounted at a tilt angle to the horizontal to achieve maximum solar gain for the application.

3.1.3.1.9 The installation of water supply system for solar water heating installation shall be carried out by a Licensed Plumber (LP). The plumbing works of solar water heating installation shall meet the requirements of the WSD.

3.1.3.1.10 The type of piping materials to be used in the solar water heating installation shall comply with the Waterworks Ordinance (Cap. 102) and the Waterworks Regulations (Cap. 102A).

3.1.3.1.11 All necessary devices and accessories to facilitate the integration of the solar hot water system to the intended applications shall be coordinated, supplied and installed.

3.1.3.1.12 The following shall be submitted prior to commencement of site works: -

(a) complete set of detailed shop drawings and calculation including the sizes, type of the proposed solar collector panels, mounting details and connection diagram;

(b) specification of the materials and method statement of installation;

(c) solar gain calculation and output estimate for the proposed solar water heating installation;

(d) manufacturer's certificates of origin, test reports and other relevant documents specified in this Specification or as required;

(e) control and monitoring point schedule and drawings;

(f) control block diagram with control logic; and

(g) operation and maintenance manual after the completion of testing & commissioning.

3.1.3.2 COMPLIANCE WITH STANDARDS AND REGULATIONS

On top of the requirements stipulated in Part 1 of this General Specification, the Works shall also comply with the latest edition of the following standards and specifications, where applicable, including all amendments prior to the closing date of the Tender: -

(a) BS EN 12975-1: 2006 + A1: 2010 - Thermal Solar Systems and Components. Solar Collectors. General Requirements;

(b) BS EN ISO 9806: 2017 Solar Energy. Solar Thermal Collectors. Test Methods;

(c) BS EN 12976-1: 2017 - Thermal Solar Systems and Components. Factory Made Systems. General Requirements;

(d) BS EN ISO 9806:2017- Thermal solar systems and components. Solar collectors - Test methods; and

(e) AS/NZS 2712: 2007 - Solar and Heat Pump Water Heaters – Design and Construction.

3.1.3.3 PERFORMANCE REQUIREMENTS

The solar hot water system shall be capable to withstand potable water or treated water with temperature up to 99°C during stagnation and under normal operating conditions. The solar collector panels shall have minimum efficiencies as specified in this Sub-section.

3.1.3.4 EVACUATED-TUBE COLLECTOR PANEL

The solar evacuated-tube collector panel shall consist of single tubes which are connected to a header pipe. All evacuated collector tubes shall either have tubes with flow of heat transfer fluid through the absorber or tubes with heat transfer between the absorber and heat transfer fluid of the collector cycle using the heat-pipe principle. The absorber surface shall be contained inside a glass tube. The glass tube enclosing the absorber surface and heat transfer tubes shall be evacuated and permanently sealed off. The glass tube shall be tempered glass to withstand the pressure difference between the atmospheric pressure and the internal vacuum. The absorber of the collector shall be coated with an appropriate selective coating.

Each solar evacuated-tube collector panel shall produce a minimum of 700 Watt per square metre (W/m^2) based on 1000 W/m^2 irradiation and difference of average fluid temperature and ambient temperature of 30K without wind.

The efficiency of the solar evacuated-tube collector panel shall be minimum of 70% efficiency at 30K temperature different between average fluid temperature and ambient temperature with solar irradiation equal to 1000 W/m^2 based on aperture area. The transmittance of the glass tube shall be minimum of 0.91 and the solar absorptivity of the absorber shall be a minimum of 0.94. The emissivity (at 80°C) of absorber material shall not exceed 0.06. The solar collector panel shall give a yield of 2.4 kWh per square metre (kWh/m^2) of solar collector aperture area per day calculated on a yearly average for the region.

3.1.3.5 FLAT PLATE TYPE SOLAR COLLECTOR

3.1.3.5.1 The Flat Plate Type Solar Collector Panels shall be connected in series and/or parallel and installed on an appropriate supporting framework with sufficient maintenance access facilities as recommended by the manufacturer.

3.1.3.5.2 A copper tube matrix that contains potable water shall be mechanically bonded to a 0.8 mm thick aluminium absorber plate or 0.2 mm thick copper absorber plate and sealed with high transference thermal paste or soldered copper to copper. The absorber plate shall be coated in black

carbon surface or approved equivalent offering up to 35% absorption. The minimum solar absorptance at normal incidence shall be 0.93 where the emittance of coating at normal incidence shall ±0.03. The solar collector panels shall be manufactured to BS EN 12975-1: 2006+A1: 2010 & BS EN ISO 9806: 2017, BS EN 12976-1: 2017 & BS EN 12976-2: 2017 and AS/NZS 2712: 2007 or approved equivalent.

3.1.3.5.3 The absorber area and aperture area of the solar collector panel shall be at least 88% and 90% of the gross area of the solar collector panel respectively, unless an equivalent performance can be proved. The absorptivity and emissivity of absorber coating shall be at least 0.96 and at most 0.08 respectively.

3.1.3.5.4 Each collector panel shall have an insulated casing that houses a copper tube matrix for transporting the collector fluid. A copper or aluminium absorber plate with appropriate coating shall be mechanically bonded or soldered to the headers.

3.1.3.5.5 Tempered solar glass glazing shall be used to seal the top of the collector and a high strength black casing protecting all the components to prevent heat losses and protect from adverse weather conditions. It shall have appropriate strength to withstand high wind load and hail. The casing shall be constructed of metal with oven baked paint finish for protection against the weather and with high outdoor durability.

3.1.3.5.6 The glazing shall be minimum of 3 mm thick with anti-reflective coating to reduce the potential of reflective glare with glazing transmittance of 0.88 minimum. Translucent interlayer shall be added to the glass to increase the portion of diffusing reflection in the total amount of reflected light. The glazing shall be sealed in good conjunction with the metal casing and tested according to the requirement of the rain penetration test as stipulated in BS EN ISO 9806: 2017.

3.1.3.5.7 The efficiency of solar collector panel shall be minimum of 65% at 30K temperature difference between average fluid temperature and ambient temperature with solar irradiation 1000W/m^2 based on aperture area.

3.1.3.5.8 Each solar collector panel shall produce minimum 650 W per square metre based on 1000 W per square metre irradiation and difference of average fluid temperature and ambient temperature (i.e. tm-ta = 30K) of 30K without wind. The solar collector panel shall give a yield of 2.3 kWh per square metre of solar collector aperture area per day calculated on a yearly average for the region.

3.1.3.6 THERMAL STORAGE HOT WATER CALORIFIER

3.1.3.6.1 The thermal storage hot water calorifier (hereinafter referred as calorifier) shall be used to store up the thermal energy delivered by the solar collector panels. The calorifier can be provided either with electric or gas fired auxiliary heater or hooked up with heat pump system. The calorifier shall be constructed of mild steel to BS EN 10028 (all parts), BS EN 10029:

2010, BS EN 10048: 1997, BS EN 10051: 2010 and BS EN ISO 9445: 2010 or stainless steel to stainless steel Grade 316. The mild steel shell shall be lined internally with copper to BS EN 1172: 2011, BS EN 1652: 1998, BS EN 1653: 1998 and BS EN 1654: 1998/C106. The copper lining shall have a minimum thickness of 1.2 mm. The copper lining shall be constructed in such a way that no part of the mild steel shell shall come into contact with water. The mild steel shell and the copper lining shall be accurately rolled to shape and the ends shall be formed in presses with generous heel radii.

3.1.3.6.2 The venting requirements of the calorifier shall comply with the requirements of local water supplies regulations. The calorifier shall be fitted with closed circuit flow and return lines capable of receiving thermal energy from solar collectors hot water flow. The calorifier (unless open vented type) shall be fitted with pressure and temperature relief valve and in accordance with local regulations.

3.1.3.6.3 The maximum working pressure in the shell and battery shall be as specified in the Particular Specification or on the drawings. The calorifier shall be hydraulically tested to 1.5 times the maximum working and design pressure respectively for both shell and heater battery at the manufacturer's works. Manufacturer's test certificate of each hot water calorifier shall be submitted, in triplicate before the equipment depart the factory and prior to shipment.

3.1.3.6.4 Calorifier with immersed auxiliary heaters shall be fitted with a manual reset over temperature thermostat that is adjustable between 40-99°C. The calorifier shall be completed with insulation of minimum 50 mm thickness mineral wool insulation or appropriate insulation as recommended by the manufacturer. The calorifier shall be completed with temperature gauge, temperature sensors, drain pipe, heating circuit in/outlet, utility circuit in/outlet, copper coil and etc.

3.1.3.6.5 The calorifier shall be factory manufactured to comply with PD 5500:2018+A1:2018 or approved equivalent. Copper coil shall capable to operate with a maximum pressure of 10 Bar and a temperature of 200°C. Temperature sensor shall be provided for electronic controller of the solar collector system for automatic control and performance monitoring purpose. Manufacturer’s working and testing pressure certificate(s) shall be submitted.

3.1.3.7 CIRCULATION PUMP

3.1.3.7.1 Circulation pump shall be of centrifugal type with direct drive and mounted on a common bed-plate or flange mounted. Circulating Pumps of small flow rate shall be of the vertical in-line type of mounting which shall be either floor mounted or pipe mounted. The pump shall have cast iron casing, gunmetal impeller and stainless steel shaft and shall be suitable for an operating temperature of up to 100°C. The materials shall comply with the requirements stipulated in Sub-Section of Water Handling Equipment in Part 6 of this General Specification.

3.1.3.7.2 Pump motors shall be suitable to operate on 380 V/3-ph./50 +/-2% Hz, of totally enclosed fan-cooled type, type of protection IP54 to IEC 60529: 2013/Corr 2: 2015 "Specification for Degrees of Protection provided by Enclosures", with insulation class F to IEC 60085: 2007, and provided with motor starters with adjustable overload protection relay and under-voltage release. The continuous rating of all motors shall cover the full specified range of duty plus a further 10% margin for the pumps.

3.1.3.1.3 For each hot water calorifier, one pair of standby and duty hot water circulating pumps shall be provided as generally indicated in the Drawings for hot water circulation. The capacity of these pumps shall be as specified in the Particular Specification. The piping layouts and hydraulic calculations shall be submitted in selecting the suitable pump heads.

3.1.3.1.4 The circulating pump shall be efficiently balanced. Suitable vibration isolation shall be provided to eliminate noise and vibration from transmitting to the pipe system or floor.

3.1.3.1.5 Pump control panel shall be provided at locations as indicated on the Drawings for control of the circulating pumps. ON/OFF switch, power-on indication and hour-run meter shall be provided on the panels for each pump. Emergency stop push button shall be provided adjacent to each pump.

3.1.3.8 HEAT EXCHANGER

3.1.3.8.1 Heat exchangers shall consist of most energy efficient metal plates pressed into a corrugated pattern and securely clamped between nitrile rubber gaskets by the pressure end plates of the mild steel framework. Plates shall be stainless steel 316 for fresh water or titanium for sea/well water. The plates shall be suspended from the top bar of the framework and located on the bottom guide bar. No part of the mild steel framework shall be in contact with the heat transfer fluids.

3.1.3.8.2 Heat transfer plates shall be clamped by lateral bolts between a stationary frame plate and a movable pressure plate such that opening of the plate heat exchangers can be done without removing any connecting pipes.

3.1.3.8.3 Heat exchanger shall be provide high heat transfer efficiency to achieve close approach temperatures as low as 1°C.

3.1.3.8.4 Heat exchanger frame shall be of mild steel and shall be suitable for bolting to a horizontal deck. The frames shall be arranged such that when the tie bars are loosened, full access to all plate surfaces is provided for cleaning and maintenance. The entire framework and all parts of the units shall be factory treated to prevent corrosion such that the heat exchanger shall be capable of corrosive environment. All holding down bolts shall be of high tensile carbon steel with plastic tube protection. Each shall be

equipped with bearing boxes and a locking washer enables the bolts to be opened from the fixed cover. No welded parts are allowed.

3.1.3.8.5 Inlet and outlet ports shall be metal lined constructed on the fixed frame plate only. Metal lining shall be of the same material as the plates.

3.1.3.8.6 The heat transfer plates for fresh water application shall be of stainless steel and in a corrugated pattern with thickness of 0.5 mm minimum, and pressing depth of about 1.9 mm with pressure rating a minimum of 1000 kPa or other rating to suit system application as specified. Maximum plate pack length shall not exceed 45% of the total framework length. Double gaskets shall be provided around the bypass port on each plate, with a drain hole between the gaskets to facilitate leak detection.

3.1.3.8.7 Distribution area shall be with regular pattern and the flow pattern shall be "counter flow". Gasket shall be on every plate to eliminate inter leakage between media.

3.1.3.8.8 The heat exchanger units shall be pressure tested in the factory prior to delivery. The plate heat exchanger shall have a working pressure not less than 1000 kPa and shall be tested with a minimum pressure of 1.5 times the working pressure for 24 hours suitable to the system application as specified. The manufacturer shall guarantee the heat exchanger free from leakage for 5 years.

3.1.3.8.9 The heat exchanger for chilled or hot water application shall be properly insulated with optimum efficiency and robust insulation against heat loss. The insulation panels shall be of the double skin aluminium/stainless steel cladded type with handles suitable for easy removable for plates access for inspection and maintenance. An insulated stainless steel drip tray shall also be equipped for chilled water application.

3.1.3.9 AUTOMATIC CONTROL AND MONITORING

3.1.3.9.1 The solar collector system shall be provided with a temperature monitoring system built into a differential controller, which will give temperature at different points in the circuit. Moreover, the solar collector system shall be provided with sensing and measurement devices suitable for remote monitoring and control by DDC controller/Programmable Logic Controller to monitor the operating status, alarm, flowrate, temperature, energy and set point of the system.

3.1.3.9.2 The solar water heating installation shall be provided with a data logging system for automatic generation of the following information: -

(a) monthly mean in-plane solar irradiation (MJ/m^2/month);

(b) monthly mean solar energy absorbed by system (MJ/month); and

(c) monthly electrical energy consumption of circulating pump (kWh/month).

3.1.3.9.3 The system shall also be provided with a data logging system to record the temperature and energy performance of the system. Interfacing devices shall also be provided for connection to the CCMS.

3.1.3.9.4 The solar water heating installation shall provide all necessary devices and software for control and monitoring interface with the CCMS terminal computer via open protocol. The software shall be able to control, monitor, indicate all operation status, data logging and alarming of solar water heating installation. All software and hardware in an open protocol system required for the effective communication with the CCMS shall be provided.

3.1.3.9.5 The CCMS points shall include, but not limited to: -

(a) Circulation Pump On/Off/Failure Status;

(b) Circulation Pump On/Off Control;

(c) Valves Position;

(d) Valves Control;

(e) Water In/Out Temperature;

(f) Water Flow Rate;

(g) System Pressure; and

(h) Electrical Energy Consumption.

3.1.3.10 STRUCTURAL REQUIREMENTS

Thorough inspection on the roof to decide the exact position of support and the mounting method for the solar water heating installation.

All the structural calculations with drawings for demonstration of the proposed structural adequacy shall be endorsed by a Registered Structural Engineer and be submitted prior to carrying out the installation.

The solar water heating installation shall be installed in compliance with the latest edition of Code of Practice on Wind Effects in Hong Kong issued by the Building Department.

SUB-SECTION 3.1.4

WIND TURBINE INSTALLATION

3.1.4.1 GENERAL REQUIREMENTS

Installing machines on top of buildings has the advantages of exposing to higher average wind speeds (at the higher elevation). However, it also introduces additional issues of structural loading and public safety. The size of machine which could be put in building projects is relatively small in order to maintain the integrity of the building itself. This part of the General Specification aims to lay down the technical requirements for small wind turbine of rating not greater than 40kW. .

All material, equipment and installation details shall be in accordance with the General Specification and instruction and recommendation from the manufacturer. All materials and equipment shall be products of manufacturers certified under the latest edition of ISO 9001 quality assurance standard.

For small wind turbine connected through the local electrical distribution system in the building, grid-connected application shall be included, proposal shall be submitted to the power supply company for their agreement of power grid connection to the power supply network. All necessary equipment, facilities and arrangement on necessary tests shall be provided as required by the power supply company.

Prior to commencement of site works, proposal shall be submitted to the Supervising Officer for approval including: -

(a) Estimated annual energy yield (kWh) under Hong Kong weather condition with the consideration of the proposed installation arrangement and surrounding environment;

(b) The configuration of blades, rotation axis, braking system, wind controller and power conversion system; and

(c) Requirements of electrical and builders' work.

3.1.4.2 COMPLIANCE WITH STANDARDS AND REGULATIONS

On top of the requirements stipulated in Part 1 of this General Specification, the Works shall also comply with the latest edition of the following standards and specifications, where applicable, including all amendments prior to the closing date of the Tender: -

(a) IEC 61400-SER: Wind Turbine Generator Systems – All Parts; and

(b) American Wind Energy Association (AWEA) Standard AWEA 9.1: 2009 - AWEA Small Wind Turbine Performance and Safety Standard.

3.1.4.3 WIND TURBINE

3.1.4.3.1 Blade

The blade system shall efficiently converting the wind energy to mechanical energy.

Blade shall be of light weight and durable materials either reinforced fiber glass plastic, aluminum, carbon fiber or other materials as approved by the Supervising Officer.

The cut-in wind speed shall not be more than 4 m/s. The blade shall be proposed and submitted to the Supervising Officer in accordance with the following factors: -

(a) Cut-in & cut-out wind speed;

(b) Aerodynamic efficiency;

(c) Loading on the bearing;

(d) Swept area of the blade;

(e) Total energy output; and

(f) Balancing and aesthetical concerns

3.1.4.3.2 Rotation Axis

The shaft and the aerofoil blades shall be configured to generate torque efficiently. For selection orientation of rotation axis, details shall be submitted to the Supervising Officer including the following: -

(a) Rotational speed;

(b) Operating noise;

(c) Spatial and structural requirements; and

(d) Rated wind speed required.

3.1.4.3.3 Braking System

In order to avoid breakdown of turbine due to overspeeding under extreme wind conditions as well as for maintenance, brake/stall and interlocking mechanism is provided to reduce the speed of the rotor shaft or stop the rotor shaft before forces on the turbine are hazardous to the turbine structure. The brake would be actuated by an automatic wind speed sensor inside the turbine when the speed reaches the cut-out speed. For Small Wind Turbine, the cut-out wind speed is around 15 m/s. Provisions shall be provided to interlocking the wind turbine for maintenance or high wind speed condition.

3.1.4.4 ELECTRICAL REQUIREMENTS

3.1.4.4.1 Electrical wirings shall be PVC insulated to IEC 60227-1 :2007 or PVC insulated and sheathed with armour to IEC 60502-1:2004+AMD1:2009. The PVC insulated wirings shall be installed in G.I. conduits. The armour cable shall be installed on metal cable tray. The IP rating of enclosures for housing the electrical installation at outdoor shall be to IP54 minimum. The wiring shall be of low smoke zero halogen type.

3.1.4.4.2 Exposed flexible cables shall be double insulated with sheathed. The sheath shall be UV-resistant and tested to ISO 4892-2: 2013 method A.

3.1.4.4.3 The electrical works shall be coordinated on the terminations of mains A.C. power supply to the wind turbine system. All wirings shall be neatly grouped and terminated in terminal blocks which shall be suitably labeled.

3.1.4.4.4 Where connection to CCMS is required for monitoring of system points of the wind turbine system as specified in the this Specification, co-ordination shall be carried out with the CCMS works to provide all necessary software and hardware interface for the effective communication with the CCMS for monitoring the points as indicated.

3.1.4.4.5 To enable the display of various parameters, all hardware and software shall be included to record and display the total energy generated by the wind turbine system. Besides, it shall include meters to measure the wind speed for calculating the overall wind conversion efficiency. The location, layout and sample of display panel shall be submitted.

3.1.4.5 CONTROLLER

The controller shall: -

(a) be capable to convert A.C. power input to D.C. power output from wind turbine generation;

(b) provide harmonic filtering function for A.C. power input;

(c) have a wide operating range of -20°C to +55°C and shall operate up to 99% relative humidity;

(d) control the brake functions;

(e) allow automatic baking of wind turbine for over-voltage, over-current protection and over-speed;

(f) protect the battery against over-charging and over-discharging; and

(g) automatically connect to dump load and dump excessive power for protection of the system such as the battery has been fully charged or anti-islanding etc.

3.1.4.6 POWER INVERTER

3.1.4.6.1 The inverters shall have nominal output of 220Vac, 1-phase, 50Hz with efficiency of not less than 94%.

3.1.4.6.2 The inverters shall have an ambient operating temperature between -20°C to +50°C.

3.1.4.6.3 The inverter shall satisfy all of the statutory requirements and power supply company's requirement for the load or grid connection system.

3.1.4.6.4 The inverter shall equipped with the following electrical protections against: -

- Input and output overvoltage;
- Output short-circuits and overloads; and
- Insulation failure.

3.1.4.6.5 The inverter shall be capable of high temperature cut protection to avoid the equipment overheated.

3.1.4.6.6 The inverter shall be embedded with anti-islanding protection with automatic disconnection

3.1.4.7 ISOLATING TRANSFORMER

3.1.4.7.1 The isolating transformers shall be single phase or three phase isolating transformers with input voltage and output voltage of 220V or 380 V at 50 Hz.

3.1.4.7.2 Powered device shall provide galvanic isolation from power source to prevent the triggering of ground loops.

3.1.4.7.3 The insolation transformer within or as part of turbine system shall comply with IEC 60076 (all parts) and IEC 61558-2-1: 2007.

3.1.4.7.4 The isolation transformer shall have an ambient operating temperature between 0°C to 50°C.

3.1.4.7.5 The isolation transformer shall be not lower than Class F with temperature rise in accordance to IEC 60034-1:2017.

3.1.4.7.6 The protection grade of isolating transformer shall not be lower than IP 23.

3.1.4.8 BATTERIES

3.1.4.8.1 Sealed Value Regulated type batteries shall be required and fulfilled FSD requirement.

3.1.4.8.2 The batteries life shall not be less than four years under the service conditions as stated in this General Specification.

3.1.4.8.3 The batteries shall comply with BS EN 60896-2:1996 and IEC 60896-21/22-2004 and other relevant international standard requirements for safety and performance.

3.1.4.8.4 Testing report and certificate shall be submitted.

3.1.4.8.5 Batteries shall have a wide operating temperature range from -25°C to +55°C.

3.1.4.8.6 Calculation of battery capacity in Ampere-hour (AH) meeting the following requirements shall be submitted to the Supervising Officer for approval.

3.1.4.9 INTERFACING WORKS

3.1.4.9.1 Interfacing with Electrical Installation

The electrical wiring from automatic changeover switch to distribution board shall be provided and terminated in the distribution board. All power cables provided shall comply with the requirement stated in this General Specification.

Trunking and conduit run drawings for his electrical works shall be submitted for approval before installation

Whenever possible, all wirings shall be grouped and installed together in a neat and tidy manner. Each connection shall terminate in an approved type of terminal block which shall also be suitably labeled.

3.1.4.9.2 Interfacing with CCMS

The works shall include all necessary software and hardware interface for the effective communication with the CCMS for monitoring the points as indicated where connection to CCMS is required for monitoring of system points of the wind turbines system.

The following information shall be interfaced with and shown in the CCMS: -

- Schematic wiring diagram for wind turbines system including the wind turbines module, power inverter(s) and all equipment;
- System ON/OFF/STANDBY/FAULT;
- System mains A.C. output voltage of each phase and three-phase;

- System mains A.C. output current of each phase and three-phase;
- Mains A.C. supply frequency;
- Accumulated maximum input and output power (kWh) each day output ;
- Instantaneous power output (kW);
- Power inverter: (for each power inverter);
- Inverter status: ON/OFF/STANDBY/FAULT;
- Inverter input and output current and voltage;
- Inverter high and low current and voltage alarm;
- Inverter input and output power;
- Inverter on line/off line indication ;
- Automatic changeover status: Normal/Fault;
- Inverter failure alarm;
- Prevailing and seasonal wind direction;
- Wind speed;
- Ambient Temperature;
- DC to AC conversion efficiency (each inverter and overall system); and
- System output against rated peak output efficiency.

3.1.4.10 ENERGY MANAGEMENT AND MONITORING SYSTEM

The wind turbine installation shall be provided with a data logging system for automatic generation of the following information: -

(a) Monthly prevailing wind direction and wind speed;

(b) Monthly wind energy absorbed by the system (MJ/month); and

(c) Monthly power generation (kWh/month).

The data logging system shall be able to record all data generated from the wind turbine and its associated system. All interfacing devices for connection to the CCMS system or other central monitoring system shall be provided.

Independently calibrated microclimate stations including one or few sensors, such as wind sensors/ anemometer, pyranometers, rain sensor, UV sensor, etc. shall be provided and installed to record insolation data. Recorded weather data could be used to estimate how much electricity generated from the wind turbine system for comparison with the actual electricity generation for verification of the system performance in future.

SECTION 3.2

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 3.2.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

3.2.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

3.2.1.2 PHOTOVOLTAIC SYSTEM

3.2.1.2.1 Testing and commissioning (T&C) procedure and check list of PV system shall be submitted together with the recommendation from the manufacturer for approval.

3.2.1.2.2 Functional and safety tests shall be performed in accordance with the technical requirements of the Technical Guidelines on Grid Connection of Renewable Energy Power Systems issued by EMSD.

3.2.1.2.3 Both the D.C. and A.C. side of the system shall be tested in according to the latest edition of IET Wiring Regulations and Code of Practice for Electricity (Wiring) Regulations, including: -

(a) Continuity of circuit, protective conductors, equipotential bonding;

(b) Earth electrode impedance for A.C. side of the system;

(c) Insulation resistance;

(d) Polarity;

(e) Earth loop impedance for A.C. side of the system; and

(f) Functions of protective devices.

3.2.1.2.4 The following pre-fabrication tests for the PV system shall be carried out: -

(a) Visual inspection on appearance of PV modules;

(b) Detailed records of PV modules' serial number with IV curve;

(c) Short-circuit current of fabricated string under reasonable sun light situation; and

(d) Open-circuit voltage of fabricated string under reasonable sun light situation.

3.2.1.2.5 The following site tests shall also be carried out: -

(a) Checking the functional aspects of PV (e.g. water-proofing properties of the system) and proper integration with structure;

(b) Operating current of individual strings under reasonable sun light situation;

(c) Operating voltage of individual systems under reasonable sun light situation;

(d) Anti-islanding tests. Disconnection time after the isolation of utility grid recorded for the following conditions: -

- LCR load with Q = 2.5 and Pgen/Pload = 1
- Resistive load with Pgen/Pload = 0.5
- Resistive load matched with combined power from all the inverters connected to the same distribution board;

(e) Reconnection time upon restoring of utility power;

(f) Disconnection time for voltage and frequency disturbances;

(g) Power factor recorded while the inverter is powered from the PV array for the duration of one sunny day;

(h) D.C. injection tests recording both polarities of the inverter output and integrated to detect D.C. components;

(i) THD and individual harmonics measurement up to 3kHz when the inverter is delivering not less than 70% of rated power;

(j) EMI measurement;

(k) Acoustic noise recording; and

(l) Visual check on markings and labels to all MCBs connecting to grid-connecting inverters.

3.2.1.2.6 Where BIPV panels are installed, the following tests shall be carried out: -

(a) Checking on proper integration with structure; and

(b) Other functional aspects of PV (e.g. waterproofing properties of the system as roof or façade).

3.2.1.3 POLE MOUNTED SOLAR-POWERED LIGHTING

3.2.1.3.1 T&C procedure and check list with recommendation from the supplier or manufacturer shall be submitted for approval.

The following inspection, safety and functional performance tests shall be carried out: -

(a) Identification of labels for conductors;

(b) Presence of danger and warning notices;

(c) Correct connections of all equipment in accordance with supplier's instruction;

(d) Insulation Resistance Test;

(e) Lightning and Earthing Continuity Test;

(f) Earth Fault loop Impedance Test;

(g) Functional performance test of PV panels, daylight sensor, motion sensor;

(h) Functional performance test of batteries and charger;

(i) Testing of auto-change-over function by simulating the voltage drop of the battery and cut-in of the city main power supply;

(j) Demonstration for the full capacity of batteries through discharging the energy to the offered solar LED luminaire at full lighting intensity for a period as stated in Sub-section 3.1.2 of this General Specification;

(k) Functional test of the Energy Management System and

(l) Verification of illumination level by site measurement.

3.2.1.4 SOLAR HOT WATER SYSTEM

3.2.1.4.1 T&C procedure and check list of Solar Water Heating Installation shall be submitted together with the recommendation from the supplier and/or manufacturer for approval.

3.2.1.4.2 Functional and safety tests shall be proposed to demonstrate the installation complying with the specified requirements. The inspection and testing shall also be carried out in accordance with the "Sample

Checklist of Inspection and Testing of Solar Water Heating Systems" as provided in the Handbook on Design, Operation and Maintenance issued by EMSD.

3.2.1.4.3 Individual components forming part of the solar water heating installation shall, in addition to this section, shall be tested in accordance with the relevant Parts of this General Specification.

3.2.1.4.4 The system shall be hydraulically tested to 1.5 times the maximum working and design pressure respectively. The alternative testing proposal, if any, with technical details, testing arrangement and justifications shall be submitted for approval.

3.2.1.5 WIND TURBINE INSTALLATION

3.2.1.5.1 T&C procedure and check list of wind turbine installation shall be submitted together with the recommendation from the supplier or manufacturer.

3.2.1.5.2 Functional and safety tests shall be carried out in accordance with the technical requirements of the Technical Guidelines on Grid Connection of Renewable Energy Power Systems issued by EMSD and this General Specification.

3.2.1.5.3 Tests on both the D.C. and A.C. side of the system, according to the latest edition of IET Wiring Regulations and Code of Practice for Electricity (Wiring) Regulations, shall be carried out including: -

(a) Continuity of circuit, protective conductors, equipotential bonding;

(b) Earth electrode impedance for A.C. side of the system;

(c) Insulation resistance;

(d) Polarity;

(e) Earth loop impedance for A.C. side of the system; and

(f) Functions of protective devices.

3.2.1.5.4 Performance test shall be carried out for the installation for the electric power generated and the corresponding wind speed, including: -

(a) Electric power;

(b) Wind speed;

(c) Wind direction;

(d) Air density;

(e) Rotational speed and pitch angle;

(f) Blade condition;

(g) Wind turbine control system; and

(h) Data acquisition system.

3.2.1.5.5 Test reports shall be submitted for the approval of the Supervising Officer in the format of scatter plots including the following parameters: -

(a) Mean, standard deviation, maximum and minimum power output;

(b) Wind speed and turbulence intensity;

(c) Average air density;

(d) Wind shear exponent;

(e) Wind direction; and

(f) Rotational speed and pitch angle.

SUB-SECTION 3.2.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

3.2.2.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during Maintenance Period shall also comply with the specific requirements in this Sub-section.

Operation, servicing and maintenance of the Installations, shall follow to the best practice of preventive maintenance schedule as recommended in the Handbooks on Design, Operation and Maintenance of Solar Photovoltaic Systems and Solar Water Heating Systems issued by EMSD.

3.2.2.2 SAFETY REQUIREMENTS

Before operating or isolating the system, all instructions of each product shall be familiarised with and the following procedures, if applicable, for electrical disconnection and restoration shall be carried out prior to and after carrying out any electrical work on the system, including but not limited to, the following: -

(a) Notify building management the shut down of system;

(b) Isolation of the system from the electricity supply and electricity grid: -

(i) Switch OFF the lockable main switch of the system at the Grid supply side to isolate the supply from the Grid. Apply lock and affix appropriate warning notice(s); and

(ii) Switch OFF the DC circuit breakers, inverters and/or associated isolation switch at the system to isolate the supply from the system. Apply lock and affix appropriate warning notice(s).

(c) Verification of complete de-energisation of the system;

(d) After completion of work, the installations shall be regularly inspected and tested. Proper certification confirming installation is safe for energisation shall be submitted;

(e) Restoration of supply from system and the electricity grid: -

(i) Remove the warning notice(s) and unlock the isolation switch(es) at the system. Switch ON the DC circuit breakers, inverters and/or isolation switch(es) to restore supply from system; and

(ii) Remove the warning notice(s) and unlock the lockable main switch of the system at the Grid supply. Switch ON the main switch to restore supply from the Grid.

3.2.2.3 ENERGY PERFORMANCE DATA

Before the end of Maintenance Period, the annual energy performance data of relevant system shall be collected, analysed and submitted to the Supervising Officer for record. The data shall include, but not limited to, the following: -

(a) Total electrical energy generated by the PV system in kWh for total 12 months (with measurement period indicated);

(b) Total electrical energy generated by the wind turbine installation in kWh for total 12 months (with measurement period indicated); and

(c) Total thermal energy collected by the solar hot water system in kWh for total 12 months (with measurement period indicated).

3.2.2.4 CHECKING AFTER CORRECTIVE MAINTENANCE

Whenever the major components are replaced, the following shall be checked: -

(a) The maximum DC power, voltage and current of the system installed shall be checked and not exceeding the inverter limit.

(b) Using different electrical characteristics of module at one inverter or connecting to the same MPP tracker shall be avoided.

(c) The operating voltage and the current carrying capacity of cables and rating of circuit breakers shall be checked before replacement.

(d) In case multiple inverters are replaced by single inverters with higher rating or vice versa, the maximum DC power, voltage and current at the DC input of the inverter shall be checked.

(e) The polarity of all DC cables shall be checked to ensure the cables are correctly identified and correctly connected into system devices such as switching devices or inverters.

(f) Bonding cables shall be checked after any replacement to ensure the earthing system is in order.

PART 4 – INTERNET OF THINGS INFRASTRUCTURE

SECTION 4.1

GENERAL REQUIREMENTS

SUB-SECTION 4.1.1

SCOPE OF WORKS

4.1.1.1 DEFINITION

4.1.1.1.1 Internet of Things (IoT) is a technology which enables the provision of communications platforms and services for interconnected devices to generate, exchange and consume data with minimal human intervention.

4.1.1.1.2 IoT Layer

(a) Device Layer

Sensors and controllers capable of sensing/control the state or behavior of the "things" with data communication to the IoT gateway.

(b) Network Layer

To serve as a media for data transfer between IoT devices and application server via wired or wireless network. This layer consists of IoT gateway that collects data from IoT devices and transmits it to the local IoT application server or remote server via Internet. The gateway will also perform load management via data pre-processing and information security.

(c) Application Layer

To process the data from IoT devices for client applications such as smart toilet, smart carpark, condition monitoring and data analytics, etc.

4.1.1.2 SCOPE OF THIS SPECIFICATION

The technical requirements stipulated in this Part of General Specification are applicable to the IoT infrastructures at device layer and network layer. The detailed scope of works at application layer, if specified, shall refer to the requirements in the Particular Specification.

4.1.1.3 GOVERNMENT WIDE IOT NETWORK INFRASTRUCTURE

4.1.1.3.1 General

Government Wide IoT Network (GWIN) is an IoT network throughout Hong Kong to support digitalisation of Mechanical, Electrical and Plumbing (MEP) installation and smart applications for the improvement of public service quality. GWIN utilises private Long Range (LoRa) network, a low power wide area network (LPWAN) modulation technology, to connect between IoT devices and the application server in EMSD via gateways. The GWIN is owned by EMSD.

4.1.1.3.2 The configuration of GWIN connection shall be as specified in the Particular Specification as follows: -

(a) Direct connection to GWIN

IoT device is connect to the GWIN direct via the GWIN gateway owned by EMSD. This is normally applicable when the premise /IoT device is within the GWIN coverage range.

(b) Connection to GWIN Server through On-premise GWIN Infrastructure

IoT device is connect to the GWIN server through on-premise IoT network infrastructure. This is normally applicable when the premise /IoT device is out of the GWIN coverage range or data integration before connection to GWIN is prefer.

4.1.1.3.3 If the premise is not fully covered by GWIN, on-premise GWIN infrastructure shall be supplied and installed when GWIN connectivity is specified in the Particular Specification. The infrastructure shall include, but not limited to, gateway, antenna, Long-Term Evolution (LTE) router, Power-Over-Ethernet Plus (POE+) injector, signal cable, cable containment, battery charger unit, equipment cabinet and necessary accessories as required for the connection of the on-premise IoT network to GWIN.

4.1.1.3.4 5G/4G Long-Term Evolution (LTE) local mobile data subscription service for each standalone IoT gateway or fixed line data subscription service for on-premise IoT network shall be provided for testing and commissioning work and during the Maintenance Period. Infrastructure for fixed line data subscription service shall be provided if mobile network coverage by local telecommunication company is not available. Each data subscription shall come with a public fixed IP address for unlimited local LTE mobile data at an uplink speed not lower than 10Mbps.

4.1.1.3.5 The works shall include the implementation of payload decoder on EMSD's L2TP network server (LNS) in JSON or other protocols agreeable by EMSD to decode the IoT sensor device payload to a meaningful human comprehensible format without the use of mapping

table, data dictionary or codebook. Technical documents including the payload format and configuration specification for LoRaWAN equipment supplied under the Works shall be submitted to the Supervising Officer for approval.

4.1.1.3.6 The connection to GWIN server shall through EMSD's LNS for information security.

4.1.1.3.7 Application Interfacing Requirements with EMSD's LoRaWAN Network Server (LNS)

(a) Interfaces on the system applications or data platform for data exchange with Application Program Interface (API) (via MQTT and/or HTTP call-back with SSL) with the EMSD's LNS in accordance to the associated EMSD standards shall be developed.

(b) Data collected by sensor devices deployed under the Works to meet the system functional requirements under the requested scope of works shall be retained. EMSD's LoRa network is not obligated to retain any data collected by the sensor devices and/or applications deployed under this Contract.

(c) User manual, login ID and password for the use of EMSD's LNS web-based platform shall be obtained via liaison with EMSD or its contractor.

(d) The provision, upkeep and troubleshoot of servers, applications and/or connectivity that integrate with the data exchange methods shall be included under the Works.

4.1.1.4 IOT NETWORK OTHER THAN GWIN

4.1.1.4.1 For IoT application specified in the Particular Specification or the Contract which is not connect to GWIN, the network infrastructure to be provided shall capable to cover the IoT device of intended use.

4.1.1.4.2 The connection of IoT device to the IoT application server shall be as follow: -

(a) Direct connection to Application Server

IoT device is connect to the IoT application server through third-party IoT cellular mobile network. This is normally applicable when the premise /IoT device is within the coverage range of available IoT cellular mobile service, for example IoT sensor in outdoor carpark where IoT cellular mobile service signal is available by telecommunication service provider, e.g. Narrowband IoT (NB-IoT) service.

(b) Connection through On-premise IoT Infrastructure

IoT device is connect to the IoT application server through on-premise IoT network infrastructure. This is normally applicable when the premise /IoT device is out of the coverage range of IoT cellular mobile service or data integration within the premise is prefer.

The on-premise IoT infrastructure shall include, but not limited to, gateway, antenna, Long-Term Evolution (LTE) router, Power-Over-Ethernet Plus (POE+) injector, signal cable, cable containment, battery charger unit, equipment cabinet and necessary accessories as required to facilitate the application.

5G/4G Long-Term Evolution (LTE) local mobile data subscription service for each standalone IoT gateway or fixed line data subscription service for on-premise IoT network shall be provided for testing and commissioning work and during the Maintenance Period. Infrastructure for fixed line data subscription service shall be provided if mobile network coverage by local telecommunication company is not available. Each data subscription shall come with a public fixed IP address for unlimited local LTE mobile data at an uplink speed not lower than 10Mbps.

Communication of IoT device to the application server through the network of building services installation, for example, wireless vibration sensor connecting to CCMS via DDC outstation equip with wireless receiver, is acceptable subject to the approval of the Supervising Officer.

(c) Connection through Computer Local Area Network

The connection of IoT device to IoT application server through client's computer local area network (LAN) of the premise shall normally not allowed unless approved by the Supervising Officer.

4.1.1.4.3 The works shall include the coordination with third-party IoT application service provider for the registration, decoding, configuration and testing of IoT device to be connected. The connection to IoT application server shall through L2TP network server (LNS) for information security.

SUB-SECTION 4.1.2

INFORMATION SECURITY

4.1.2.1 GENERAL

Information security measures shall be adopted to protect against the risks to IoT devices. Proposed measures including physical protection, access controls, network segmentation, cryptographic protection, log management, device management such as applying security patch and firmware upgrade, malware detection and prevention as well as data protection shall be submitted to the Supervising Officer for approval. The proposal shall also include rules and advice on how to connect IoT devices to government networks securely as well as avoid being controlled by malicious attackers.

The information security measures shall cover the IoT device, network and the application server as a whole.

The connection to IoT application server shall be through L2TP network server (LNS) for information security unless otherwise approved by the Supervising Officer.

Firmware shall be of latest available version in the market. Necessary upgrade and security patches to all software or firmware shall be provided and installed during the Maintenance Period.

SECTION 4.2

TECHNICAL REQUIREMENTS

SUB-SECTION 4.2.1

IOT SENSOR AND DEVICE

4.2.1.1 GENERAL

The use of frequency bands and transmission powers of IoT sensor device shall comply with the requirements set by the Office of the Communications Authority (OFCA).

The equipment shall comply with the Performance Specification for Radio Equipment Operating in the 920 – 925 MHz Band for the Provision of Public Telecommunications Services issued by OFCA.

The accuracy, operation range and performance requirement (except the communication frequency) of the sensors with using IoT technology shall have no difference with other sensors by using traditional wiring.

Unless other specified, IoT sensor may be of self-contained battery type or AC-power connected type. Self-contained battery type IoT sensor shall be used for application without high demand of parameters sensing and data exchange.

Detail requirements for particular application shall refer to relevant Sub-sections in this General Specification.

4.2.1.2 WIRELESS LONG RANGE (LoRa) SENSOR

Equipment shall be compatible and comply with the latest LoRaWAN specification issued by the LoRa Alliance. The use of frequency bands and transmission powers shall comply with the requirements set by OFCA and LoRa Alliance on LoRaWAN equipment and applications.

The equipment shall operate with the following parameters: -

Frequency range	:	920MHz to 925MHz
Regulation	:	Radio Equipment Specifications (HKCA 1078) issued by OFCA
Standard	:	Compliant with LoRaWAN specification v1.0.2 or latest version issued by LoRa Alliance™

The equipment shall be capable of operating in the full band of the frequency range.

In case downlink command and/or confirmed uplink function is to be adopted, the proposed LoRaWAN sensor device shall support reasonable receiver sensitivity for ensuring the stable connection with LoRa network.

The maximum transmission duty cycle of sensor devices shall be 1% and the maximum dwell time per frequency channel shall be 400 millisecond, unless otherwise approved by Supervising Officer.

For battery-powered LoRa sensor device, its battery shall be able to last for at least one year without battery replacement under normal operating condition and with the data transmission frequency of at least one uplink message per hour. Calculation or test report to demonstrate the battery life of the proposed IoT sensor device shall be submitted to the Supervising Officer.

The LoRa sensor device shall be interoperable with major LoRaWAN network servers in the market.

Sensor devices shall have the following features: -

(a) Over-the-Air Activation (OTAA) mode;

(b) Adaptive Data Rate (ADR);

(c) Random LoRaWAN frequency channel selection;

(d) Battery level in payload (if applicable); and

(e) Hearbeat message at least once a day.

Sensor device data shall be capable to decode to human-interpretable content without intervention of any third-party proprietary system.

Data upload interval shall be configurable.

4.2.1.3 WIRELESS IOT SENSOR OF OTHER TECHNOLOGIES

Wireless IoT sensors employing other technologies such as Narrowband IoT, Zigbee IoT, WiFi and Bluetooth technologies will be acceptable provided that the sensors and the infrastructure can satisfy the performance and functional requirements of the intended applications.

SECTION 4.2

TECHNICAL REQUIREMENTS

SUB-SECTION 4.2.2

IOT GATEWAY

4.2.2.1 GENERAL

Designated gateways and accessories, including but not limited to, antenna, coaxial cable, signal cable, power supply connection, battery charger, power cable, surge arrestor, electrical devices, waterproof cabinet / housing, SIM card, shall be supplied and installed. Other associated services shall also include the configuration and registration for the gateways supplied such that the gateways and other equipment can operate normally as a completed system in the designated location and environment.

The Works shall include the design of the complete system. System design and proposed material /equipment shall be submitted to the Supervising Officer for approval.

Configuration for all devices and equipment including gateways, PoE+ injectors, LTE routers, sensors, internet services (if applicable) and all 4G mobile data subscription for each gateway shall be carried out to ensure its proper connection to the Internet.

220V 13A single phase power supply shall be provided by contractor responsible for electrical installation for each outdoor gateway location. The wiring and connection of the power from the power supply termination point to the equipment shall be carried out under the Works.

4.2.2.2 OUTDOOR TYPE LoRaWAN GATEWAY

4.2.2.2.1 Outdoor type LoRaWAN Gateway shall comply with the following requirements /performance as minimum: -

Cellular	:	(i) 4G-LTE Category 4, with HSPA+ 42/GPRS fallback; (ii) Global frequency band suitable for use in Hong Kong including – - 4G: 1800(B3)/2600(B7); - 3G: 900(B8)/2100(B1); and - 2G: 900/1800
Processor and memory	:	32-bit 400MHz, 128x16M DDR RAM
Packet Data	:	Up to 100 Mbps downlink, up to 50 Mbps uplink
Radio frequency (LoRa)	:	Compatible with AS 923 MHz

Radio frequency (WiFi and BT/BLE)	:	802.11 a/b/n/g 2.4 GHz and 5 GHz; BT Classic BLE 4.1
LoRaWAN channel	:	8 channels or above duplex
Storage	:	Micro SD
Input voltage	:	48V D.C. or Power over Ethernet (PoE) compliant to IEEE 802.3at
Local Ethernet	:	IEEE 802.3 10/100 base T compliant
Ethernet connector	:	1 x RJ45 Ethernet 10/100 port
USB connector	:	1 x USB port
Antenna	:	1 no. of at least 3dBi antenna for 4G LTE; 1 no. of at least 3dBi antenna for LoRa; 1 no. of GPS antenna
Transmission power	:	27dBm maximum
SIM connector	:	Micro SIM (3FF)
Accessories	:	Equipped with all necessary accessories, including antenna and mounting kit
Weight	:	Less than 3kg
Chassis type	:	IP67 rated, aluminum
Environmental ratings	:	Operating temperature: 0°C to +55°C; Relative humidity: 20% - 90%, non-condensing
Certification	:	Electromagnetic compatibility: EN 55022 Class B, EN 55024 compliant; Safety: IEC 60950-1 2nd Ed compliant; and Radio: EN 300 220 compliant
Software	:	- Enhanced and embedded Linux platform or equivalent; - LoRa packet forwarder; - WAN Connection; - Cellular PPP, Dynamic DNS, DHCP Server/Client; - WAN connection via Ethernet or cellular; - LAN/WAN Security; - Secure firewall with NAT and port forwarding;

- Static routing;
- Node-RED integration;
- Built-in Node-RED application development environment;
- Language Support;
- C, C++, Python, Javascript, node.js, bash;
- Router/Modem management;
- Graphical web interface for configuration and management;
- Remote Access;
- Configuration backup and restore; and
- Easy firmware upgrade through web interface.

4.2.2.2.2 The location of outdoor gateway /antenna shall be installed at position for good signal reception. There are two typical installation locations for outdoor gateway: -

(a) Metal enclosure housing gateway and associated accessories (approximate 400mm W x 500mm L x 200mm D) being wall-mounted inside plant room area while the outdoor antenna (approximately 1000mm L) to be extended for mounting at outdoor locations using coaxial cables with cable distance not exceeding 10m.

(b) Metal enclosure and outdoor antenna being wall-mounted at building rooftop

4.2.2.2.4 The gateway /antenna to be installed shall be mounted at position under the protection coverage zone of lightning protection system of the premise

4.2.2.3 INDOOR TYPE LoRa GATEWAY

4.2.2.3.1 Indoor type LoRaWAN Gateway shall comply with the following requirements /performance as minimum: -

Cellular	:	(i) 4G-LTE Category 4, with HSPA+ 42/GPRS fallback; (ii) Global frequency band suitable for use in Hong Kong including – - 4G: 1800(B3)/2600(B7); - 3G: 900(B8)/2100(B1); and - 2G: 900/1800
Processor and memory	:	32-bit 400MHz, 128x16M DDR RAM
Packet Data	:	Up to 100 Mbps downlink, up to 50 Mbps uplink

Radio frequency (LoRa)	:	Compatible with AS 923 MHz
Radio frequency (WiFi and BT/BLE)	:	802.11 a/b/n/g 2.4 GHz and 5 GHz; BT Classic BLE 4.1
LoRaWAN channel	:	8 channels or above duplex
Storage	:	Micro SD
Input voltage	:	48V D.C. or Power over Ethernet (PoE) compliant to IEEE 802.3at
Local Ethernet	:	IEEE 802.3 10/100 base T compliant
Ethernet connector	:	1 x RJ45 Ethernet 10/100 port
USB connector	:	1 x USB port
Antenna	:	1 no. of at least 2dBi antenna for 4G LTE; 1 no. GPS antenna; and 1 no. of WiFi/BT antenna
Transmission power	:	27dBm maximum
SIM connector	:	SIM/USIM(2FF)
Accessories	:	Equipped with LoRa module and at least 3dbi RP-SMA antenna for LoRa, power supply/adaptor and mounting kit, etc.
Weight	:	Less than 1kg
Chassis type	:	IP67 rated, aluminum
Environmental ratings	:	Operating temperature: 0°C to +55°C; Relative humidity: 20% - 90%, non-condensing
Certification	:	Electromagnetic compatibility: EN 55022 Class B, compliant; Safety: IEC 60950-1 2nd Ed compliant; and Radio: FCC Part 22, 24, 27 compliant
Software	:	- Enhanced and embedded Linux platform or equivalent; - LoRa packet forwarder; - WAN Connection; - Cellular PPP, Dynamic DNS, DHCP Server/Client; - WAN connection via Ethernet or cellular;

- LAN/WAN Security;
- Secure firewall with NAT and port forwarding;
- Static routing;
- Node-RED integration;
- Built-in Node-RED application development environment;
- RS-232, RS-485;
- Language Support;
- C, C++, Python, Javascript, node.js, bash;
- Router/Modem management;
- Graphical web interface for configuration and management;
- Remote Access;
- Configuration backup and restore; and
- Easy firmware upgrade through web interface.

4.2.2.4 LTE ROUTER

4.2.2.4.1 LTE router, associated accessories and services including but not limited to, power supply, charger, cablings, antenna, surge arrestor, waterproof cabinet/ housing for the gateways shall be supplied and installed such that the gateways, injectors and other equipment can operate normally as a completed system in the designated location and environment.

4.2.2.4.2 LTE router shall comply with the following requirements /performance as minimum: -

Bands	:	LTE bands 1, 3, 7, 8, 20 800(B20), 900(B8), 1800(B3), 2100(B1), and 2600(B7) MHz
Download (DL) /Upload (UL) speeds	:	Up to 100 Mbps downlink; up to 50 Mbps uplink
Radio frequency (LoRa)	:	Compatible with AS 923 MHz
Wi-Fi connectivity	:	Compliant to IEEE 802.11ac
SIM slot	:	At least 1 SIM slot compliant to ISO 7816-2
SIM and Global Positioning System (GPS)	:	- GPS antenna: SMA connector; - Send and receive SMS (maximum 160 characters); - Standalone GPS; - Separate active GPS with SMA; - Configure multiple profile.

Management Information Base (MIB)	:	- Enhanced 3G MIB with 4G MIB extension; - Entity MIB; - IF MIB; - 3G wireless WAN (WWAN) MIB persistence.
4G LTE network management and diagnostics	:	- In-band and out-of-band management using Telnet and SNMP, including MIB II and other extensions; - Industry-standard 4G LTE diagnostics and monitoring tools (QUALCOMM CDMA Air interface Tester (CAIT) and Spirent Universal Diagnostic Monitor (UDM))
Modem	:	Modem form factor: Embedded Peripheral Component Interconnect (PCI) minicard
Wireless technologies	:	- LTE 800MHz (band 20), 900MHz (band 8), 1800MHz (band 3), 2100MHz (band 1), and 2600MHz (band 7); - Backward compatible with UMTS and HSPA+: 900 and 2100MHz, and DC-HSPA+, Tri-band EDGE, GPRS, and GSM.

4.2.2.5 POWER OVER ETHERNET PLUS INJECTOR

Power-Over-Ethernet Plus (PoE+) injector, associated accessories and services including but not limited to, power supply, BATTERY charger, cablings, waterproof cabinet/ housing for the gateways shall be supplied and installed such that the gateways, routers, other equipment operate normally as a completed system in the designated location and environment.

The PoE+ injector shall support sufficient output power for the gateway installed and support IEEE 802.3at with power supply for use in Hong Kong.

4.2.2.6 ADDITIONAL ANTENNA FOR GATEWAY

4.2.2.6.1 Indoor Gateway

External 3dBi antenna of omni-directional type or directional type for indoor use as approved by the Supervising Officer with associated accessories and services, including coaxial cable, signal cable, connector, mounting bracket, mounting pole, cabinet, etc., in additional to or in replacing the existing antenna of the gateway, shall be supplied and installed.

4.2.2.6.2 Outdoor Gateway

External 6dBi or 9dBi antenna of omni-directional type or directional type for outdoor use as approved by the Supervising Officer with associated accessories and services, including coaxial cable, signal cable, connector, mounting bracket, mounting pole, cabinet, etc., in additional to or in replacing the existing antenna of the gateway, shall be supplied and installed.

4.2.2.7 CABINET FOR GATEWAY

Waterproof cabinet with mechanical lock with key for housing each gateway, associated antennae, Ethernet and power cables supplied and / or installed under this Contract shall be provided. The cabinets shall be tailor-made (including all necessary materials and works inside the cabinet, e.g. cables, holes, openings, screws, connectors, cable glands, etc.) to fit each individual gateway, antennae, lightning arrestors / surge protectors and the associated accessories. The material of the cabinets shall be of stainless steel or other materials as approved by the Supervising Officer. The design of the cabinet for each installation scenario shall be submitted to the Supervising Officer for approval.

The metal enclosure shall be located to accessible location for maintenance. The mounting details of the equipment for each mounting scenarios shall be certified by the Registered Structural Engineer (RSE). Protective conductor shall be provided for the metal enclosure.

4.2.2.8 CABLE AND WIRING

4.2.2.8.1 Power cables shall be 3-core PVC insulated, non-armoured, multi-strand with each copper conductors of not less than 2.5 mm2 to BS6004 and with an overall protective sheath of PVC.

4.2.2.8.2 The non-armoured control cables used shall satisfy the following minimum characteristics and with an overall protective sheath of PVC: -

(a) at least 7 strands per conductor;

(b) strand diameter not less than 0.2 mm;

(c) conductor resistance less than 90 Ohm/km; and

(d) insulation resistance better than 20 M Ohm/km measured between cores or between core and screen.

4.2.2.8.3 Cables installed in underground trenches shall be steel wire armoured.

4.2.2.8.4 Cable including CAT6 STP cable, antenna cable and / or power supply cable with cable containment shall be provided. Cables shall have appropriate shielding and protective coating for usage at outdoor / semi-outdoor environment subject to the approval of the Supervising Officer.

SECTION 4.3

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 4.3.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

4.3.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

4.3.1.2 TESTING AND COMMISSIONING OF SENSOR DEVICES

4.3.1.2.1 The following minimum pre-requisite shall be met before the commencement of testing of IoT sensor devices: -

(a) Sensor's baseline information should be recorded in the test form, i.e. brand, model, serial number, device ID, device name, device EUI, installed location with geospatial data;

(b) Sensor's baseline configuration should be recorded in the test form, i.e. heartbeat, frequency, reporting interval, triggering event;

(c) The parameters for test environment should be recorded including but not limited to the RSSI, package loss rate taken on site with field tester as the reference value for the sensor under test;

(d) The latest activity for the sensor from the LNS should be recorded i.e. the sensor activity for last 7 days before the SAT; and

(e) The sensor device should be alive for at least 7 days before the SAT.

4.3.1.2.2 Signal test for the sensor devices shall be carried out. Parameters including, but not limited to, uplink Received Signal Strength Indicator (RSSI), uplink Signal to Noise Ratio (SNR), Spreading Factor (SF), Data Rate (DR) of acceptable level shall be recorded.

4.3.1.2.3 Upon the completion of site test, the sensor device inventory list recording the information including, but not limited to, brand name, model, serial number, device ID, device name, device EUI, installed location with geospatial data shall be submitted.

4.3.1.2.4 Before the approval of offered material /equipment by the Supervising Officer, samples of equipment to conduct bench test with EMSD's LoRa network shall be provided when requested by the Supervising Officer. Samples of sensor devices, necessary gateways, tools and accessories shall be arranged and the test shall be completed within 2 week or at a period approved by the Supervising Officer.

4.3.1.2.5 Site survey, registration, decoding, configuration and testing of IoT device to be connected to GWIN shall be included under the Works if the device is to be provided under the Contract. Coordination with EMSD and its contractor for the Works shall be executed. Instructions for sensor device registration (i.e. join request & accept using OTAA) and decoding standard, if applicable, shall be followed as required by EMSD.

4.3.1.3 TEMPORARY WORKS

The works shall include the temporary provisions of gateway and necessary accessories for connecting the IoT sensor device for testing and commissioning. The temporary provision shall be removed upon successful test, commissioning and data migration to the GWIN Server or IoT application server of third parties.

The migration works shall not deteriorate the performance of the system. Necessary on-site troubleshooting and configuration services, including but not limited to, re-joining of sensor devices, sensor device parameters updates, sensor device parts replacement and firmware updates, to ensure the connectivity to the network /application layer shall be performed.

SUB-SECTION 4.3.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

4.3.2.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during Maintenance Period shall also comply with the specific requirements in this Sub-section.

Operation, servicing and maintenance of the Installations, if specified, shall also refer to the equipment manufacturer's recommendations and specifications.

4.3.2.2 MONITORING OF SENSOR DEVICES

The health status of IoT sensor device deployed under this Contract shall be remotely monitored during the Maintenance Period. System health report shall be submitted on monthly basis or upon the request by the Supervising Officer.

PART 5

[RESERVED]

PART 6 – AIR CONDITIONING, REFRIGERATION AND MECHANICAL VENTILATION INSTALLATION

SECTION 6.1

INSTALLATION METHODOLOGY

SUB-SECTION 6.1.1

AIR CLEANING EQUIPMENT

6.1.1.1 GENERAL

The complete air filter set for the following types of filters shall be of heavy-duty airtight factory fabrication to ensure a positive seal against leakage of unfiltered air. Generally, it shall be complete with robust enclosure, holding frames and housing, all supplied by the same manufacturer, as below: -

6.1.1.1.1 The robust enclosure shall be factory assembled in such a manner that a rigid and durable enclosure for the filter packs is ensured. The periphery of the filter pack shall be continuously bonded to the inside of the enclosing frame to eliminate air bypass and to ensure the optimum filtration efficiency.

6.1.1.1.2 The holding frames, which are to accommodate standard sized filters of the specified efficiency, shall be factory assembled and manufactured by the filter manufacturer. It shall be constructed of minimum 1.6 mm galvanised steel sheet and equipped with positive gasket seals at the entire length of the holding frames. The gaskets are provided to stop the air bypass between the filter cell and the frames, between the adjacent frames, and also between the frames and the housing. To firmly hold the filter cells against sealing gaskets, fixtures shall be provided adequately. The above elements are to be fully supported against the direction of airflow and become totally rigid when installed. The holding frames shall be equipped with fixtures for easy removal of the filter cells without the use of any special tools, unless otherwise specified.

6.1.1.1.3 The housing shall be constructed of minimum 1.6 mm galvanised sheet steel and factory assembled in accordance with the recommended installation details of the filter manufacturer. It shall incorporate access doors, extruded aluminium tracks, individual holding frames and flanged joints for ductwork connections. Positive gasket seals shall be provided to stop the air leakage between the housing and the connected ductwork. For air conditioning application, the housing shall be constructed of minimum 1.6 mm double skin galvanised sheet steel with 32 mm 80 kg/m^3 mineral wool insulation or factory coated/injected with suitable thermal insulation material approved by the Supervising Officer. The above material shall have the insulation property same as or better than that of the air-conditioning ductwork connected to the complete air filter set. For filters used in corrosion resistant ductwork, the associated housing, holding

frames, enclosures and all metal surfaces in contact with the air stream shall be applied with the same anti-corrosion coating as the ductwork. Accessories of which the operation will be affected by the coating shall be of AISI 316 stainless steel but with the coating omitted. The housing shall have finishing painting with colour to match the air handling equipment. It shall be with factory punched holes with gland plates for each stage of filter for field connections of manufacturers and/or automatic control devices. All holes shall be sealed after the connection work.

In any case, all components of the air filter set and its associated accessories, which are within the air stream, shall comply with requirements of the FSD.

To indicate the filter condition, differential pressure gauge shall be provided for easy inspection, operation and maintenance. Facilities for Central Control and Monitoring System (CCMS) interfacing filter condition monitoring shall also be equipped. They shall be fixed in such a position, outside the casing that they will be accessible and easily read. The gauges shall be properly installed with all necessary galvanised steel support brackets and ductwork stiffeners onto the ductwork without damaging the thermal insulation. The complete mounting assembly shall ensure leakage-proof and to avoid condensation at any surface in contact with the filter section.

New filters for all air handling equipment at the date of the substantial completion shall be provided. For disposable type filters, at least 4 extra sets of each type of installed filters for spare and replacement shall be provided. Filters shall be replaced when necessary during the Maintenance Period. At least one set of filters shall be handed over to the Supervising Officer at the expiry of the Maintenance Period.

For cleanable filters, at least 1 extra set of each type of installed filters shall be provided for spare and be responsible for the cleaning of filters when necessary during the Maintenance Period. This set of filters shall be handled over to the Supervising Officer at the end of the Maintenance Period.

6.1.1.2 WASHABLE PANEL FILTER

For filter cells installed inside air handling unit, separate housing is not required. However, the holding frames shall be factory mounted in the air handling unit casing and installed to provide service from the air side.

6.1.1.3 AUTOMATIC VISCOUS FILTER

The holding frames shall be equipped with fixtures for easy removal of filter cells without the use of any special tools.

6.1.1.4 DISPOSABLE PANEL FILTER

For filter cells installed inside air handling unit, separate housing is not required. However, the holding frames shall be factory mounted in the air handling unit casing and installed to provide easy servicing.

6.1.1.5 DISPOSABLE PLEATED PANEL FILTER

For filter cells installed inside air handling unit, separate housing is not required. However, the holding frames shall be factory mounted in the air handling unit casing and installed to provide service from the air side.

6.1.1.6 RENEWABLE PANEL FILTER

For filter cells installed inside air handling unit, separate housing is not required. However, the holding frames shall be factory mounted in the air handling unit casing and installed to provide easy servicing.

6.1.1.7 AUTOMATIC FABRIC ROLL FILTER

All necessary electrical cables/accessories for proper operation of the complete air filter set in accordance with the manufacturer's installation details shall be provided.

6.1.1.8 BAG FILTER

The holding frames shall be equipped with at least four heavy duty spring type positive sealing latches for each filter cell to ensure a positive seal against leakage of unfiltered air.

For filter cells installed inside air handling unit, separate filter housing is not required. However, the holding frames shall be factory mounted in the air handling unit casing and installed to provide easy servicing.

6.1.1.9 CARTRIDGE FILTER

The holding frames shall be equipped with at least four heavy duty spring type positive sealing latches for each filter cell to ensure a positive seal against leakage of unfiltered air.

For the filter cells installed inside air handling unit, separate filter housing is not required. However, the holding frames shall be factory mounted in the air handling unit casing and installed to provide service from the air side.

6.1.1.10 HIGH-EFFICIENCY PARTICULATE ARRESTANCE (HEPA) FILTER

The holding frames shall be equipped with at least four heavy duty spring type positive sealing latches for each filter cell to ensure a positive seal against leakage of unfiltered air.

For filters installed inside air handling unit, separate housing is not required. However, the holding frames shall be factory mounted in the air handling unit casing and installed to provide service from the air side.

6.1.1.11 AUTOMATIC RECLEANABLE FILTER

The complete automatic recleanable filter set including filter cells, holding frames and housing shall be factory fabricated and assembled.

Manufacturer's installation details shall be followed and all necessary electrical cables/accessories shall be provided for proper operation of the complete Installations.

6.1.1.12 AUTOMATIC RECLEANABLE HEPA FILTER

The complete automatic recleanable filter set including filter cells, holding frames and housing shall be factory fabricated and assembled.

Manufacturer's installation details shall be followed and all necessary electrical cables/accessories for proper operation of the complete Installations shall be provided.

6.1.1.13 AUTOMATIC RECLEANABLE HIGH VOLTAGE ELECTROSTATIC FILTER

The complete automatic recleanable high voltage electrostatic filter set including filter cells, holding frames and housing shall be factory fabricated and assembled.

Manufacturer's installation details shall be followed and all necessary electrical cables/accessories for proper operation of the complete Installations shall be provided. All necessary safety measures including automatic cut-off switch and high voltage warning label at each access panel for the electrostatic filter to prevent any possibility of electrical shock to personnel during operation, inspection and maintenance shall be provided.

The operation of the electrostatic filter shall be interlocked with the fan or air handling unit in such a way that the filter is in operation whenever the fan or air handling unit is operated and the unit is cut off when the fan or air handling unit is cut off.

6.1.1.14 GAS FILTER

Housings shall be constructed of minimum 1.6 mm thick galvanised steel with extruded aluminium filter slide tracks. Doors, on both sides, shall be hinged permanently and attached with positive locking latches. Gaskets shall be provided to prevent air leakage around doors and between the doors and the filters.

Housing shall consist of two sections, first section for housing 50mm washable type pre-filters and second section for housing filter modules.

Media shall be contained in modules which shall be constructed of ABS grade DGA-R thermoplastic with V-shaped cross section.

6.1.1.15 ACTIVATED OXYGEN AIR PURIFIER

The air purifier shall be factory fabricated and assembled in accordance with the manufacturer's installation details. All necessary electrical cables/accessories for proper and safe operation of the complete Installations shall be provided. All necessary safety measures including automatic cut-off switch and high voltage warning label at each access panel for the unit to prevent any possibility of electrical shock to personnel during operation, inspection and maintenance shall be provided.

The complete assembly shall be mounted onto the wall of ductwork by the manufacturer's mounting flange provided by the manufacturer with the power generator outside the air stream and the electrode tubes within the air stream. The glass tube electrodes shall be mounted perpendicular to the direction of air flow and installed at a distance at least 150 mm away from any air distribution accessories within the ductwork. The power generator shall be installed with all necessary support brackets and ductwork stiffeners onto the ductwork and sealed without damaging the thermal insulation and without causing air leaking.

The mounting shall ensure leakage-proof and to avoid condensation at any surface in contact with the ductwork. However, easy withdrawal of the complete unit for routine inspection and maintenance shall be allowed also.

The air purifier shall be installed in suitable location of the air stream as recommended by the manufacturer for best operating efficiency using a stainless steel mounting frame provided by the manufacturer and interlocked with the fan or air handling unit in such a way that the unit is in operation whenever the fan or air handling unit is operated and the unit is cut off when the fan or air handling unit is cut off.

The air purifier shall be wired strictly in accordance with the manufacturer's wiring diagram. It shall be wired so that the units may be unplugged and removed for regular cleaning and maintenance.

A secondary switch to automatic switch off the unit shall also be provided in case the mechanical part of the fan failure.

6.1.1.16 ULTRA-VIOLET (UV) STERILISING LIGHT ASSEMBLY

The UV sterilising light shall be factory fabricated. All necessary safety measures including automatic cut-off switch, proper cover on viewing glass and UV warning label at each access panel for the unit to prevent direct exposure, which may cause eye and skin discomfort to personnel, during operation, inspection and maintenance shall be provided. The warning sign shall state: -

WARNING
DO NOT EXPOSE EYES AND SKIN TO ULTRA-VIOLET LIGHT
RAYS ARE HARMFUL TO UNPROTECTED EYES AND SKIN
警告
切勿讓眼睛及皮膚暴露於紫外光之下, 可引致損害

The complete assembly shall consist of UV lights, light fitting set, power supply unit and monitoring unit. It shall have a minimum bacteria removal efficiency of 90%. Equipment shall be selected on basis of UV lethal dosage requirement, not less than 5,000 μWs/cm, for bacteria removal. Relevant selection method and test reports and certificates by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved to show the removal efficiency of the unit shall be submitted to the Supervising Officer for approval.

The complete assembly shall be mounted onto the wall of ductwork by the manufacturer's mounting flange or inside a section of the air handling unit with the power supply unit outside the air stream and the UV lamps within the air stream. The UV lamps shall be mounted perpendicular to the direction of air flow at velocity less than 5.0 m/s to allow maximum exposure. The power supply unit shall be installed with all necessary support brackets and ductwork stiffeners onto the ductwork without damaging the thermal insulation.

The mounting shall ensure leakage-proof and to avoid condensation at any surface in contact with the ductwork. However, easy withdrawal of the complete unit for routine inspection and maintenance shall be allowed. In some cases such as exposure level exceeds 0.2 micron W/cm^2 over 8 hours, baffle filters may be necessary to install for those air discharge louvres or ductwork openings near the unit to reduce the UV light intensity level in case the safety limit of the exposure level is exceeded.

The UV sterilising light assembly shall be installed in suitable location of the air stream for best operating efficiency as recommended by the manufacturer and interlocked with the fan or air handling unit in such a way that the UV sterilising light assembly is in operation whenever the fan or air handling unit is operated and the unit is cut off when the fan or air handling unit is not operated.

The generated ozone from the UV sterilizing light assembly shall be at a level less than 0.05 ppmv of air circulating through the assembly.

The monitoring unit shall be an independent wall mounted unit installed in the vicinity of the assembly. It shall be able to give information about used life span and lamp replacements. It shall be equipped with an RS 232 or Ethernet interface for external communication via CCMS. All of the operation status and fault signals shall be monitored by the CCMS.

On-site performance test shall be conducted to verify: -

(a) The total bacteria count (TBC) removal efficiency;
(b) Background UV intensity; and
(c) Ozone level.

At least one extra set of UV sterilizing lamp bulb/unit shall be provided for spare and be responsible for the replacement when necessary during the Maintenance Period.

6.1.1.17 WATER SCRUBBER

The complete water scrubber set shall be factory fabricated and tested. The unit may be re-assembled on Site in accordance with the manufacturer's recommended installation details subject to the approval of the Supervising Officer. All necessary electrical cables/accessories for proper operation of the complete Installations shall be provided.

SUB-SECTION 6.1.2

DUCTWORK

6.1.2.1 GENERAL

The zinc coating of the ducts shall not be damaged during fabrication, delivery and installation. Any damage to the galvanised finish shall be made good with three coats of aluminium zinc rich paint or other approved corrosion resisting paint to the satisfaction of the Supervising Officer, in addition to any other protective or finishing paint/coats required in the Particular Specification.

Fabrication and testing of all ductwork shall conform to DW/143:2013 - Guide to Good Practice – Ductwork Air Leakage Testing & DW/144:2016 - Specification for Sheet Metal Ductwork published by BESA and the requirements stipulated in this General Specification.

If insulation is applied to the pre-fabricated ductwork in the factory, leakage test of the ductwork shall be carried out before the application of insulation. Every precaution shall be made to ensure that the insulation and vapour barriers applied to the ductwork shall not be mechanically damaged before erection on Site.

If anti-microbial and/or anti-dust coating is applied to the internal surface of ductwork, manufacturer's installation details shall be followed.

Any damaged ductwork found shall be replaced. All inspection tests carried out in factory are part of the quality control process and shall in no way be treated as substitution of the field tests required on Site.

The ducting system shall be complete with all necessary supports, access doors, dampers, fire dampers, cleaning points and test holes.

All ducts shall be fabricated and installed so as to be rigid and free from swinging, drumming and movement.

All material of ductwork, gasket, flexible joints, acoustic linings and sealants shall not support bacteria growth or posing fire hazard.

6.1.2.2 DUCTWORK CONSTRUCTION AND ACCESSORIES

The ductwork shall be properly and correctly constructed with all necessary accessories to minimise waste of energy and pressure losses due to eddies, vortices, etc. and shall not create, amplify or transmit any noise or vibration. Any necessary sound reducing linings or boxes to reduce noise transmission shall be provided in accordance with the Sub-sections regarding Noise and Vibration Control of this General Specification.

Internal roughness and obstructions to air flow (other than dampers, splitter, vanes, etc.) will not be accepted for ductwork constructed from sheet materials. Sharp edges or corners on the outside of ductwork, fittings and supports will not be accepted.

Perforated rivets shall not be used in manufacture of ductwork. Generally, the use of self tapping screws is not allowed. Where the use of other fastenings is impracticable, self-tapping screws may be used subject to the written approval of the Supervising Officer.

At each point where a duct passes through a roof or external wall, a weather "cravat" or other purpose made arrangement shall ensure a waterproof and weatherproof fixing.

All intake and discharge openings to the Building shall be fitted with 10 mm galvanised mesh bird wires and is additional to any grilles or louvers indicated for these locations.

Duct connections between individual components of an air handling unit and connections between an assembly and a ductwork system shall be made with angle flanged joints. Removable sections shall be provided for access of cleaning and maintenance.

Proprietary duct-flanges shall be installed in accordance with the manufacturer's recommendations and clamped together with screw lock clamps. Angle duct-flanges shall be installed in accordance with DW144.

Unless otherwise specified, duct sizes given on the Drawings are all clear internal dimensions and allowance shall be made for both internal and external insulation on the ducts where applicable.

All ductwork shall be cleaned internally and externally before the system is set into testing, commissioning and operation. Timing of this work shall be set such that minimum inconvenience shall be caused to the work of other trades.

All ductwork installed in the protected areas or lobbies shall be properly enclosed in fire-rated enclosure in according to the requirement of the FSD and Buildings Ordinance. All fire-rated enclosure shall have fire rating meeting the requirements of the FSD and Buildings Ordinance, but shall in no case be less than 2 hours.

Take-off from main ducts shall be conical, bell mouth, or shoe type. Square take-off is not permitted.

6.1.2.3 HANGERS AND SUPPORTS

All ductwork shall be securely supported by hangers, brackets and other appropriate forms of support as detailed in DW/144:2016 - Specification for Sheet Metal Ductwork published by BESA.

All supports and hangers for air duct installed shall be rigid galvanised steel rod, angle bar or U-channel construction free from rust approved by the Supervising Officer.

All hangers shall be provided with screwed lengths drop rods with open turn buckles for adjustment of duct level. All fixings shall be provided with washers and lock-nuts and projecting ends of drop rods shall be cut off and protected with plastic caps.

All ductwork shall be securely supported so as to prevent vibrations or movements and arranged to allow expansion due to thermal stresses without distortion of the ductwork, rupture of insulation or damage to the supporting structure. Additional ductwork supports shall be positioned close to dampers, diffusers and all similar equipment which

are not subjected to distortion, in addition to those hangers and supports generally required. Allowance shall be made in ductwork construction for instrument and controls connections and adequate local stiffening shall be incorporated to provide ridge mountings.

Noise and vibration shall not be transferred to the structure or any other element through hangers and brackets and in this respect the requirements in Sub-sections regarding Noise and Vibration Control of this General Specification.

Approval shall be obtained from the Supervising Officer for the material submission, installation method statement and shop drawing of hangers and support before manufacture and installation. Furthermore, approval for the method statement including sizing and calculation of fixing to the structure shall also be obtained as this may have structural implications.

All metal mounting and fixing brackets for air ductwork shall be pre-fabricated off-site.

6.1.2.4 FLEXIBLE DUCT JOINTS

Flexible joints shall be provided on all in-line fan inlet and outlet connections, at expansion joints in the building, on the connections of ductwork between prefabricated modules, and elsewhere on ductwork where indicated. Flexible joints shall be of the same cross-sectional area as the mating fan inlet/outlet or duct section. The centre lines of flexible joint connections shall be coaxial.

For general ventilation, flexible joints shall be tested in accordance with BS 476-6:1989+A1:2009 and BS 476-7:1997 with Class 1 on surface spread of flame. For smoke extraction application, BS 476-20:1987 shall also be complied.

Under no circumstances shall materials containing asbestos fibres be used. The material used for the flexible connections shall withstand the specified conditions of temperature and air pressure, and comply with the standard of air tightness.

6.1.2.5 FLEXIBLE DUCTWORK

Where flexible ductwork is indicated, or required between rigid ductwork and items of equipment, the internal diameter of the flexible duct shall be equal to the external diameter of the rigid duct and equipment spigot. Flexible ductwork shall be kept to a minimum length and shall not be used between rigid sections of ductwork to change direction unless indicated or approved by the Supervising Officer. The maximum length of any individual flexible duct shall not exceed 2000mm unless otherwise approved by the Supervising Officer.

Joints at flexible duct connections shall be made with a sealant which permanently retains adhesion and elasticity throughout the design working temperature range, or shall be made with clip and complete with aluminium tape as approved by the Supervising Officer. The installation details and method of application of such connections shall be in accordance with the ductwork manufacturer's recommendations and as approved by the Supervising Officer.

Flexible ductwork shall be independently supported from the underside of the concrete slab. On all circular spigots, the flexible ductwork up to and including 140 mm diameter shall be secured with a worm drive type hose clip complying with BS 5315:1991. Ductwork over 140 mm diameter shall be secured with a band clip. On rectangular connections, the flexible ductwork shall be held in place by a mating flange with a backing plate, or alternatively, proprietary material may be used, in which case the metal edge shall be held in position by backing flat. Backing flat shall not be less than 3 mm thick. No flexible ductwork shall be less than 50 mm long between rigid components.

The frictional resistance to air flow per unit length of flexible duct shall not exceed 150% of the frictional resistance per unit length of galvanised steel duct of similar diameter.

The flexible duct shall be installed in as straight a manner as possible. In situations where bending is required, the bending radius shall be sufficient to prevent tensioning of the bend and restriction of the throat likely to cause deformation and/or leakage. The radius ratio R/D for bends shall be not less than 2, where R is the centre line radius and D is the diameter of the flexible duct. In no case shall flexible ductwork be used to correct misaligned ducts.

6.1.2.6 DUCTWORK ACOUSTIC TREATMENT

Where specialised acoustic attenuation is required either as in-line sound attenuator inserts or by internal duct lining acoustic treatment, these shall comply with the Sub-sections regarding Noise and Vibration Control of this General Specification.

6.1.2.7 EXTRACT HOODS AND VALANCES FOR KITCHENS

Hoods shall be of galvanised sheet steel, stainless steel, aluminium, wired glass, polyester resin-bonded glass fibre or PVC as indicated in the Particular Specification. The hoods shall be rigidly formed and shall be supported independent of the ductwork. Unless otherwise indicated, they shall be supported either from above or from a side wall. The type and size of hood shall be as indicated in the Drawing but the exact position in relation to the associated item of kitchen equipment to be covered shall be verified in consultation with the Supervising Officer. Length of ductwork between hoods and air treatment equipment shall be shortened. The ductwork arrangement shall be submitted to the Supervising Officer for approval.

Hoods for kitchen equipment and for the extraction of condensable vapours shall have all joints in sheets vertical and shall have a drip gutter all round with a drain connection plugged, unless instructed by the Supervising Officer, to run a drain to a suitable point. Hoods in high fire risk situations, such as for cooking ranges in kitchen, shall overlap the equipment by minimum 500 mm.

Stainless steel hood shall be manufactured from minimum 1 mm thick 304 or higher grade stainless steel with joints continuously welded; all external welds shall be ground and polished. All stiffening and supported shall be hidden.

The stainless steel shall be free from scale and all surfaces shall be polished to type 4 commercial (satin) finish.

Unless otherwise specified, welding of the stainless steel shall be by inert-gas arc welding to ISO 9692-1:2013.

Kitchen exhaust hood shall be completed with make-up air grilles or make-up ductwork complete with air grilles as approved by the Supervising Officer and constructed in such position for the best efficiency in evacuating exhausted fumes released during the cooking process.

Light fitting shall be provided within the hoods, fittings shall be bulkhead type with die cast aluminium base and glass diffuser to IP rating of "IP54" or better suitable for kitchen hood application. The fittings as well as the wiring for the fittings shall be suitable for continuous use of high operating conditions over 100°C temperature and 100% RH.

For kitchen hood with water scrubber, the requirement shall be in accordance with Sub-sections regarding Air Cleaning Equipment of this General Specification.

6.1.2.8 GREASE FILTER

Hoods and valances positioned over cooking appliances shall be fitted with grease filters as specified in Sub-sections regarding Air Cleaning Equipment of this General Specification.

6.1.2.9 DUCTWORK CLEANING POINTS AND ACCESS PANELS

Proprietary air duct cleaning points or access panel to the ductwork systems shall be provided for maintenance, inspection and cleaning.

Cleaning points shall in general be installed at maximum distance of 4 metres between centres in fully accessible locations and shall also be fitted before and after bends, tees and other locations with difficulties in gaining access. For fan coil units, at least one air duct cleaning point shall be provided in each supply air duct, and any two points at 4 metres maximum distance apart.

If access panels to be provided, they shall be installed at maximum distance of 15 metres between centres in fully accessible locations and shall also be fitted before and after bends, tees and dampers etc. following the requirements specified in BESA DW144 and TR19.

The maximum distance of 4 metres may be increased if the Supervising Officer considers that the ductwork system has compatible service openings which can serve the similar purposes as the air duct cleaning points. The proposed layout of air duct cleaning points and services opening in the ductwork system shall be submitted to the Supervising Officer’s approval prior to the site work.

Where the cleaning sleeve penetrates the air duct, the gap shall be sealed by an expanded foam sealing ring held in position by secure flanges. Where the sleeve penetrates the insulation, the vapour barrier shall be maintained. Where the sleeve penetrates the false ceilings, the sleeve shall be secured by matching flanges.

The cleaning sleeve shall be kept straight and shall terminate at a readily accessible position. The termination flange shall bear an instruction plate indicating an air conditioning and ventilation access point in both Chinese and English. It shall incorporate a threaded port and a screw cap which when removed shall allow the coupling of air duct inspection and cleaning probes.

Ceiling access panels requirement shall also be provided after the confirmation of service panels and air duct cleaning points.

Ductwork conveying greasy air from kitchen hoods shall be graded downward towards suitable drain points in order to facilitate drainage of water at which also is the cleaning out points.

All joints shall be air tight to prevent leakage. Air leakage for cleaning points shall comply with DW/143:2013 and all FSD requirements. A set of proprietary type compressed air lance, disinfection application lance and sampling probe which shall be suitable for use of leakage test to the cleaning points shall be provided. All operating and serving instruction manuals shall be supplied with the set of equipment.

The whole air duct installation shall be disinfected thoroughly using an approved disinfection agent immediately before the complete ductwork installation is handed over to the Employer, as directed by the Supervising Officer. Ten bottles of one litre approved disinfection agent shall be provided to the Supervising Officer before hand-over of the ductwork installation. The disinfection agent shall be easily available locally.

Interior of all ductwork shall be cleaned by rotating mechanical brush or compressed air as approved by the Supervising Officer. All contaminants shall then be removed by high efficiency vacuum pumps of sufficient degree of vacuum to ensure removal of heavier particles.

6.1.2.10 TESTING

All installed ductwork shall meet the maximum allowable air leakage limit according to Code of Practice for Energy Efficiency of Building Services Installation. The method of air leakage test shall follow Appendix A of DW/144:2016 and to the BESA standard DW/143:2013 and as directed by the Supervising Officer as necessary to prove the quality of the Installations. Air leakage testing of ductwork on any section of completed Installations shall be carried out and shall be in accordance with Appendix A of DW/144:2016 and "Method of Testing" of DW/143:2013. For those items not covered in DW/144:2016 and subject to the approval of the Supervising Officer, the recommendations of the "HVAC Duct Construction Standards-Metal and Flexible":2005 and "HVAC Air Duct Leakage Test Manual":2012 issued by the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) of U.S.A. shall be applied. Air ducts shall be leakage tested as necessary and any defects rectified before applying insulation and commissioning.

SUB-SECTION 6.1.3

AIR HANDLING EQUIPMENT

6.1.3.1 GENERAL

Fans shall be installed using galvanised steel plate, supports, bolts, nuts and washers with all "as cast" bearing surfaces for bolt heads and washers counter-faced. Anti-vibration mountings shall be in accordance with Sub-sections regarding Noise and Vibration Control of this General Specification.

Fans heavier than 50 kg shall be provided with eyebolts certified by an Authorised Person (e.g. surveyor or structural engineer) for safe working load or other purpose made lifting facilities at convenient location for fan maintenance.

Fan V-belt drives shall comply with BS 3790:2006 (or related clauses of ISO 254:2011, ISO 1081:2013, ISO 1813:2014, ISO 4183:1995, ISO 4184:1992 & ISO 5292:1995) and shall be capable of transmitting at least the rated output with one belt removed. Minimum two belts per drive shall be used for motor rated higher than 4 kW unless otherwise specified. Pulleys shall be exactly aligned.

Fan guards shall be provided for all open unprotected intakes to centrifugal fans; for unprotected intakes to and exhausts from axial flow fans; for open unprotected and easily accessible intakes to and exhausts from propeller fans; for V-belt drives; for drive couplings and elsewhere as indicated.

Flexible joint shall be provided for air duct connecting to the inlet and outlet of fans.

Air flow direction, fan designation and fan number shall be clearly marked on the fan casing.

Galvanised steel or superior materials shall be used for all supports and fixing accessories and suitable paint shall also be applied.

6.1.3.2 AIR HANDLING UNIT (AHU)

Air handling unit shall be mounted on a hot dipped galvanised I beam or U-channel mounting frame of manufacturer’s standard which is either fixed on concrete plinths by builder or ceiling mounted by suspension galvanised steel hangers. Sufficient space shall be allowed for installation of drain trap and fall of condensate drain.

For ceiling mounted air handling unit, the mounting frame and hanging rods shall be constructed to account for the operation loading of the air handling unit and the associated ducting and piping. Hanging rods shall be threaded and completed with locking nuts for level adjustment. All AHU steel supports and supporting accessories shall be hot dipped galvanised.

Neoprene pad shall be installed continuously between the air handling unit mounting frame and concrete plinth as vibration absorption media.

The routing of piping, ducting, electrical, control wiring and accessories shall be so arranged that all access panels of the air handling unit shall be free from obstruction.

Air handling unit or individual module heavier than 50 kg shall be provided with eyebolts or other lifting device approved by the Supervising Officer.

All gauges and meters other than insertion type shall not be mounted on the casing of the air handling unit to avoid breaking the thermal insulation. All such provision required for connection shall be purposely selected and mounted in the factory.

Chequer plate cover shall be provided for protecting services along the access route to the air handling unit.

6.1.3.3 AXIAL FLOW FAN

Suitable galvanised steel mounting plates or bracket provided from the same manufacturer shall be used for fixing the fan. The fans shall be mounted on anti-vibration mountings.

6.1.3.4 CEILING FAN

Unless otherwise stated, ceiling fans shall be mounted no lower than 2400 mm and no higher than 2600 mm from finished floor levels. Down rod lengths shall be sized to meet these requirements.

In case the installed ceiling fan will be lower than 2400 mm, 400 mm sweep rotary ceiling fans in accordance with Sub-section – Air Handling and Treatment Equipment of this General Specification shall be used instead.

Where ceiling heights are too high for the practical installation of ceiling fans because the rods would be too long and unstable, 400 mm or larger sweep rotary wall fixed fans in accordance with Sub-section – Air Handling and Treatment Equipment of this General Specification shall be used.

6.1.3.5 HIGH VOLUME LOW SPEED PROPELLER FAN

For high volume low speed fan, safety components shall be equipped to reduce torque transmission and prevention of accidental falling off. Guard wire shall be fixed securely from the fan motor to roofing member. Fixing details shall follow the manufacturer's recommendations. Structural calculation verified by a registered structural engineer shall be submitted for approval by the Supervising Officer.

6.1.3.6 CENTRIFUGAL FAN

For floor mounted arrangement, the fan shall be mounted on G.I. support with anti-vibration mountings and sit on concrete plinth provided by builder.

For ceiling mounted arrangement, the fan shall sit on anti-vibration mountings fixed on steel mounting frame. Threaded suspension rods with lock nuts shall be used for level adjustment.

Anti-vibration mounting shall be selected to cater for different point load of the fan at four corners.

6.1.3.7 DUCT TYPE & EXPOSED TYPE FAN COIL UNIT

6.1.3.7.1 Threaded suspension rods with lock nut and washer shall be used for ceiling mounted fan coil units for level adjustment.

6.1.3.7.2 Flexible pipe connector shall be provided for the connection to the chilled water pipe and the condensate drain pipe. When using copper pipe flare nut connection between the chilled water pipe and the unit, the installation shall comply with the manufacturer's recommended technical details and methods of installation.

6.1.3.7.3 For concealed type fan coil unit, sufficient access panels shall be provided at the supply air duct and the return air plenum for servicing the blower and duct heater. Demountable return air grille of minimum dimensions 600 mm × 600 mm can be considered as an access panel subject to the approval of the Supervising Officer.

6.1.3.7.4 Power supply shall be provided under the Works of Electrical Installation and terminated at fused connector unit with pilot light and isolation switch adjacent to each fan coil unit. Cabling from the power source (e.g. connector unit) to the control box of the fan coil unit and fan coil room remote control and accessories at convenient position including the termination shall be included under ACMV Installation works. G.I. metal boxes for housing the fused connector unit and all necessary conduit works inside ventilated ceiling or otherwise indicated shall be supplied and installed.

6.1.3.7.5 The location of the local control box shall be within 600 mm from the terminal box of the fan coil unit and the duct heater.

6.1.3.7.6 All unit shall be selected to suit the limited space within the false ceiling, with due consideration to access for maintenance and servicing.

6.1.3.7.7 Blower and motor of fan coil unit shall be demountable from the ceiling void for maintenance purpose without causing damage to the associated ductwork and insulation.

6.1.3.7.8 A second or additional larger stainless steel insulated drain pan shall be provided for those air conditioning units, evaporators of direct expansion system and alike installed in switch rooms, lift machine rooms, UPS rooms, control rooms, TBE rooms, Ozone Generator Room, Computer Room (including Server Room and Network Data Room etc.) and other essential areas sensible to water damage. A water overflow alarm indication shall be equipped at conspicuous place outside the room or connected to CCMS.

Air conditioning units, evaporators of direct expansion system and alike and its associated piping and ducting shall not be mounted above essential electrical and control equipment such as switchboard, lift machine, control panel and UPS, etc.

6.1.3.7.9 For unoccupied rooms and other areas sensible to water damage as specified, an overflow detection device shall be installed inside the drain pan or at the connection to the overflow drain pipe which fitted at the overflow level of the drain pan. Upon water accumulating in the drain pan due to malfunction of the condensate drain system, the device shall be activated to shut down the corresponding fan coil unit and trigger an overflow alarm at conspicuous place outside the room, and/or in the CCMS.

6.1.3.8 CASSETTE TYPE FAN COIL UNIT

Refer to Sub-section on Air Handling and Treatment Equipment of this General Specification.

6.1.3.9 MIXED FLOW FAN

Mixed flow fans shall be mounted on a G.I. steel support. Threaded steel rod with lock nuts shall be used for ceiling mounted purposes. Neoprene pad shall be provided.

6.1.3.10 MECHANICAL ROOF EXTRACT UNIT

Mechanical roof extract unit shall be mounted on a vermin proof hard wood sill and concrete curb provided by the Building Contractor with dimensions according to requirements of the manufacturer. All gaps between the mounting frame and structural base shall be sealed up properly.

6.1.3.11 PROPELLER FAN

Where propeller fan is mounted in a casing, the casing shall be longer than the length of the fan and motor. The casing shall be of galvanised steel or aluminium sheet or stainless steel as specified, and shall have flanged ends and an inspection door. A terminal box shall be mounted externally on the casing.

6.1.3.12 PROTECTIVELY COATED FANS AND FANS FOR CORROSIVE OR HAZARDOUS APPLICATIONS

All steel mounting brackets, bolts, washers and nuts shall be hot dip galvanised and painted with protective coatings to meet the appropriated corrosive environment.

6.1.3.13 ROTARY FAN

Refer to Sub-section 6.2.3 of this General Specification.

6.1.3.14 IN-LINE CENTRIFUGAL FAN

In-line centrifugal fan shall be mounted on G.I. steel support. Threaded steel rod with lock nuts shall be used for ceiling mounted purposes. Neoprene pad shall be provided.

6.1.3.15 ELECTRONICALLY COMMUTATED (EC) PLUG FAN

Same as requirements of centrifugal fan in this Sub-section.

6.1.3.16 JET FAN

Refer to Sub-section 6.2.3 of this General Specification.

6.1.3.17 CONDUCTING FAN

Refer to Sub-section 6.2.3 of this General Specification.

6.1.3.18 TERMINAL AIR CONTROL DEVICE

Terminal air control devices shall be mounted on a steel support. Threaded steel rod with lock nuts shall be used for ceiling mounted purposes. Neoprene pad shall be provided.

Fixture shall be installed on the steel support to govern the lateral movement of the unit.

The power supply to the unit shall refer to Clauses 6.1.3.7 of this General Specification.

Flexible duct connecting the inlet/outlet of the unit shall be fixed by omega clip or similar approved devices.

6.1.3.19 GRILLE AND DIFFUSER

Grille and diffuser shall be fixed on air duct by self-tapping stainless steel screw or purposely made spring or locking devices. When installing at high ceiling area, safety wire should be used to secure the grille or air diffuser. Fixing the grille or diffuser by self-taping screw on the face panel exposed to view shall be avoided.

For linear diffuser or special made air fittings, lifting brackets or fixing devices shall be provided to facilitate site installation.

6.1.3.20 DOMESTIC EXHAUST FAN

The installation of domestic exhaust fan shall follow the installation instruction of the manufacturer or refer to the contract drawings. All domestic fans shall be protected with safety guard.

SUB-SECTION 6.1.4

AUTOMATIC CONTROL

6.1.4.1 AUTOMATIC CONTROL SYSTEM (ACS)

The Automatic Control System (ACS) is the Master Control of a building that controls and monitors the proper, effective and efficient operation of the Air-conditioning and other Building Services System(s) in building(s). An ACS can be a part of the Central Control and Monitoring System (CCMS), refers to Sub-section 6.1.5 or as simple as an electronic controller with built-in real time clock for scheduling controls. The appropriate ACS shall be designed under this Works to meet the requirements and operation needs of the building operation and management team and the operation requirements of the end users in building(s). As different equipment and systems may have different operation schedules, the ACS shall have adequate capacity for scheduling all the operation needs.

The ACS described below shall be applied to buildings completed with Air-conditioning and other Building Services System(s), with or without CCMS for the normal operation and control of the systems installed in the buildings if so specified. The main function of an ACS is for on/off controls, optimisation, monitoring of operation status and alarms generation of the connected systems in building(s). Comprehensive system controls and monitoring functions of each individual system shall be carried out by the system controller of each individual air conditioning, building services or E&M system. The ACS shall achieve a reliable control in performing the control and monitoring functions set in the design criteria and shall be of electronic or direct digital control type as specified. Unless otherwise specified, the ACS controller shall be located inside the A/C Supervisory Control Panel.

6.1.4.1.1 Electronic Controller with Micro-processor and REAL Time Clock Control

With the application of micro-processor and real time clock, all building services systems specified shall be turned on and off in accordance with the time schedules pre-set in the built-in program so required by the users. A monitoring and alarm system shall be incorporated in the controller in giving audio and visual status and alarm of faults for each building services system in the building.

For easy programming, user friendly input/output (I/O) devices shall be provided for the setting and re-setting of the operation schedules. To prevent malfunctioning of the real time clock and losing of memory, uninterrupted power system with power healthy indicator and alarm shall be provided.

6.1.4.1.2 Direct Digital Controller (DDC)

(a) Each controller shall operate as a standalone unit capable of performing its specified control responsibilities independently from other controllers in the network.

(b) Portable operator's terminals shall be provided for local viewing and operation.

(c) Power Failure Protection – All system set point, control algorithm and other programmable parameter shall be stored such that power failure of any duration does not necessitate reprogramming the DDC controller.

(d) The DDC controller resident software features shall comply with the following: -

(i) Energy Calculation – refers to Clause 6.1.5.5.8

(ii) Duty Cycle – refers to Clause 6.1.5.5.9

(iii) Power Demand Monitoring / Load Shedding – refers to Clause 6.1.5.5.10

(iv) Optimum Start Time – refers to Clause 6.1.5.5.11

(v) Supply Air Reset – refers to Clause 6.1.5.5.12

(vi) Chilled Water Optimisation – refers to Clause 6.1.5.5.13

6.1.4.1.3 Control of Chiller Plant

(a) General

(i) Controllers

Built-in micro-processor based electronic controller or DDC for each chiller plus a micro-processor based electronic controller or DDC for chiller plant Sequential/Step/Interfacing controls. (for chillers and chilled water pumps controls and interfacing with ACS and other system controllers)

(ii) Start – Stop Control

Make provision for the following control functions unless otherwise specified in the Particular Specification or Drawings: -

- Manual on/off (maintenance/manual mode);
- On/off by the Automatic Control System as scheduled; and
- On/off by special demand overriding the pre-set schedule for dehumidification and/or cooling during night purging or other special duty cycles as specified.

(iii) Faults and Abnormal Operation Controls and Monitoring by the Chiller Controller

- High condenser pressure;
- Low refrigerant pressure/temperature;
- High motor temperature;
- Motor overload;
- Low oil pressure;
- Low oil sump temperature;
- High oil sump temperature;
- Chilled water flow interlocked;
- Condenser water flow interlock (water cooled only);
- Back-up for the low chilled water temperature controller (if required by the chiller manufacturer); and
- Plus other items as specified or recommended by the chiller manufacturer.

(iv) Fault Surveillance

Fault surveillance and safety controls of chiller shall be carried out by the built-in electronic controller or DDC of the chiller. Interfacing shall be provided for communication between the built-in chiller controller and the chiller plant controller. Interfacing system shall also be provided for the chiller plant controller in receiving operation instructions from the ACS and sending out chiller status and alarm signals to the ACS and the A/C Supervisory Control Panel.

(v) Energy Conservation

If specified in the Particular Specification or Drawings, sufficient control provision shall be allowed in the chiller controllers for the proper operation of the following energy systems: -

- Heat recovery condenser for the supply of heat source as specified;

- Cycling of condenser fans by head pressure control for energy saving;

- Variable Speed Drive for chiller. The application of electronic speed controller in maintaining higher chiller energy efficiency at partial load operation; and

- Reset of supply chilled water temperature to optimise the chiller energy efficiency.

(b) Single Chiller

(i) Capacity Control

Make provision for the following control functions plus other special requirements specified in the Particular Specification or Drawings:-

- Chiller output capacity modulated to maintain the pre-set supply or return chilled water temperature (after mixing with the by-pass); and

- The chiller controller shall modulate its refrigeration capacity to meet the cooling load demand in the chilled water circulation system.

(c) Multiple Chillers in Parallel

(i) Capacity Control

Make provision for the following control functions plus other special requirements specified in the Particular Specification or Drawings: -

- Built-in controller of each chiller modulates output capacity to maintain a constant supply chilled water temperature pre-set at the outlet of each operating chiller; and

- The Chiller Plant Controller shall control the sequencing of chillers and cut-in or cut-out a chiller in accordance with the return chilled water (with by-passed chilled water well mixed) temperatures pre-set in the controller. The sequencing logic shall be as follows: -

    - Chiller that has run longest since last start is first to stop;
    - Chiller that is idle for the longest time is first to start; and

- Chiller(s) in manual or maintenance mode shall be by-passed from the automatic sequencing control operation.

(d) Make provision of monitoring and Alarm Signals to ACS and the A/C Supervisory Control Panel

Other special requirement as specified in the Particular Specification or Drawings.

6.1.4.1.4 Control of Chilled Water Pumping System (by chiller plant controller)

Unless otherwise specified in the Particular Specification or the Drawings, chilled water control system shall perform the following: -

(a) Circulation Pumps with Differential Pressure By-Pass

(i) For a single chiller system, the duty chilled water pump shall be operated as long as the system is in operation mode. During partial load condition, excessive chilled water supply shall be by-passed by the differential pressure by-pass valve and hence lower the system return chilled water temperature. Dropping of the return chilled water temperature shall then call for refrigeration capacity control in the chiller. There is possibility that the cooling load demand is so low that the chiller will be cut off and at idle condition for a period of time. However it is important to keep the chilled water pump to run continuously for sensing the correct chilled water temperature. The pump shall only be cut-off when the chiller plant is turned off by the ACS;

(ii) For a multiple chiller system, the number of chillers put into operation and chiller refrigeration capacity controls shall be in accordance with the system return chilled water temperature, which is affected by the amount of chilled water by-passed by the differential pressure by-pass valve. Each chilled water pump shall be operated in accordance with its associated or delegated chiller. The delegated chilled water pump shall be cut-in earlier than the chiller in order to maintain the chilled water flow required for the chiller operation. The same logic of leaving at least one chilled water pump to operate for monitoring the chilled water temperature shall be applied; and

(iii) Manual on/off for pumps (maintenance/manual mode).

(b) Primary and Secondary Pumps (Decoupled) System

In a typical decoupled pumping system, the primary pumps are of constant flow and the secondary system can be of all variable flow pumps or a combination of constant and variable flow pumps. Exact configuration shall refer to the Particular Specification or the Drawings.

(i) Primary chilled water pump

Primary chilled water pump shall be of constant flow type, which shall be operated with time leading its associated or delegated chiller and cut-out when the associated chiller is turned off. When a reverse flow is detected in the by-pass, an additional chiller shall be cut in and when the by-pass flow is greater than the designed full capacity flow rate of a chiller, an operating chiller shall be cut off. The associated primary chilled water pumps shall then be operated in the same arrangement. The logic of keeping at least one pump operated in the primary circuit (when the system is in operation mode) is still valid.

(ii) Secondary chilled water pumps

Secondary chilled water pumps shall be operated to meet the flow demand at the load side. Discharge head pressure or differential pressure control (across supply and return mains of the secondary loop) shall be used to monitor the flow demand. The secondary pumps (no matter constant or variable flow) shall be operated in such a configuration that a constant chilled water supply pressure (i.e. in proportion to the amount of chilled water supplied) is maintained and hence meets the chilled water flow demand.

For a system with constant and variable flow pumps, the constant flow pump(s) shall only be operated as long as the demand flow is greater than the full capacity of that constant flow pump. The variable speed pump shall always be operated first to handle any partial load demand for energy saving.

(iii) Manual on/off for all pumps (maintenance/manual mode)

(c) Variable Primary Flow System

In a typical variable primary flow system, variable flow pumps shall be used in conjunction with chillers that adaptable to variable flow. The number and capacity of pumps normally match with the capacity of chillers but not necessarily. Exact configuration shall refer to the Particular Specification or the Drawings.

(i) Chilled water pumps shall be operated to maintain a pre-set differential pressure at a specific point in the system. Whenever the control valves of air terminal units open with an increase in cooling demand, the pressure tends to decrease. The variable speed drive of the pumps in operation shall be increased in such a configuration that a constant chilled water pressure difference between supply and return is maintained;

(ii) When the chilled water demand flow reduces with the system load to a low load condition that the minimum evaporator flow limit of the operating chiller, the modulating valve in the bypass pipe shall be opened to deliver the water necessary to maintain the minimum flow of the chiller; and

(iii) Manual on/off for pumps (maintenance/manual mode).

(iv) Other alternative control methods shall be considered subject to the approval of the Supervising Officer.

(d) Make provision of monitoring and Alarm Signals to ACS and the A/C Supervisory Control Panel

Other special requirement as specified in the Particular Specification or Drawings.

6.1.4.1.5 Control of Cooling Towers and Condenser Water System (by condenser plant controller)

Micro-processor based electronic controller or DDC for Condenser Water Plant Sequential/Step/Condenser Water Temperature By-Pass/ Cooling Tower Fans Cycling/Interfacing controls. (for condenser water plant controls and interfacing with the chiller plant controller and ACS)

(a) Start-stop Control

Condenser water pumps shall be interlocked with their associated water-cooled chillers and shall be started in advance and turned off after their associated chillers.

(i) Manual on/off (maintenance and manual mode) Condenser water pumps on/off are interlocked with the chiller plant, which is started /stopped by the ACS as scheduled.

(ii) Cooling towers and their associated control valves shall be opened for the reticulation of condenser water.

(iii) Once the condenser water plant is turned on, its ancillary equipment such as water treatment plant, condenser water

filtration and cleansing devices shall be energised accordingly.

(iv) For cooling tower system installed with multiple cooling towers and/or standby cooling tower(s), sequence control shall be provided to allow each cooling tower to be operated at least one hour per week.

(b) Capacity Control

(i) For energy saving, variable speed fans shall be used in cooling tower to maintain the supply condenser water temperature entering the chillers at the designed value.

(ii) If the supply condenser water temperature drops below the pre-set value even with all the cooling tower fans cut off, the temperature by-pass valve shall be modulated to by-pass condenser water leaving the chillers from entering the cooling tower but to mix with the condenser water supply.

(iii) For a system with variable flow pumps, the speed of pumps shall be adjusted by the temperature of condensing water leaving the chillers or maintaining a designed temperature difference between condensing water supply and return to chillers. The water flow shall be reduced with decreasing cooling demand and hence the heat rejection capacity, while the minimum condensing flow limit shall be satisfied at all time.

(iv) Other alternative control methods shall be considered subject to the approval of the Supervising Officer.

(c) Faults and Abnormal Operation Controls and Monitoring by the Condenser Water Plant Controller

(i) High condenser water temperature.

(ii) Extra high condenser water temperature. (chillers to be cut off one by one if so specified)

(iii) Low water level of cooling towers.

(iv) Faults of cooling tower fans.

(v) Faults of condenser water pump. (associated chiller to cut off)

(vi) Faults of water treatment plant(s).

(vii) Faults of condenser water filtration and cleansing equipment.

(viii) Plus other items as specified or recommended by the condenser water plant manufacturer.

(d) Make Provision of Monitoring and Alarm Signals to ACS and the A/C Supervisory Control Panel

Other special requirement as specified in the Particular Specification or Drawings.

(e) For chemical dosing control for Water Quality in cooling tower, please refer to Clause 6.1.4.6.

6.1.4.1.6 Control of Primary Air Handling Unit (PAU)

Micro-processor based electronic controller or DDC as specified shall be used for the control of the PAU, its associated equipment and the interfacing and communication with the ACS and its associated zone AHUs, FCUs, etc. The following functions shall be provided unless otherwise specified: -

(a) Start-stop Control

(i) Automatic fire tripping as specified or required by the FSD;

(ii) Manual on/off control (maintenance/manual mode);

(iii) On/off control by the ACS as scheduled;

(iv) On/off controls by special demand overriding the pre-set schedule for dehumidification and/or cooling during night purging or other special duty cycles as specified;

If so specified in the Particular Specification or the Drawings, the demand control function in sub-clause (v) below shall be adopted; and

(v) Demand on/off control. The operation of any AHU/ FCU served by the unit shall energise the PAU. Unit will only be cut-out when all associated AHUs/FCUs are turned off or the whole system is turned off by the ACS as scheduled.

(b) Capacity Control

(i) For constant air flow design

Constant flow, full capacity at all the time during operation.

(ii) For variable air flow design

- Air flow modulated by variable speed drive in order to reduce the indoor CO_2 level within the specified range (applicable for single zone system only); and

- Air flow modulated by variable speed drive to maintain the pre-set static pressure at the main supply air duct. Amount of fresh air supply to each zone shall be controlled by motorised damper, which is modulated to reduce the indoor CO_2 level at that particular zone to be within the range specified (applicable for multi-zone system).

(c) Temperature and Relative Humidity Control

(i) Temperature Control

- Cooling (outdoor air temperature higher than the pre-set value)

  If the supply air temperature rises above the pre-set upper temperature, chilled water flow through the cooling coil of the PAU shall be increased by a modulating valve and vice versa when the supply air temperature drops below the pre-set lower temperature. The controller shall respond to modulate the control valve in maintaining the pre-set supply air temperature.

- Heating (outdoor air temperature lower than the pre-set value)

  The supply air temperature is maintained within the range specified by modulating the control valve and hence regulating the amount of hot water (for space heating) from entering the heating coil of the PAU or for electric heating by staging of electric heaters to maintain the supply air temperature specified.

(ii) Humidity Control

- Dehumidification (when the outdoor air enthalpy/moisture content is higher than the pre-set cut-in value)

  Despite of the PAU is in cooling mode or heating mode, the humidistat shall modulate the chilled water control valve to open for dehumidification until the humidity condition of the outdoor air drops below the pre-set cut-out value. If the supply air temperature drops below the lower limit due to

the dehumidification process, the hot water coil or electric heaters shall be actuated for re-heating.

If so specified in the Particular Specification or the Drawings, the dehumidification process shall be carried out by a separate dehumidification system installed at the fresh air intake section.

- Humidification (outdoor air relative humidity lower than the pre-set value)

  Humidification process is not taken place in the PAU. If the room humidity condition at the space inside the building is lower than the value specified, humidification by means of steam or water spray humidifier shall be operated at the relevant AHUs. For fan coil system, individual room/zone humidifier or system shall be used as specified.

(d) Filters and Air Cleaners

Controller of PAU shall also control the proper operation of its ancillary equipment such as automatic air filter, air cleaner, air steriliser, etc. Unless otherwise specified, the following alarm signals shall be sent to the A/C Supervisory Control Panel:-

(i) Filter clog alarms;

(ii) Filter detached from filter chamber;

(iii) Time for replacement of absorption filters; and

(iv) Status and fault alarms of air cleaner & steriliser.

(e) Make provision of monitoring and Alarm Signals to ACS and the A/C Supervisory Control Panel

Other special requirement as specified in the Particular Specification or Drawings.

6.1.4.1.7 Control of Air Handling Unit (AHU)

Micro-processor based electronic controller or DDC as specified shall be used for the control of the AHU and its associated equipment and the interfacing and communication with the ACS and its associated zone terminal, VAV units, etc. The following functions shall be provided unless otherwise specified: -

(a) Start-Stop Control

(i) Same as Clause 6.1.4.1.6(a).

If so specified in the Particular Specification or the Drawings, the demand control function in sub-clause (ii) below shall be adapted; and

(ii) Demand on/off control. The operation of any VAV unit served by the unit shall energise the AHU. Unit shall only be cut-out when all associated VAV units are turned off or the whole system is turned off by the ACS as scheduled.

(b) Capacity Control

(i) For Constant Air Volume System

Single zone constant volume; full flow capacity to a single zone at all the time during operation (applicable for single zone system only); and

Multi zone constant volume, the amount of air supplied to each zone is still constant. However zone reheater shall be provided at each zone for temperature control (applicable for multi zone system).

(ii) For Variable Air Volume System

Airflow modulated by variable speed drive to maintain the pre-set static pressure at the main supply air duct. Amount of air supplied to each zone shall be controlled by motorised damper of each VAV unit. The VAV damper shall be modulated to open or close in order to maintain the room temperature/supply air flow rate to be within the range specified.

(c) Temperature and Relative Humidity Control

(i) Temperature Control for Constant Air Volume Systems

- Cooling

If the room air temperature rises above the pre-set upper temperature, chilled water flow through the cooling coil of the AHU shall be increased by opening the modulating valve and vice versa when the room air temperature drops below the pre-set lower temperature. By modulating the control valve, chilled water flowing through the cooling coil of the AHU shall be regulated to meet the cooling demand load.

- Heating

  The room air temperature shall be maintained within the range specified by the control valve and hence the amount of heating hot water from entering the heating coil of the AHU or by staging of electric heaters to maintain the room air temperature specified.

(ii) Temperature Control for Variable Air Volume Systems

Unless otherwise specified, the supply air temperature at the discharge of a variable air volume AHU shall be maintained at a pre-set value by controlling the flow of chilled/hot water entering the cooling/heating coil. Space/room temperatures shall be controlled by the VAV units as described in Clause 6.1.4.1.8 (b).

(iii) Humidity Control

- Dehumidification (indoor air relative humidity higher the pre-set value)

  Despite of the AHU is in cooling mode or heating mode, the humidistat shall modulate the chilled water control valve to open for dehumidification until the relative humidity of the room air drops below the pre-set cut-out value. If the room air temperature drops below the lower limit, the hot water coil or electric heaters shall be actuated for re-heating.

  If so specified in the Particular Specification or the Drawings, the dehumidification process shall be carried out by a separate dehumidification system installed at the air handling system.

- Humidification (indoor air relative humidity lower than the pre-set value)

  If the room relative humidity at the space inside the building is lower than the value specified, humidification by means of steam or humidifier shall be provided at the relevant AHUs as specified.

(iv) Temperature Display

LCD or 7-bit segment (self-illuminated) digital display of the room temperature thermostat within readable size from three metres apart at the appropriate locations inside the air-conditioned areas shall be provided. Temperature

display shall be setting up in steps not coarser than 0.5K. Numbers of the display units shall be in accordance with the air-conditioning layout design and to be specified in the Particular Specification.

(d) Fresh Air Supply Control

CO_2 sensor at return air of AHU shall be used to modulate the fresh air intake damper. Sufficient amount of fresh air shall be sucked in to reduce CO_2 level at all zones to be within the range specified. If so specified, a minimum amount of outdoor air supply shall be maintained for the proper pressurisation of the air-conditioned areas.

(e) Filters and Air Cleaners/Sterilisers

Same as Clause 6.1.4.1.6 (d).

(f) Make provision of monitoring and Alarm Signals to ACS and the A/C Supervisory Control Panel

Other special requirement as specified in the Particular Specification or Drawings.

6.1.4.1.8 Control of Zone Air Distribution Units

(a) Fan Coil Unit (FCU)

Unless otherwise specified, controller for FCU shall be of micro-processor based electronic type or DDC type as specified. Backup battery shall be provided for all programmable controller and controller with real time clock. Unless otherwise specified, the control functions listed below shall be performed by the controller:-

(i) Start-stop control

- Automatic fire tripping as specified or required by the FSD. Automatic reset is required once the fire signal is clear;

- Manual on/off control by the three-speed controller;

- c/w space temperature sensor; and

- Automatic on/off control by ACS as scheduled plus manual override control located at management office or other location as specified (for public areas, corridor, etc.).

If so specified in the Particular Specification or the Drawings, the following control function shall be adopted.

Automatic on/off control by Occupancy Detector (dual mode) plus manual override control by three-speed controller c/w space temperature sensor.

(ii) Temperature Control

- Cooling

  Motorised on/off control valve shall be turned on and off to maintain the room temperatures pre-set in the controller. Chilled water shall only flow through the cooling coil of the FCU when the FCU is turned on and the control valve is opened.

- Heating

  When the controller is set to the heating mode, the electric heater shall be turned on and off to maintain the room temperatures set in the controller. If hot water heating is used, a motorised on/off control valve shall be turned on and off to maintain the room temperatures set.

- Temperature Display

  LCD or 7-bit segment (self-illuminated) digital display of the room temperature thermostat within readable size from three metres apart inside the air-conditioned areas shall be provided. Temperature display shall be setting up in steps not coarser than 0.5K.

(iii) Fresh Air Supply Control

For a variable volume primary air supply system, a zone CO_2 sensor shall be used to control a modulating damper, which will increase or decrease the amount of fresh air supply from the PAU to a FCU or a group of FCUs in the same control zone. The motorised damper shall be modulated to reduce CO_2 level to be within the range pre-set. If so specified in the Particular Specification, a minimum amount of fresh air supply shall be maintained when individual FCU or any zone FCU is switched off. A separate electronic controller or DDC instead of the FCU controllers shall be used for the control of this fresh air modulating system.

(iv) Monitoring & Alarm Control

Unless otherwise specified, the following controls shall be incorporated in the controller of each FCU and signals and alarms shall be sent to the zone or main supervisory control panel as specified:-

- Filter clog alarms;

- Overheat of electric heater; and

- Room temperature outside upper and lower limits pre-set.

(b) Variable Air Volume (VAV) Unit

Controller for all types of VAV units shall be of micro-processor based electronic type or DDC type as specified. Backup battery shall be provided for programmable controller and controller with real time clock. Unless otherwise specified, the control functions listed below shall be performed by the controller:-

(i) Start-Stop Control

- Automatic fire tripping as specified or required by the FSD. Automatic reset is required once fire signal is clear;

- Manual on/off control by user; and

- Automatic on/off control by ACS as scheduled plus manual override control located at management office or other location as specified (for public areas, corridor, etc.).

If so specified in the Particular Specification or the Drawings, the following control function shall be adopted.

Automatic on/off control by Occupancy Detector (dual mode) plus manual override control.

(ii) Temperature Control

- Cooling

Unless otherwise specified, pressure independent type VAV units shall be adopted.

- Pressure Independent Type

The room temperature sensor shall send signal to the controller, which works together with the supply air flow measuring device and shall actuate the motorised modulating control damper to supply the designed amount of cooled air required in maintaining the room temperature pre-set. With the installation of the air flow measuring device, adjustment of the supply air quantity shall not be affected by the fluctuation of the supply air pressure at the distribution air duct and be well within the design limits. There shall also be a minimum open position in the control damper to maintain the minimum air movement and fresh air to the room. If the room temperature continues to drop when the damper is already at its minimum open position, reheat or supply temperature reset is required as specified.

- Heating / Reheating (for VAV units with heating and reheating)

  The electric heater shall be turned on and off to maintain the room temperatures and humidity set in the controller. If hot water heating is used, motorised control valve shall be turned on and off to maintain the room temperatures set.

- Temperature Display

  LCD or 7-bit segment (self-illuminated) digital display of the room temperature within readable size from three metres apart inside the air-conditioned areas shall be provided. Temperature display shall be as described in 6.1.4.1.7(c)(iv) and the numbers of the display unit required are to be specified in the Particular Specification.

(iii) Fresh Air Supply Control

Fresh air supply control is generally carried out in the AHU. If so specified, zone CO_2 sensor shall be installed to send a signal to the room VAV unit(s) for higher supply air quantity (i.e. more fresh air in proportion). Excessive cooling effect shall be offset by reheating or reset of supply air temperature in the AHU.

(iv) Monitoring, Alarm and Other Controls

Unless otherwise specified, the following controls shall be incorporated in the controller of each VAV unit and signals and alarms shall be sent to the zone or main supervisory panel as specified:-

- Flow sensor clog alarm (flow detected beyond limits);

- Overheat of electric heater;

- Room temperature outside upper and lower limits set; and

- Part load signal to the AHU for supply air temperature reset.

(v) Communication with the ACS / CCMS Server

Each box controller shall communicate individually with the central processing unit. Should any part or all of central system experience downtime, each and all of the boxes shall maintain room control with the set point residing within the individual room controller.

Two-way communication to the central system shall be provided for setting the following functions: -

- Fan operating point – resettable from Server

- Cooling set point – resettable from Server

- Room Temperature;

- Supply ductwork velocity;

- Minimum velocity setting – resettable from Server

- Maximum velocity setting – resettable from Server

- Night setback command – resettable from Server; and

- Damper position

6.1.4.1.9 Ventilation System Control

(a) Toilet Exhaust System

(i) Start/stop

- Automatic fire tripping as specified or required by the FSD. Automatic reset is required once fire signal is clear.

- Manual on/off (for manual operation and maintenance) plus

- On/off by ACS as scheduled; or

- On/off interlocked with lighting of the room if specified.

(ii) Capacity Control

Unless otherwise specified, constant exhaust air flow rate.

(b) Printer Room Exhaust System

Same as Clause 6.1.4.1.9 (a).

(c) Plant Room Ventilation System

(i) Start/stop

- Manual on/off (for manual operation and maintenance) plus

- On/off by ACS as scheduled; or

- On/off by thermostat or other local sensing devices as specified.

(ii) Capacity Control

Unless otherwise specified, constant exhaust air flow rate.

(d) Car Park Ventilation System

(i) Start/stop

- Automatic fire tripping as specified or required by the FSD.

- Manual on/off (for manual operation and maintenance) plus

- On/off by ACS as scheduled; or

- On/off or modulated by zone CO and/or NO2 sensors as specified.

(ii) Capacity Control

- Constant air flow rate;

- Variable air flow by staging of multi-fans; or

- Variable airflow by variable speed fans.

Unless otherwise specified, all demand ventilation systems using CO/NO2 sensors shall be equipped with variable speed fans for energy saving.

(e) Make Provision for the Monitoring and Alarm Signals to ACS and the A/C Supervisory Control Panel

Other special requirement as specified in Clause 6.2.4.5.54 of this specification or the Particular Specification or Drawings.

6.1.4.2 AIR COOLING CONTROL

6.1.4.2.1 Control valves used for heating or cooling circuits shall be provided with an isolating valve on each port. The isolating valve on the by-pass port being of the double regulating type to enable regulation such that the pressure drop through the by-pass can be set to equal to that through the cooling coils.

6.1.4.2.2 The control valves shall be quiet in operation.

6.1.4.2.3 All valves shall operate in sequence with another valve when required by the sequence of operations.

6.1.4.2.4 All control valves shall be suitable for the system flow conditions and close against the differential pressures involved.

6.1.4.3 AIR HEATING CONTROL

6.1.4.3.1 Control valves used for heating or cooling circuits shall be provided with an isolating valve on each port. The isolating valve on the by-pass port shall be of the double regulating type to enable regulation such that the pressure drop through the by-pass can be set to equal to that through the heating coils.

6.1.4.3.2 Electric air heaters shall be energised in three phase-balanced stages not exceeding 6 kW per three-phase stage. Single-phase stages shall not be more than 2 kW each. There shall be a time lag of not less than five seconds between successive stages on demand for heating.

6.1.4.3.3 Arrangements shall generally be such that in the event of electrical supply failure, or after normal shut down, the control system will recycle to the "OFF" position. Unless otherwise specified, the control sequence shall start automatically.

A vane or differential pressure switch wired in series with the high limit temperature cut-outs shall also be provided to switch off the heater in the

event of a fan or other failure. Any cut out on these items shall require to be manually reset.

6.1.4.3.4 The control valves shall be quiet in operation.

6.1.4.3.5 All valves shall operate in sequence with another valve when required by the sequence of operations.

6.1.4.3.6 All control valves shall be suitable for the system flow conditions and close against the differential pressures involved.

6.1.4.4 ELECTRICAL/ELECTRONIC (LOCALISED) CONTROL SYSTEM

6.1.4.4.1 The systems shall be operated at single-phase mains voltage or at extra low voltage such as 12 or 24 V as indicated in the Particular Specification.

6.1.4.4.2 Where a particular manufacturer's system is offered and accepted, the Installations shall be installed to comply with that manufacturer's recommended technical details and methods of installation.

6.1.4.5 CHEMICAL DOSING CONTROL FOR WATER QUALITY IN COOLING TOWER

6.1.4.5.1 The chemical dosing system shall perform the following functions: -

(a) Monitor the water quality by residual chlorine sensor, pH sensor, conductivity sensor, oxidation reduction potential (ORP) probe and turbidity sensor;

(b) To control the amount of bleed-off water by actuating the motorised control valve to maintain the conductivity and turbidity at pre-set range and provide high /low level alarm;

(c) Conduct auto-dosing of chemicals to maintain the pH value, residual chlorine content and ORP at pre-set ranges range and provide high /low level alarm;

(d) Automatically switch to timer control of auto dosing of chemicals when dosing pumps not running for a pre-set period;

(e) Provide manual control of chemical dosing under abnormal situation; and

(f) Interfacing with the CCMS to perform real-time monitoring of the required parameters. Status, warning alarm and trend log shall be available at remote station through CCMS or IoT connection.

6.1.4.5.2 The bleed-off control and the chemical dosing control shall be interlocked to avoid performing bleed-off and chemical dosing at the same time.

6.1.4.5.3 The system shall be interfaced with CCMS with trend log object achieving package as follows: -

(a) Data of the monitored object shall be recorded upon Change of Value (COV) subscription or periodic poll as specified.

(b) Periodic polled data shall be continuously and real time generated in pre-set time interval, normally 15-minute interval and able to be set down to 5-minute interval.

(c) Data as required in the Schedule of functions shall be backed up and stored permanently on the historian server in CCMS. The server shall have a storage size capable for storing a minimum of 36-month data period.

(d) All required trend data could be automatically recorded and uploaded on a periodic basis without operator intervention.

(e) The database of the historian server shall have full functions enabling pruning and deleting individual trends.

SUB-SECTION 6.1.5

CENTRAL CONTROL AND MONITORING SYSTEM (CCMS)

6.1.5.1 GENERAL REQUIREMENTS

6.1.5.1.1 Complete Building Automation System

The system shall perform the general functions for ACMV installation and shall incorporate the facilities for developing other building automation systems, such as automatic fire alarm, automatic security and access control in future without replacement of existing equipment. Energy Management is an integral part of the CCMS; other management functions that include self-diagnostics, maintenance and facilities shall also be made available for future connection. Unless otherwise specified in the Particular Specification, a central uninterrupted power supply (UPS) with suitable capacity not less than 60 minutes shall be equipped for the CCMS.

6.1.5.1.2 Coordination with Other Parties

Technical support shall be provided as instructed by the Supervising Officer to deliver the CCMS with all input/output object details as well as virtual objects for the completion of the system with all source codes to the maintenance counterpart for the completion of system integration and data exchange.

Coordination meetings as requested by the Supervising Officer for the purpose of setting up the integration of other building automation systems at remote site and data exchange shall be attended.

6.1.5.1.3 Submittals and Deliverables

Submittals

(a) Working drawings shall be prepared in AutoCAD software of A0 or A1 size, unless otherwise specified.

(b) Working drawing submissions shall include a block diagram depicting locations of all controllers and workstations with associated network wiring.

(c) Working drawing submissions shall also include schematic diagrams for ACMV installations indicating all connected points with reference controllers. Details and typical installation shall be shown.

(d) Manufacturer's data on all hardware and software products shall be indicated clearly with relevant BACnet Testing Laboratory (BTL) Listing and Protocol Implementation Conformation Statement (PICS). Other equipment such as valve, damper and

airflow stations shall be shown with size, configuration, capacity and location of fixing.

(e) Software submittals shall be detailed with description of sequences of operation, program listings, point lists and the Graphic User Interface (GUI), pre-set report types, alarms and events configuration to be furnished with the CCMS software.

(f) All licenses of software and firmware installed for the CCMS under this Contract.

(g) Operation and maintenance manual together with rewritable storage media shall be submitted to the Supervising Officer in accordance with the Contract requirement.

(h) All documentations, software, firmware and hardware, shall become the property of the Government upon substantial completion. Perpetual right to disseminate such information to third parties shall be granted to the HKSAR Government.

6.1.5.1.4 System Clean up

Upon completion, all equipment pertinent to installation shall be checked and cleaned. Such cleaning shall extend to the exposed surfaces of tubing, hangers and other exposed metal of grease, plaster and other areas around the equipment.

6.1.5.1.5 System Start-up & Commissioning

Upon complete installation prior to put into operation, the following works shall be carried out with satisfactory results: -

(a) All equipment shall be calibrated and the transmission media operation shall be verified before the system is put into operation. The work shall include testing for both hardware and software functionality of each point in the system as well as the sequence of operation of ACMV sub-systems under the CCMS control;

(b) Commissioning shall be carried out that includes field testing, calibrating and adjusting and set in operating conditions for all major installations such as chilled water, hot water and all air handling systems under the direction of the manufacturer or its authorised representatives; and

(c) Operation parameters and control settings shall not be modified without notification to the Supervising Officer.

6.1.5.1.6 Operation and Maintenance Manual

Operation and maintenance manual together with CAD CD Rewritable shall be submitted to the Supervising Officer in accordance with the Contract requirement: -

(a) All details essential for operation, maintenance, replacement, installation and parts procurement for the system;

(b) Specific part numbers and software versions and dates together with a complete list of spare parts;

(c) Relevant as-built drawings, test certificates and commissioning records;

(d) A copy of all application software both in written form and on diskette;

(e) Step-by-step system recovery procedures for system re-start up after fatal breakdown. Such procedures shall be properly demonstrated to the Supervising Officer's Representatives during the Testing & Commissioning. Any engineering tools required for system re-start shall be supplied together with the System; and

(f) All passwords to initiate functioning of the complete CCMS to initial start-up and to work after any modification or reprogramming.

6.1.5.1.7 Adequate training shall be provided to the operators for the day-to-day operation and routine maintenance. Unless otherwise specified, the training shall include both on-site and classroom courses with training handouts/manuals to the designated personnel, details as follows: -

(a) On Site Training

It shall consist of a minimum of 30 working days of hands-on instruction geared at the operation and maintenance of the systems. The activities shall include:-

(i) System overview;

(ii) System software and operation;

(iii) Operation sequences including start-up, shutdown, adjusting and balancing;

(iv) Equipment maintenance; and

(v) Data logging and Alarm reporting.

(b) Classroom Training

It shall contain a comprehensive understanding of the hardware and software course materials covering workstation operation and controller programming. The number of attendance and period shall be agreed with the Supervising Officer and shall not be less

than two weeks, unless otherwise specified in the Particular Specification.

6.1.5.1.8 Warranty

(a) During the Maintenance Period, all services, materials and equipment necessary for proper operation of the system shall be provided.

(b) All necessary revisions to the software as required to provide a complete and operable system being consistent with the sequence of operations shall be included. All updates to the manufacturer's software shall bear no extra costs.

6.1.5.2 SYSTEM ARCHITECTURE

6.1.5.2.1 Network and Server

It shall be either a single network or a hierarchical system architecture that may be a multi-user computer system to allow remote access as specified in the Particular Specification. The system shall comprise central and satellite operator workstations, controllers, gateway/interfacing units, communication network for signal/data transmission among controllers and various floor level support hardware to form a true "Distributed Intelligence Techniques".

The system shall base on a BACnet four-layer collapsed architecture that corresponds to the physical, data link, network, and application layers of the Open System Interconnection (OSI) - Basic Reference Model. Connection shall be made possible via BACnet/IP, BACnet MS/TP and other standard BACnet network protocols.

The system shall be able to segment through software into multiple local area networks distributed over a wide area network with self-operated building controllers and communicate with other controllers on the network via a network controller unit, if necessary. The workstations, controllers and servers shall be able to use standard network components to utilise the existing network and/or structural cabling system.

6.1.5.2.2 Open Communication Protocol

The BACnet open communication protocol refers in this Specification shall mean the compliance of the following: -

(a) Data of the monitored object shall be recorded upon Change of Value (COV) subscription or periodic poll as specified.

(b) All products, include but not limited to CCMS servers, workstations, Network controller units (NCUs) and Direct Digital Control (DDC) controllers, shall conform to ANSI/ASHRAE Standard 135-2016 and ISO 16484-5:2017. The products shall be

listed with BACnet Testing Laboratory (BTL) and truly open and writable in Protocol Implementation Conformance (PIC) Statement.

(c) Workstations shall be able to communicate with next level controllers through BACnet. BTL listing for the workstation shall satisfy the requirement of Device Profile of B-AWS (Advanced Operator Workstation) as per ASHRAE Standard 135-2016.

(d) Workstations, building controllers and other devices, where applicable, shall comply with relevant BACnet device profiles such as B-AWS, B-BC, B-AAC and B-ASC of BIBB table.

(e) System architecture with workstations which can only accept BACnet information but cannot provide BACnet information to DDC controllers or other workstations is not acceptable. That is, workstations with only BACnet client function is not acceptable.

(f) Engineering software and licenses shall be provided with ownership being transferred to the Government. Licensing restriction of such engineering tools shall not be placed and the tools shall be able to use for the lifetime of the BACnet products installed.

(g) Engineering tools provided shall allow the users to create, modify and delete the objects (e.g. points, trends, schedules, alarms, reports, etc) in the system without relying on the original manufacturer.

6.1.5.2.3 Data Interfacing Requirement

Data format shall use BACnet open communication protocol. Other formats such as XML, CSV shall not be accepted without the approval by the Supervising Officer.

A data within a BACnet device shall be modelled in terms of a BACnet object. Each object represents either a physical or software information. The appropriate object type shall be selected for the specific application along with other object properties according to BACnet standard. The creation of non-standard or proprietary object shall not be accepted without approval by the Supervising Officer.

All BACnet data object required interfacing to CCMS shall include a trend log object achieving package as follows: -

(a) Data of the monitored object shall be recorded upon Change of Value (COV) subscription or periodic poll as specified.

(b) Periodic polled data shall be continuously generated in pre-set time intervals in real time. The time interval shall be pre-set to 15 minutes and shall be able to be set down to 5 minutes. The data

generation interval, the content and format of the file shall be approved by the Supervising Officer.

(c) Data as required in the Point Schedule shall be backed up and stored permanently on the historian server provided under the Works. The server shall have a storage size capable for storing data for a minimum period of 36 months under normal CCMS operation.

(d) The CCMS shall be configured for enabling the periodical recording of required data upon the completion of the Installations.

(e) The automatic recording of required trend data and the automatic upload of data on a periodic basis without operator intervention shall be verified. Demonstration shall be conducted. The database of the historian server shall have full functions enabling pruning and deleting individual trends.

6.1.5.2.4 Expandability

The system shall be able to expand memory and enhance programming language and to upgrade all existing controllers and remote control units without interrupting its operation. The system shall be able to expand 20% of the system hardware and software points without the need of upgrading of the existing hardware or software and causing any adverse effect on the system performance.

The system shall be modular in nature, distributed intelligence and consist of no centralised equipment to avoid over-loading of single device or information bottlenecked, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices using the same software interface such that replacement of either the workstation software or field controllers are not required.

Sufficient technical information of the CCMS and any information upon the Supervising Officer's request for further connection with third party BACnet compliant equipment shall be provided. Such technical information shall become the property of the HKSAR Government for future interfacing/expansion works and/or maintenance of the CCMS, irrespective of whether the HKSAR Government procures the maintenance services from the original CCMS supplier.

Adequate numbers of Direct Digital Control (DDC) controllers / input/output (I/O) modules shall be supplied and installed so that the system can function normally under the verified point schedules. The number of DDC controllers and I/O modules shall be determined in accordance with the capacity of equipment offered to accommodate I/O points required for the application, i.e., the points to be controlled and monitored, together with capacity of at least 25% spare points provided for future expansion on the addition points.

6.1.5.2.5 Demonstration for Compatibility

The CCMS shall be ready for, through the BACnet controllers, exporting CCMS data under an authentic protocol/ means that connected and interfaced with other systems as directed by the Supervising Officer. All relevant information, data and proposal of the system architecture shall be submitted to the Supervising Officer for his approval.

The compatibility between the CCMS and designated remote site to receive the exported CCMS data, through the BACnet controllers with third-party BACnet compliant equipment as directed by the Supervising Officer, shall be tested and demonstrated. General purpose open source network protocol analyser software application shall be used for such testing purpose. The objective is to test if the following items are compatible with smooth communication with the building management system at remote site as specified by the Supervising Officer: -

(a) BACnet controllers for the communication with remote site with network address assigned by the Supervising Officer; and

(b) BACnet points according to the point schedule with point abbreviation as deemed appropriate by the Supervising Officer

Such demonstration shall be set up and carried out off-line with the equipment supplied should the Supervising Officer consider it will interfere with the master project progress and other systems based on available information provided in the method statement. Relevant equipment for simulating the configuration shall at least include: -

(a) System server;

(b) System software;

(c) Workstation;

(d) Supervisory controller (if any);

(e) DDC controllers;

(f) Network controller unit (NCU) or devices with similar function; and

(g) All ancillary networking equipment and all associated cablings

This demonstration is merely for testing the practical interoperability of the CCMS with other BACnet compliant products. It shall be a pre-requisite check on compatibility of equipment before proceeding to the testing and commissioning of the enabling works.

6.1.5.2.6 Software Upgrade

From time to time, software may need to be upgraded for reasons, such as those due to debugging of the software itself, and/or due to upgrades in the Operating System (OS). Written statement from manufacturers shall be submitted to guarantee that the necessary software tools and/or software patches for implementing such upgrades are freely available to the Employer for at least five (5) years after completion of the Maintenance Period in order to maintain the functions of the CCMS and Data servers as specified in this Contract.

The CCMC database, programming, graphic software key and engineering tools are the property of the Employer perpetually. All licenses for equipment including software in the CCMS Installation shall be one-off life-time subscription.

6.1.5.3 WIRING AND TUBING

Application guidelines of TIA/EIA 568.1-D, TIA/EIA 485-A, and TIA/EIA 232-F shall be complied whenever applicable.

All wiring work and electrical devices and material necessary to complete the Controls and Instrumentation System shall be included. Complete metal cable trays or enclosures shall be provided for conductors throughout all systems specified. Equipment and devices, which are not constructed with housings for mounting and enclosing all live parts, shall be installed in metal cabinets. All equipment, enclosures, cable trays, etc., shall be appropriate for the atmosphere and hazards encountered within their associated areas.

"Low" and "line" voltage wiring shall be done in strict accordance with the authority referred to this Section as mentioned above. Conduit shall be concealed in building construction in all finished spaces. Conduit runs exposed shall be run in a parallel manner to building surfaces. Conduit shall be supported in approved manner. Rigid conduit shall be used in all concrete pours. All connections from instruments shall terminate on terminal strips, properly tagged for ease of identification, located in control centres. No splices or junctions of wirings will be permitted in the field.

All interlock wiring required to make system operate in accordance with the Particular Specification or Drawings. All wiring diagrams, etc., required shall be provided and co-ordinated. Wiring shall begin on terminals of control device and terminate on terminals of controlled device.

The term "wiring" shall include wire, conduit, wiring device, conduit boxes/accessories and miscellaneous materials and labour required for mounting and wiring electrical control devices and services.

Unless otherwise specified, wiring and tubing installations shall comply with the following: -

(a) Wiring shall be dedicated runs with separate circuit breaker and each run shall include a separate neutral and ground wire;

(b) A proper earth system shall be provided and shall be separated from other services for dedicated run;

(c) Wires shall be properly fixed at intervals;

(d) Wires shall be kept away from hot water pipe, steam and condensing piping, etc;

(e) Wires shall not run across telephone equipment;

(f) Surface conduits shall be of galvanised steel. Embedment of concealed PVC conduits shall refer to Clause 7.1.2.3.10;

(g) Surface conduits shall be installed in plant room or other area as approved by the Supervising Officer;

(h) Flexible conduits shall be adapted for connection to the equipment and/or sensors, etc;

(i) Control air tubing shall be in concealed run unless otherwise approved by the Supervising Officer;

(j) All control tubing run in surface to controls, control panels or run in equipment rooms, plant rooms, apparatus rooms, mechanical shafts and return air plenums, etc. shall be enclosed in metal raceway; and

(k) All control air tubing shall be thoroughly cleaned before putting the system into operation.

6.1.5.4 HARDWARE INSTALLATION

6.1.5.4.1 Enclosures

Construction standards for panels, racks, cabinets and other equipment provided shall meet with the following minimum requirement: -

(a) All field interface devices shall be mounted in a panel that shall be provided with enclosures to protect from dusts and moisture;

(b) The panel shall be adequate for installation of power supply for sensors, interfacing relays, contactors, safety circuits and transducers, etc;

(c) Sufficient heat dissipation device shall be provided to prevent over-heat of equipment;

(d) The panel shall be steel enclosure with hinged door, keyed lock and earthed, suitably reinforced and braced so as to provide flat-surfaced, rigid construction;

(e) Racks and panels shall comply with ANSI/EIA-310-D:1992 or equivalent standard;

(f) Material surfaces shall be free of scale, welding slag and dirt;

(g) Panel surfaces shall be flat and free from waviness;

(h) Stiffness and bracing shall be provided as required;

(i) Handling during installation shall be such that the panels will not suffer distortion or buckling;

(j) Cut outs shall be square with consoles to ensure that the controls shall be installed level and square. Finished cut outs and holes shall be free of burrs and sharp edges and fitted with rubber grommets to prevent cable insulation damage;

(k) All enclosures mounted outdoor or semi-outdoor shall be of weatherproof type;

(l) All control items shall be mounted on DIN rail within the control panel. All cables shall be housed in plastic trunking; and

(m) ON/OFF power switch with overcurrent protection shall be provided for each panel.

6.1.5.4.2 Identification

(a) All control wires and pneumatic tubing shall be identified with labelling tape or sleeves using word, letters, or numbers that will be cross-reference with the as-built drawings.

(b) All field enclosures shall be identified with nameplates.

(c) All junction boxes shall be marked to identify for CCMS.

(d) All field devices mounted inside the panel shall be labelled.

(e) All field devices outside the panel shall be identified with nameplate.

6.1.5.4.3 Location

(a) The panel for enclosing interface devices shall be installed immediately adjacent to the controller panels being interfaced.

(b) Room humidity or temperature sensors shall be mounted away from the machines that would generate heat, direct sunlight and diffuser air streams.

(c) Outside air sensors shall be mounted on suitable location on the north building face directly in the outside air.

6.1.5.5 CENTRAL WORKSTATION

6.1.5.5.1 Workstation Functionality

The workstation shall be the main access window to the CCMS and all configurations including but not limited to graphics and database, scheduling, programming and control logic at controller level. The workstation shall be furnished an up to date concurrent multi-tasking operation system to perform the following tasks at minimum: -

(a) Discover and display BACnet devices and all objects and properties of these devices;

(b) Graphically visualise plant information and indicate object properties upon mouse over of the data in a graphic;

(c) Display alarm and event information and trend data;

(d) Manual operation of plants and associated components;

(e) Create and change time schedule of a system operation;

(f) Change set points, limit values and parameters under object properties;

(g) Archive historian data;

(h) Synchronise date and time of all BACnet devices;

(i) Monitor the connection status of all BACnet devices; and

(j) Back-up and restore programs and data of the building controller.

6.1.5.5.2 Graphic Display

The system shall provide graphic filter to import AutoCAD drawing, JPEG graphic file, Compuserve GIF graphic file, Corel Draw graphic file, Microsoft Bitmap graphic file, Microsoft PC Paintbrush graphic file, Microsoft Metafile graphic file, Adobe Photoshop graphic file, HP Graphic Language graphic file, Postscript graphic file and other common graphic formats for graphic display.

The system shall provide a series of tools including a graphics library covering standard equipment graphics and symbols which support the creation, modification, cataloguing, and subsequent display of real-time colour schematics which shall represent a process, equipment, or geographical areas.

The schematics shall dynamically present the current state and/or values of operator-selected field or calculated points. These status or values shall be overlaid at the appropriate location on the schematic.

When the operator calls for the colour graphics tools, a tool box shall automatically appear on the screen. The tool box shall allow the operator to select a number of commands. The commands shall include, but not be limited to, the following: -

(a) Master Schematic Display;

(b) Schematic Index Display;

(c) Direct Access to Schematics by Schematic Number;

(d) Direct Access to Schematics by Point Acronym;

(e) Add or Change Schematics Titles and Labels;

(f) Add or Modify Schematics;

(g) Add or modify Real-Time Data to Schematics;

(h) Develop New Schematic Symbols; and

(i) Return to the Operating System.

The displaying of the master schematic shall allow the operator to use a hierarchical method to display areas of increasing scale sequentially. The master schematic shall be an overview of the entire facility. The schematic shall be broken up into zones which represent logical areas for display. The operator shall be able to select a particular zone he wishes to view. The graphic files of the selected zone shall also be able to be broken up into smaller geographical areas of larger scale. The number of hierarchical tiers shall not be limited and the hierarchical selection shall be bi-directional.

Selecting the "index to schematics" command from the tool box shall cause the first page of the schematic index to appear automatically. The index shall consist of the schematic number followed by the schematic title. The operator shall be able to select previewing the schematic in preview windows. The operator shall be able to select a schematic display, roll to the next page of the index, or exit back to the master index.

The direct access to schematics command shall allow the operator to display a schematic by entering the schematic number or by entering an acronym of a point on a schematic.

The operator shall be able to assign real-time data to the schematics. The different types of points shall include, but not be limited to: -

- Start/Stop;
- Start/Stop/Auto;
- Off/High/Low;
- Analogue Inputs;
- Binary Inputs; and

- Calculated Points.

The status of the point shall be indicated by the colour code. Unless otherwise specified, colour codes shall be as follows: -

- On/Normal – Green;
- Off/Normal – Yellow;
- Disabled or Locked Out – White; and
- Alarm - flashing Red.

Real-time data shall be automatically updated on the screen at least once a minute or as stated in the Particular Specification.

The operator shall be able to issue commands by utilising the keyboard or mouse. Once a schematic is displayed, the operator shall be able to call up an individual point and a menu shall appear on the page indicating the commands available for that point. At the same time, additional information on the point shall appear on the screen. This information shall include the full English language description of the selected point. Commands shall include, but not be limited to, the following: -

- Start;
- Stop;
- Auto;
- High;
- Low;
- Change Set point and Alarm Limits;
- Disable;
- Enable;
- Lockout;
- Restore;
- Alarm Message Display;
- Plot graph of totalised or averaged values for the last 24 hour; and
- Initiate Program.

6.1.5.5.3 Access Control

The software shall be capable of restricting any operator commands to any point at any specified device.

There shall be a minimum of 200 system accounts, each individually identifiable and each changeable through keyboard entry.

There shall be a minimum of 3 access levels, defined as: -

(a) User - view all applications and acknowledge alarms, but cannot modify database;

(b) Operator - all privileges except system configuration; and

(c) Administrator - all configuration privileges.

Operator inputs executed under valid system request shall be logged. This record shall contain the operator command and the time and date of input execution.

The system shall automatically terminate all operator-input capability that is previously available by valid system access after a predetermined time from the execution of the last operator's input requiring a valid system access request.

The system shall have a Graphic User Interface for adding, changing or deleting the system user accounts and assigning the access levels for administrator.

6.1.5.5.4 Alarm and Event Management

The system shall be able to log an alarm or event such that it shall be journalised in the event file and optionally printed on the event printer. The journal shall contain the following event information: -

- Alarms
- Alarm Acknowledgements
- Return to Normal
- Operator Control Actions
- Operator Login & Security Level Changes
- On-line Database Modifications
- Communications Alarms
- System Restart Messages

Standard displays shall be provided to show the current journal file with the most recent event at the top of the display. Subsequent page forward actions shall allow display of progressively older events. Sorting and filtering of the journal shall be possible via a standard report which shall be configurable by filling-in-the-blanks. Coding or scripting of any kind shall not be required. If events are viewed on the screen, it shall be possible to pause the real time view and prevent events from scrolling off the screen as new events occur.

The alarm and event database entries shall contain the following information: -

- Time & date stamp point
- Name event type alarm
- Priority point description
- Point value or status at time of the event
- Engineering units

The event database shall also be accessible from other sub-systems such as the operator interface, report generation and application programmers interface. It shall be possible to have an online event file as large as the disk capacity can accommodate.

The event file shall store events on line. The system shall be able to automatically or manually archive these online events periodically at a time period specified by the user. Operators shall be notified by an alarm that event archiving is required if manual operation is chosen. Events may be archived to media such as CD, Zip drive or file systems. If archiving does not take place, the event system shall continue to collect events until it reaches a nominated disk space limit. It shall then overwrite the oldest events until archiving takes place or more disk space is made available.

Archived events may be restored to the CCMS at a later time if required for reporting purposes. Multiple archives shall be able to be restored at any time. The CCMS shall indicate to the operator the range of events in a particular archive file.

The operator shall be able to restore previously archived files and review or print them from the workstations.

The software shall be capable to display an alarm notification using the following method(s) according to the alarm priority settings: -

- Notification history window in tabular format with colour and icon for different alarm types
- Notification popup messages
- Notification sounds different from each alarm groups
- Notification status bars

An alarm summary shall be provided which contains the point status of all points in the alarm condition. Alarm filtering and text search shall be available to operators to allow creation of tailored made alarm list to facilitate fault-finding.

6.1.5.5.5 Scheduling and Database

The system shall provide a real-time database incorporating data from analogue, logical or pulse inputs. All schedule and calendar objects in the building controllers shall be accessed by the workstations and allowed to be modified on-line without interrupting operation of the system. Configuring time schedules shall be able to perform through a graphical user interface whereby the operator selects the appropriate time span from a calendar. Systems where time and days shall be manually entered are not acceptable.

In addition to the point-based information, the database shall also provide historisation capabilities for analogue, digital, pulse and event-based information. This information shall be accessible by all facilities of the system such as custom displays, reports, trends, user written applications, etc.

The system shall maintain portions of the database requiring frequent high-speed access as memory resident information and other less frequently accessed data as disk resident data. Memory resident data shall

be checkpoint to disk every minute to minimise loss of data in the event of loss of power or other system failure.

Database backup shall be possible with the system on-line including backup of historical based data with not less than 2,000 GB storage capacity. The backup shall be possible via standard Microsoft Windows operating system utilities. The system shall be restored using the database backup and restore services providing for quick disaster recovery.

6.1.5.5.6 Trend and Historian Data

The system shall support archiving of historical data to allow a continuous record of history to be built up over a period of time. Archived data may be stored on the hard disk of the system. The number of archives maintained on the system before transferal to off-line media shall only be limited by the size of the hard disk. The system shall allow the user to define the specific intervals of history to be archived to avoid archiving of unnecessary data.

Once archived, the data shall be available for re-trending through the system trend facilities in combination with the current on-line history or other archives. Providing the archived history is present on the system server's hard disk, the trend facilities shall be able to access it transparently for display when a user scrolls beyond current online history limits.

Collection of historical point data shall be configurable as part of the point definition. Once configured, this data shall be collected automatically. Historical data collection shall be provided for both snapshots and averages with intervals ranging from 60 seconds to 24 hours.

Once assigned to history, point data shall be available by Point Parameter access used in conjunction with a history offset to locate the particular value of interest. The graphical operator interface, trend, report generation and application interfaces shall be able to access historical data.

Modifications to the history collection of a point shall be possible online without the loss of previously collected data for the point being changed or any other points in the system currently being historised.

History shall be able to be archived to an alternative file system or offline media. Different archive settings shall be available for different history types.

(a) Trend Data Storage

The system including the control network and field panels, shall be capable of collecting and storing all point data at a uniform sampling interval of one minute without measurably affecting control performance.

The system will take average of the sampling data at an interval of every 15 minutes and trend data shall be archived in a database in time intervals no less frequently than one per day.

The database shall allow applications to access the data while the database is running. The database shall not require shutting down in order to provide read-write access to the data. Data shall be able to be read from the database without interrupting the continuous storage of trend data being carried.

The system server shall be capable of periodically gathering performance data stored in the field equipment and automatically archiving these data without operator intervention. All data from sensors, meters, etc. shall be archived. Archive files shall be appended with new data, allowing data to be accumulated. Systems that write over archived data shall not be allowed unless limited file size is specified and automatic archiving is employed on a scheduled basis to prevent loss of data. Display all performance data in standard engineering units.

(b) Historical Profiles

The system shall provide the capability for the operator to build historical profiles through the operator's terminal and initiate the profile immediately, automatically at some future specified time of day and/or automatically on a time increment. Profile shall be displayed on the operator's terminal or printed as selected by the operator. Any averaged or totalised point shall be able to be assigned to a profile. Multiple profiles shall be able to be defined and multiple points shall be able to be assigned to a single profile. Unless otherwise indicated, minimum profile formatting shall be as follows: -

- Last 36 Months, by Month or accounting period;
- Last 30 Days, by Day;
- Last 24 Hours, by Hour;
- Last Hour, by Five Minute Intervals;
- Last Ten Minutes, by Minute;
- Hourly-to-Hour for Today;
- Day-by-Day for Current Accounting Period;
- Total/Average for Today, so far;
- Total/Average for Last Accounting Period;
- Total/Average for Year-to-Date;
- Total/Average for Hour, so far; and
- Total/Average for Last Ten Minutes Only.

The accounting period shall be defined by the operator through the operator's terminal.

The operator shall be able to obtain a summary of defined profiles on the operator's terminal or on the printer as selected by the operator.

(c) Data Export to other Software

Historical and current data held in temporary memory shall be exportable as specified by the owner to one or more formats for analysis by external software. Examples include: -

- Text (Comma or tab delimited with " " text delimiters)
- MS Excel
- MS Access
- dBase
- SQL

Date transfer shall be accomplished by open database connective (ODBC) or Web services.

Exported data shall have the following characteristic: -

- There shall be no duplicate records. Each time / date stamp for a specific point shall be unique.
- The data shall be fully contained in a single file or table for each point. Data shall not span multiple files or database tables.
- Each field of data shall have one and only one unique identifier. The label shall be in the first row of the file. Labels shall not be repeated in the stream of data.
- Each table or file shall have a single date/time stamp. Multiple fields that are sampled on the same time stamp can be combined in a single file or table provided that they have the same number of records.

The system shall allow for the user to change the performance monitoring setup. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All points on the system shall be capable of being displayed, archived, and re-displayed from archive.

Archiving program shall follow password requirements for users to delete, modify, or change archive parameters.

6.1.5.5.7 Engineering Tools

Engineering tools provided shall allow the users to create, modify and delete the objects (e.g. points, trends, schedules, alarms, reports, etc.) in the system without relying on the original manufacturer.

(a) Database Configuration Tool

A database configuration tool shall be provided with the system that allow configuration of all point records, printers, controllers and operator workstation connections. The utility shall also have the ability to export information to and import information from

Microsoft applications such as Microsoft Excel. Systems that do not provide such function shall not be acceptable.

Users with sufficient security access shall be able to configure the database while the system is online. Configuration shall not require the need for any programming, compiling or linking and shall not require shutting down or restarting of the system. In addition, historical data collection shall not be interrupted for points not affected by configuration changes.

It shall be possible to launch the database configuration tool from the operator workstation interface. The utility shall have the ability to configure database changes and download them from the server directly.

It shall be possible to modify a range of communications and other parameters for each device. The parameters of a particular device made available for modification shall be specific to the device or hardware item being configured, i.e. baud rate, parity, data and stop bit information in the case of serial devices. Hardware configuration utilities that rely solely on text-based configuration files shall not be acceptable.

All documentation for the configuration utility shall be provided online. The help facility shall operate using standard Microsoft features such as context sensitive help using the F1 function key.

The utility shall provide features that reduce configuration time of the CCMS system. These features shall include adding multiple points, controllers etc. at once. The utility shall automatically increment names or numbers of any information that is required to be unique by the system (such as point names). The user shall be able to select multiple items (such as points) and then edit fields that are common to all selected items to assist in global changes. Standard copy and paste facilities are to be provided by the utility.

The utility shall also support free format text fields which the user can use for additional information such as cabinet or wire numbers. These additional fields shall be simple extensions to existing items in the database.

A filtering mechanism shall be provided with the utility so that the user need view only relevant information. The filter shall provide standard choices for the user to select and also provide user defined filtering.

Database management reports shall be provided by the utility as standard. The utility shall also provide support for ad-hoc reporting facilities for engineering use.

(b) Diagnostic Capture Tool

The system shall enable easy diagnostics of the health of the system. All diagnostic information shall be viewable through an easy to use user interface and shall be able to be easily exported as a standalone collection of material for later analysis. This information shall include the followings: -

- Communications traces to selected controllers
- All system log files
- Details on system software installation
- Application status information

6.1.5.5.8 Energy Calculation

Energy Calculation shall perform the following functions: -

(a) Air Flow Rate

Calculate airflow rate from air flow meter or on differential pressure in supply and return ductwork.

(b) Liquid Flow

Calculate flow rate from differential pressure across an orifice or venturi, or from an annubar sensor or Electro-magnetic flow sensor. Sensor acronym and type shall be input by the operator.

(c) Fluid Energy Rate

Based on flow and differential temperature.

(d) Zone Cooling Energy and Zone Heating Energy

Calculate total cooling or heating energy in a zone based on supply and return air dry bulb and either wet bulb or relative humidity and the volume flow rate of the space.

(e) Electrical Power

Calculate electrical power based on voltage and amperage, or on pulse meter input.

The operator shall be able to determine the time increment for performing calculations on a resolution of 1 minute.

Calculated points shall be defined through the operator's terminal in the same manner as for sensed points with additional information requested as required. The calculated point shall appear to the operator as any real point (with a sensor) and the operator shall be able to use the acronym of the calculated point in the same manner as a real point.

6.1.5.5.9 Duty Cycle

The operator shall be able to assign through the operator's terminal any controlled load in the system to the duty cycle programme and define associated parameters. Parameters shall be individually assigned per load. Parameters shall be at least as follows: -

(a) Acronym of load start/stop point;

(b) Acronym of Space temperature point that will feedback space conditions to the programme. If no space temperature point exists, this parameter shall not have to be defined;

(c) The minimum on and off times for the load required for equipment protection from damages;

(d) The beginning and ending times of the duty cycle periods. Capability of up to seven unique cycle periods per load shall be provided;

(e) The maximum allowable off time per load individually defined per period;

(f) The time resolution for cycling within each period. The resolution shall be, as a minimum, selectable on 1 minute increments between 1 and 120 minutes;

(g) The percentage "off" time within each time resolution. The percentage shall be selected, as a minimum, on 5% increments between 5 and 95%; and

(h) The commanded status of the load on a high alarm and the commanded status of the load on a low alarm of the space temperature feedback.

The operator shall be able to modify any parameter on an individual basis at any time.

Each load assigned to the duty cycle shall be cycled based on the individual parameters assigned to it. The load shall be "off" for the percentage of time defined for each time resolution, but never for more than the maximum "off" time for any one time. Space temperature alarm shall command the load to its defined status. In no case shall the load ever be put "on" or "off" for less time than the minimum "on" or "off" time defined.

The operator shall be able to display or print all the parameters associated with a load assigned to the duty cycler on request. Summaries shall be able to be requested for all points or restricted to a particular location or load by operator choice.

Loads shall be able to be locked out from or restored to the Duty Cycler by the operator at any time.

6.1.5.5.10 Power Demand Monitoring / Load Shedding

The operator shall be able to assign through the operator's terminal on-line any controlled load in the system to the load shed programme and define associated parameters. Parameters shall be individually assigned per load. Parameters shall be at least as follows: -

(a) Acronym of the load start/stop point;

(b) Acronym of the space temperature point that will feedback space conditions to the programme. If no space temperature point exists, this parameter shall not have to be defined;

(c) The minimum on and off times for the load required for equipment protection from damage;

(d) The kilowatt rating of the load;

(e) The acronym of the electric meter that the load is associated with; and

(f) The priority level of the load. Providing capability of 16 priority levels.

The operator shall be able to modify any load parameter on an individual basis at any time.

The operator shall be able to display or print all of the parameters associated with a load assigned to the load shedding programme on request. Summaries shall be able to be requested for all points, or restricted to a particular location or load by operator choice.

Demand meters shall be defined by the operator through the operator's terminal. Parameters associated with demand meters are as follows: -

- Acronym of the meter;
- The demand limit to begin shedding loads;
- The demand at which loads shall begin to be restored;
- The number of priority levels associated with the meter; and
- The demand interval length.

The operator shall be able to modify any meter parameters on an individual basis at any time.

The operator shall be able to display or print all parameters associated with a particular demand meter on request.

The power demand programme shall operate on a sliding window basis. Each minute shall be considered to be in the middle of the cycle interval.

The demand data shall be gathered each minute. The data from the last N minutes (where N equals one-half the interval length) shall then be used to create a best fit first-degree polynomial curve. The curve shall then be examined at what would be the end of the interval (N minutes ahead). If this value is greater than the shed limit, the power demand programme shall calculate the excess load and initiate load shedding. The shedding shall begin with the lowest priority loads and shall be governed by the point's minimum "on" time, maximum "off" time, point disability, and status of the space temperature point (if one has been defined). If the point has not satisfied (continuously) its minimum "on" time, if the maximum "off" time has already been reached, if the point is disabled, or if the space temperature point is in alarm, the load initially shall not be shed. If the power demand programme finds that it has examined all loads in all priorities and more shedding is still necessary, according to the predicted load, it shall go back to the lowest level and re-examine the points, this time overlooking the maximum "off" time criteria. If the power demand programme finds itself again not able to adequately shed enough load to prevent the predicted power peak, it shall again go through the loads in order of priority and disregard the status of space temperature points. If it is still unable to adequately reduce the load level, the operator shall be informed of the number of kilowatts still needed to be shed. Under no circumstances shall the system shed a load if the points minimum "on" time has not been reached or if the points are disabled.

If at any time after load shedding has been initiated, the system forecasts the end of cycle consumption to be below the restore limit, the power demand programme shall begin starting up the loads in order to bring the system back into the state in which it was operating before the shedding began. Load restoration shall be performed in reverse order from that observed in the shedding process. The first group of points to be restored shall consist of those whose sample area is in alarm. The second group shall be the remainder of the power demand monitored points that are currently "off" and have met their minimum "off" time. Under no circumstances shall the power demand programme restore a point that is either disabled or has not yet satisfied its minimum "off" time. The starts shall be performed in an efficient manner, each being delayed by the amount of time specified by the preceding point within the same controller. When enough load has been restored so that the forecasted consumption is above the restore limit, the power demand programme shall discontinue the restoration process.

Points that are both duty cycled and power demand monitored may be shed by the power demand programme, but shall only be started up by the duty cycler. If the duty cycler deems it necessary to start such a point, it shall determine whether the point is off due to load shedding or normal cycling. If the point was shed and an entire power demand programme interval has not elapsed since the time of the shed, the duty cycler shall then locate and shed enough other load to allow the original point to be started, without affecting the total system power consumption.

A power demand profile shall be available to the operator upon request. The profile shall be displayed or printed by operator selection. The profile

shall include the demand meter description, the time, date, demand limit, restore limit, interval length, current demand, highest demand today and time of occurrence, highest demand yesterday and time of occurrence, highest demand during current building period with time and date of occurrence, and the highest demand for the last 11 billing periods by billing period with time and date of occurrence. Billing periods shall be able to be defined by the operator through the operator's terminal.

6.1.5.5.11 Optimum Start Time

The optimum start programme shall calculate the latest start time for air handling units in each operator-defined zone. The calculations shall consider occupancy time, outdoor temperature, indoor temperature, desired indoor temperature at occupancy, and the capacity of the air handlers.

The programme shall run at a reschedule interval of no more than five minutes before the start-up time for all of the optimum start zones. The programme shall examine each zone at the frequency defined for that zone.

When the programme determines that the optimum start time has been reached, it shall start all of the air handling units included in the zone definition.

At the zone occupancy time, the system shall record the actual zone temperature and any deviation from desired temperature. If any unit within the zone was found to have been off-line between the start-up time and the occupancy time, the data shall be flagged as invalid.

Optimum start zones shall be defined by the operator through the operator's terminal. Parameters shall include as a minimum the following: -

- Occupancy time for each day of the week;
- Desired temperature at occupancy;
- Acronym of outdoor temperature sensor;
- Acronym of indoor temperature sensor;
- Acronyms of air handlers to be started; and
- Acronym of the zone.

The operator shall be able to modify the parameters at any time. A summary of the zone parameters shall be available on command. The summary shall be displayed on the operator's terminal or printed on the printer. The summary shall be of all zones or an individual zone.

An optimum start performance summary shall be available to the operator on request. The summary shall be able to be displayed on the operator's terminal or printed on the printer. This summary shall detail the conditions presented to the optimum start programme as well as the results of the optimum start function for one week. The information, output by zone, shall include the difference between the target

temperature and both the inside and outside air temperatures at the zone start time, the difference between the target temperature and the actual room temperature at occupancy time, and the start time measured in minutes before occupancy. Performance summaries shall be able to be requested for individual or multiple zones.

6.1.5.5.12 Supply Air Reset (SAR)

The SAR programme shall monitor status and adjust the supply air temperature set point, and shall ensure that space temperature conditions are maintained and that the space relative humidity upper limit is not exceeded. The system operator shall be able to define, modify and delete the following parameters: -

- Areas to be enabled/disabled for SAR;
- High and low rest limits; and
- Sampled time interval.

A log shall be provided detailing each parameter associated with supply air reset area.

6.1.5.5.13 Chilled Water Optimisation (CHO)

The automation system shall include a software programme to perform chilled water reset, soft loading and chiller sequence. The CHO programme shall optimise the use of chilled water in either one of the two ways - the chilled water supply reset shall be based on either maintaining a constant return temperature or supply sufficient cooling to satisfy zone requirements.

(a) When the CHO programme is based on maintaining a constant chilled water return temperature, the software shall incrementally adjust the supply water set point to achieve the desired space conditions. It shall be possible to individually monitor and control each chilled water loop; or

(b) When the CHO programme is based on supplying sufficient cooling to satisfy zone requirements, the software shall incrementally adjust the chilled water set point upwards until at least one zone is requiring additional cooling.

The system operator shall be able to define, modify and delete the following parameters: -

- Loops to be enabled/disabled for CHO;
- High and low reset limits;
- Incremental adjustment magnitude;
- Sampled time interval; and
- Sequence patterns based on building load in kW.

A log shall be provided detailing each parameter associated with a chilled water optimisation loop.

6.1.5.6 BUILDING CONTROLLER

6.1.5.6.1 General

Building controllers are networked yet autonomous devices to enable automatic control on air conditioning systems and other sub-systems as required. Building controllers cover Direct Digital Control (DDC) controllers and other types of devices which are able to provide similar functions including but not limited to Gateways, Routers and Unitary Controllers.

Adequate numbers of DDC controllers / input/output (I/O) modules shall be supplied and installed so that the system can function normally under the verified point schedules. The number of DDC controllers / I/O modules shall be determined in accordance with the capacity of equipment offered to accommodate points required for the application, i.e., the points to be controlled and monitored, together with capacity of at least 25% spare points provided for future expansion on the addition points.

The point abbreviation and definition shall be proposed according to the CCMS Point Schedule as specified and include it in the point database submission to the Supervising Officer for approval prior to the setup of the Building controllers.

6.1.5.6.2 Trending

The system shall provide flexible trending allowing real-time historical or archived data to be trended in a variety of formats. In addition, trend data types shall be able to be combined to allow for comparisons between data, e.g. current real-time data versus archived data.

(a) Trend Capabilities

The system shall provide trending capability with the following functions: -

- Real Time Trending
- Historical Trending
- Archived History Trending
- Trend Scrolling
- Trend Zoom
- Engineering Unit or Percent
- Cursor Readout of Trend Data
- Trend comparisons between archived, real-time and historical data (for example, this year vs. last year). Comparisons between the same point offset in time, or different points shall be possible.
- Trend de-cluttering via per-pen enable/disable on multi-plot style trends
- Independent Y-axis per point on multi-plot style trends. It shall be possible to display the Y-axis for any point on

the trend by simply selecting the point using the mouse or keyboard
- Copying the currently displayed trend data to the clipboard for pasting into spreadsheet or document.

A trend log object shall be used to allow saving trend data in the controllers and bundle transfer of trend data to the historian server. The name of the trend log object shall be easily traceable with its corresponding trend data. Configuration of trends shall only require the entry of the Point Name into the desired trend template to produce the trend. All trend configurations shall be possible on-line without interruption to the system. Historisation of data shall not be affected by changes to trend configuration. Systems that only provide trending via a third-party package will not be acceptable.

(b) Trend Types

The system shall be able to present real-time, historical or archived data in a variety of formats including single, dual and multiple value trends of up to 8 points. For each trend set display, it shall be possible for operators to configure the number of historical samples and ranges displayed. Points configured in trend sets shall be changeable online.

Operators shall be able to zoom in on information displayed on trend sets for closer inspection by dragging out an area of interest with the mouse or other pointing device. From such a selection, it shall be possible to copy the underlying data to the Windows clipboard for subsequent pasting into a spreadsheet application such as Microsoft Excel. Systems that do not provide support for Microsoft Excel in this respect shall not be acceptable.

Scroll bars shall be available to move the Trend set backwards and forwards across the historical records. The trend sets shall automatically access archived history files without operator configuration.

It shall be possible to embed trend objects as part of custom displays. The following formats shall be available: -

- Bar Trend
- Line Trend
- Numeric Trend
- Tuning Trend Pie
- Trend X-Y Plot

6.1.5.6.3 Alarm and Event Management

A Building controller shall be used to setup an alarm or an event for all data objects created in that controller unless with reasonable explanation for the exception. The Building controller can be used to extend its

functional scope for other BACnet devices such as unitary controllers and other sub-systems interfacing to the CCMS.

Notifications shall only be generated in the Buliding controllers rather than in the workstations. Notification class objects shall be determined with the proper settings of following items:-

- Notification class objects
- Recipient list
- Priority
- Acknowledgement

The selection of event categories for maintenance, fault, alarm notifications shall be clearly specified and defined before application.

Additional notification classes and event enrolments shall be set up to enable tailored alarms to third party's Integrated Building Management System for remote monitoring purpose. The notification classes shall be at the minimum divided into system level, equipment level and venue level.

Other than the above-mentioned, an event enrolment object for algorithmic change reporting shall only be used when simple setup by intrinsic reporting could not serve the purpose.

Status flags shall be used to distinguish the following states properly:-

- Alarm state
- System fault
- Overridden
- Out of service

The setting details as required in this clause shall be submitted for approval by the Supervising Officer before carrying out the engineering works.

6.1.5.6.4 Scheduling and Time Sychronisation

Scheduling function shall be implemented in the Building controller at all time by using appropriate schedule and calendar objects. It shall be possible to specify time schedules for the control of all control points. A large number of individual points shall be controlled by a single time schedule. A single time schedule shall define the control to any combination of day and time. The time schedule shall also provide the ability to override the normal schedule for holidays or special occasions.

Each controller shall have minimum calendar and schedule object to support the functional requirements. The objects shall be able to be read and write through workstations and locally in the controller. The operating option shall be equal and the last entry is valid.

Each controller shall have a system clock with battery buffer with a BACnet device acts as the system time master. All Building controllers shall be assigned to the time master take over the time and synchronise the clocks accordingly.

The Building controller shall automatically initiate equipment or system commands based on a preselected time schedule for those points specified as programmable in the point list. This time schedule shall provide programme times for each day of the week (Monday through Sunday) on a per point basis.

Any point not responding to a programme function command shall automatically generate a change-of-state output as herein before defined.

6.1.5.6.5 Run-Time Totalising

The Building controller shall provide the capability to totalise the number of hours that any binary point in the system is in the "on" condition. Every binary point shall be able to be totalised as run-time hours upon operator's assignment.

Run-time hours shall be logged in seconds in accordance with BACnet Standard. Logged seconds shall be converted and displayed as run-time hours via an additional analogue object. The time value shall be able to convert to hour as unit for display in the workstation.

The operator shall be able to set an upper limit associated with run-time to trigger maintenance notification automatically. Run-time totals and limits shall be able to be reset from the workstation on command.

Any analogue or calculated point in the system shall be able to be assigned to the totaliser and/or average programme. The points assigned shall be totalised or averaged a minimum of once a minute. The following totals and averages for each point assigned shall be kept in storage: -

- Last 12 Months, by Month;
- Last 30 Days, by Day;
- Last 24 Hours, by Hour;
- Last Hour, by Five Minute Increment; and
- Last Ten Minutes, by Minutes.

6.1.5.7 FIELD DEVICE

6.1.5.7.1 General Requirements

Basic adjustments for original setting (such as control characteristic, wind and sun effect settings, set-back, boost, etc.) shall be concealed and tamper proof and housed within lockable panels. Temperature setting scales shall be clearly marked in °C.

Unregulated power supplies shall be filtered. Shielded cable shall be used when it is necessary to install DC signal leads in the same control wiring conduit.

Suitable support and easy access facilities shall be equipped for all sensors, monitoring and measuring equipment. Suitable protection guard against damage shall be provided for equipment exposed to public contact.

Thermal conduction compound shall be applied to ensure good heat transfer to the well-mounted sensor.

The high-pressure port of the duct type static pressure sensors shall be connected to a metal static pressure probe that shall be inserted into the duct pointing upstream. While the low pressure port shall be left open to the plenum area at the point that the high-pressure port is being tapped into the air duct.

Building static sensors shall be installed with the high-pressure port to be inserted into the space via a metal tube and the low-pressure port to outside.

Actuators shall be installed firm and be mounted to give a positive movement throughout 100 percent of the stroke.

The relays shall be installed such that transient suppression shall be across all coils.

6.1.5.7.2 Sensing Elements in Liquids

(a) Elements sensing liquid temperature in pipework shall be: -

(i) Provided with means for withdrawal for calibration, servicing, etc., without the need for draining the system;
(ii) Positioned so that the active part of the element is wholly within the liquid;
(iii) Positioned so that the element is not less than 10 pipe diameters downstream from a point of mixing, unless otherwise recommended by the manufacturer;
(iv) Positioned so that sufficient length of flexible conduit can be allowed to permit complete withdrawal of the element; and
(v) Positioned downstream from the valve, after the pumps, for the control of mixed flow temperature using mixing valves.

(b) Elements sensing liquid flow in pipework shall be positioned so that: -

(i) The element is mounted in a section of pipe where there is a straight run of at least five pipe diameters on each side of the flow switch;

(ii) The element is mounted so that the terminals or wire leads are easily accessible for wiring; and

(iii) The element shall not be subjected to water hammering. If a fast-closing valve is located downstream of the element, a suitable water hammer arrester shall be used.

6.1.5.7.3 Sensing Elements in Air or Gases

(a) Elements sensing the temperature of air in room or other such space shall be: -

(i) Positioned so that the element is not subjected to thermal radiation and shall be away from door, windows, and heat sources, etc.;

(ii) Positioned so that all conduit openings are sealed to avoid false temperature measurement; and

(iii) Positioned in a representative position.

(b) Elements sensing the temperature of air in a duct shall be positioned so that: -

(i) The element is not subjected to thermal radiation;

(ii) The active part of the element is wholly immersed in the controlled air stream;

(iii) The element in supply air duct is fitted a few metres downstream from the heating coil;

(iv) The element in extract air duct is fitted before the extract fan to avoid thermal radiation influence;

(v) Temperature stratification is accounted for, i.e. positioning for low temperature limit sensing, positioning for high temperature limit sensing, positioning for average temperature sensing;

(vi) If of the capacity averaging type, it is installed on a suitable framework and is suitably arranged for servicing; and

(vii) If used for determining the dew point, the air adjacent to the element is known to be saturated within acceptable limits.

(c) Elements sensing the temperature of a solid surface shall be positioned and fixed so as to give good thermal contact.

(d) Elements sensing the temperature of air external to a building shall be positioned: -

(i) Generally as indicated and away from the influence of direct solar radiation and local heat gains;

(ii) Far away from the warm air outlets such as windows or extract; and

(iii) Where special requirements are indicated (e.g. the determination of solar gain, or wind influence), the

control sensor manufacturer's recommendations for positioning the sensors shall be followed.

(e) Humidity sensing element shall be positioned: -

(i) In a representative of the space in which the humidity is being measured;
(ii) Such that the air velocity is within the range required by the sensing element; and
(iii) To ensure that the air reaching the element is free from airborne contaminants.

(f) Element sensing both temperature and humidity shall be: -

(i) Positioned so that the element is not subjected to thermal radiation and shall be away from door, windows, and heat sources, etc.;
(ii) Positioned so that all conduit openings are sealed to avoid false temperature measurement; and
(iii) Positioned in a representative position.

(g) Elements sensing differential pressure of air in a duct shall be positioned so that: -

(i) Sensor stem is fully immersed in the controlled air stream;
(ii) Differential air switch shall be positioned where it will not be exposed to corrosive or flammable atmosphere or vibration;
(iii) The pressure switch shall be mounted on a vertical surface and has two air pressure tappings which are connected with tubing to the sensing points in the duct;
(iv) The mounting method of the pressure transmitter shall be subjected to the manufacturer's recommendations; and
(v) All sensors shall be arranged to give convenient access for servicing the sensor.

(h) Elements sensing carbon dioxide of air in a room shall be positioned so that: -

(i) Areas with low air exchange or close to supply air outlets; windows, doors, etc. shall be avoided;
(ii) The sensors shall be mounted at a minimum of 2 m above finished floor level;
(iii) All sensors for any individual installation shall be of same appearance; and
(iv) For sensors exposed to view, the precise location shall be approved by the Supervising Officer.

(i) Elements sensing carbon dioxide of air in a duct shall be positioned so that: -

(i) Sensor is mounted with rigid support in the return duct in a position far away from external heat sources;
(ii) Sensor stem shall be fully immersed in the controlled air stream; and
(iii) All sensors shall be arranged to give convenient access for servicing the sensor.

(j) Elements sensing carbon monoxide and nitrogen dioxide for carpark shall be positioned so that: -

(i) The Practice Notes on Control of Air Pollution in Car Parks issued by the Environmental Protection Department shall be complied;
(ii) The exact quantities of sensors shall be based on the regulation but not less than $500m^2$ per one detector; and
(iii) For sensors exposed to view, the precise locations shall be approved by the Supervising Officer.

(k) Air velocity sensors shall be: -

(i) Sensor tube made of stainless steel material carrying a scale to indicate the immersion length; and
(ii) The location and immersion length shall be in accordance with the manufacturer's recommendation.

(l) Sensing elements shall in all cases be installed in accordance with the manufacturer's recommendations and instructions.

(m) All room or space mounted sensing elements to temperature or humidity for any individual installation shall be of the same appearance.

(n) For sensors exposed to view, the precise location shall be approved by the Supervising Officer.

(o) All sensors shall be arranged to give convenient access for servicing.

6.1.5.7.4 Internet of Things (IoT) Technology

(a) For the situation that signal wiring sensor is not preferred, wireless sensors with IoT element could be adopted if site condition is allowed.

(d) The following sensors could be considered with IoT technology:-

(i) Air temperature sensor;
(ii) Humidity sensor;
(iii) Enthalpy sensor;
(iv) Indoor Air Quality (IAQ) sensor (CO, CO_2, NOx, etc)
(v) Water quality sensor (Residual chlorine, Total organic carbon, Acidity, etc)

(vi) Smoke detector
(vii) Level sensor
(viii) Other boolean signal sensor (binary input)

(e) The following application could be considered to use IoT Technology in Air-conditioning system to facilitate the installation and effective monitoring:-

(i) Monitoring on indoor air parameter, air quality sensing in large room volume space (e.g. Atrium, Void, etc.);
(ii) Monitoring on E&M condition in remote site (e.g. water tank, water pump operation condition);
(iii) Monitoring on water quality of a dedicated plant equipment (e.g. Cooling tower); and
(iv) Other applications with physical wirings and comprehensive data structure installation not preferred.

(f) Common communication technology shall be adopted for the sensor selection and the setup of IoT local communication network. One of, or combination of the following technology shall be considered in accordance with the application, range of coverage, data rate, power usage and resilient factor. However, due consideration shall be made if the frequency of the IoT technology selected to be interfered with the mobile communication and/or WiFi. Celluar type IoT technology shall only be considered in case there is difficulty on physical connection to CCMS inside the building.

Technology	Power Consumption	Coverage	Typical Form of Transmission
LoRa	Low	Long	Non-Cellular / Cellular
ZigBee	Low	Short	Non-Cellular
NB-IoT	Low	Long	Cellular
Bluetooth	Low	Short	Non-Cellular
WiFi	Medium to High	Medium	Non-Cellular

(g) System architectural design of a local IoT network shall be compactible to the CCMS network and protocol in accordance with the details stipulated in Sub-section 6.2.5.

(h) For the intra-building connection, the IoT system architecture shall consist of two levels, an Ethernet based backbone network for the commination to CCMS and the field level networks (FLN) of IoT field devices, actuators and sensors.

(i) Protocol Gateway shall be provided to handle all the signals amongst IoT field device and convert the signal to BACnet/IP protocol for CCMS connection such as Lora to BACnet Protocol gateway, ZigBee to BACnet Protocol Gateway.

SUB-SECTION 6.1.6

CENTRAL REFRIGERATION MACHINE, DIRECT EXPANSION EVAPORATOR AND HEAT REJECTION PLANT

6.1.6.1 GENERAL

In this section, refrigeration machine may refer to chiller or heat pump.

Refrigerants are classified in four flammability safety classifications (ie. Class 1, Class 2, Class 2L and Class 3) according to ANSI/ASHRAE Standard 34-2019: Designation and Safety Classification of Refrigerants. For refrigeration and air-conditioning system in government building projects, only non-flammable Class 1 refrigerants, such as R-134a, R-410A, R-1233zd and R-513A etc., shall be adopted.

Use of highly flammable hydrocarbon refrigerants under Class 3 shall be prohibited and under no circumstances should they be adopted in government building projects.

Use of refrigerants under Class 2L and Class 2 shall only be considered under special consideration on individual project basis and subject to the conditions that such application fully complies with relevant safety procedures and standards such as ANSI/ASHRAE 15-2019 and ANSI/ASHRAE 34-2019 : Safety Standard for Refrigeration Systems, Designation and Safety Classification of Refrigerants and the statutory requirements from local authorities including but not limited to the Dangerous Goods Ordinance, the Gas Safety Ordinance, the Factories and Industrial Undertakings Ordinance enforced by FSD, EMSD and Labour Department respectively.

No “Controlled Refrigerant” as defined under the Ozone Layer Protection (Controlled Refrigerants) Regulation, Cap 403 of Laws of Hong Kong shall be used in the refrigeration machine.

The air-conditioning and refrigeration equipment shall fulfil the maximum threshold for the combined contributions to ozone depletion and global warming potentials in accordance to the BEAM Plus New Buildings Version 2.0 issued by the HKGBC and provide the required supporting documents to facilitate BEAM Plus certification submission.

All necessary refrigerant and lubricating oil shall be supplied during testing and commissioning and plant operation stages until the plant is accepted at the expiry of the Maintenance Period.

Each unit shall have an electronic/microcomputer control panel factory installed and tested. Full automatic control function shall be provided as detailed in Sub-sections 6.1.4, 6.1.5, 6.2.4 and 6.2.5.

Plant room with central refrigeration facilities shall conform to the building requirements, provision of detection and alarm system, mechanical ventilation and personal protective equipment, in accordance to ANSI/ASHARE 15-2019. Eye wash, shower facilities, tight fitting door, water supply and discharge connection shall be provided by the Building Contractor and located at the exit(s) of the A/C plant room where the central refrigeration plant is installed.

The plant shall be so selected and installed with sufficient space allowed for effective heat dissipation to surrounding air, and for easy maintenance and servicing.

Appropriate corrosion resistant materials and assembly methods shall be used including isolation of dissimilar metals against galvanic interaction, etc.

Mounting and fixing details including details and dimensions of equipment bases, fixing bolts, supporting steelwork, flexible connections, vibration isolators and any special builder's work requirements, etc. shall be provided in good time to meet the building programme.

Any damage to finishes of the equipment which may have occurred during transit, storage, installation or other causes shall be made good in the manner recommended by the manufacturer and to the satisfaction of the Supervising Officer. Same type of paint shall be used for making good the damages.

Apart from the fixed maintenance platform provided by the Building Contractor as indicated on the Drawings, removable rigid working and service platform shall be equipped for the easy inspection and maintenance of the refrigeration plant and associated equipment. The platform shall be assembled from galvanised steel structure or fibreglass reinforced polyester with stainless steel fixing bolts, nuts and washers, and accessories approved by the Supervising Officer.

All mounting and fixing supports shall be of galvanised steel and exposed metal surface after cutting shall be treated against corrosion and painted in accordance with Part 1 of this General Specification.

6.1.6.2 LAYOUT AND ISOLATION OF PLANT COMPONENTS

The plant layout shall be so arranged with physical division and valves such that any plant component may be isolated for servicing without completely draining the refrigerant or water circuits of the whole plant and shall follow the ANSI/ASHRAE 15-2019 and ANSI/ASHRAE 34-2019 or BS EN 378-2:2016 to BS EN 378-3:2016+A1:2020. All equipment shall be located within safety marking perimeter. Clear floor safety marking in durable brilliant colour approved by the Supervising Officer shall be provided.

Motor control centre and central monitoring and supervisory console shall be installed inside a control room which is free from water pipes with double glazing window for plant viewing provided by the Building Contractor.

6.1.6.3 REFRIGERATION PIPEWORK AND FITTINGS

Joints in copper pipe shall be flanged, flared (up to 20 mm OD only), or brazed with or without capillary fittings.

Joints in steel pipe shall be flanged or welded. Mitre or segmented bends will not be accepted.

Screwed joints will not be accepted in refrigerant pipes except on the equipment accessories. In such cases, the thread shall either be of taper form and used in conjunction with PTFE tape or an anaerobic sealant, or of parallel form associated with machined joint faces and a suitable joint.

Plastic pipe with compression fittings will be accepted for feed piping to control cabinet door mounted pressure gauges and similar fittings. The grades of pipe used shall withstand the test pressure applied and the effects of refrigerant and oil. Plastic pipe will not be accepted for any other refrigerant pipework.

Compression fittings will not be accepted on refrigerant pipework.

Refrigerant pipework shall not be arranged for running compressors in parallel (i.e. with common suction and/or discharge pipes). The use of multi-compressors each having an independent refrigerant circuit in a common evaporator will be permitted provided pressure tests between adjacent refrigerant circuits in the evaporator are carried out during manufacturing.

The pipework shall be so arranged that oil in the refrigerant leaving the compressor (and passing any oil separator fitted) shall be carried through the system and back to the compressor at the lowest stage of capacity unloading.

Pipework shall be firmly supported and secured to minimise vibration. Vibration eliminators shall be fitted to the compressor suction and discharge pipes to minimise transmission of vibration or noise. Where indicated, a gas pulsation damper shall be fitted at the refrigerant discharge pipe, in the plant room, as close as possible to the refrigeration compressor.

All parts and components containing refrigerant shall be clean and dry before they are connected to the system. No mill scale shall be permitted in pipes and all pipes shall be capped on Site until welded in. Prior to charging refrigerant to the refrigeration system, field pressure tests shall be carried out in accordance with Part 2. Any leak found shall be repaired before the system can be considered tight.

Hangers, clips and other hanging or clamping studs shall be galvanised and they shall not be welded to tubes and pressure vessels containing refrigerant. Pipework and other parts shall be erected and clamped so that vibration and noise are kept to minimum.

Both insulated and uninsulated components, pipes and vessels shall be cleaned and painted with anti-corrosion primer. Finished coatings shall be applied to uninsulated metals. Insulated vessels shall be supported on high density insulation material at the support cradles.

The air-conditioning installation works in connection with the handling (including installing, commissioning and testing) of hydrofluorocarbon (HFC) and blend type refrigerants shall be undertaken by a minimum percentage of workers who shall have a valid certificate of completing satisfactorily the relevant refrigerant handling training courses organised by the recognised association as specified in the contract. Upon request, details and particulars of these workers shall be submitted to the Supervising Officer for approval.

All installed pipework for blended refrigerant shall not be pressurised with refrigerant and air. Blowing of the refrigerant pipework shall not be done by means of the blended refrigerant mixed with air. Particular attention and precaution shall be paid when handling the blended refrigerant pipework installation. For charging of refrigerant to the system, the recommendations from the supplier and the procedures stipulated in the Testing and Commissioning Procedure for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control Systems Installation in Government Buildings Hong Kong shall be followed. The work shall also be carried out by trained and qualified persons approved by the Supervising Officer.

6.1.6.4 AIR-COOLED PACKAGED REFRIGERATION MACHINE

6.1.6.4.1 Installation Requirements

(a) When lifting the unit to position, clevis connectors shall be installed through the lifting plates provided on the unit. Required lifting beam dimensions shall comply with the manufacturer's recommendations. To prevent unit damage, the lifting beam shall be positioned so that cables will not be in contact with the unit or otherwise appropriate protection shall be applied on the unit casing.

(b) If the unit is installed on spring isolators, it shall be located on the isolators and the isolators shall be securely fixed to the roof curb structure. The requirements on strength of the roof curb structure shall be advised according to the manufacturer's recommendations. Selection of the spring isolators shall be submitted to the Supervising Officer for approval prior to execution of work.

(c) The unit shall be installed so that air can circulate through the condenser coils without any hindrance, and the air discharged from the condenser fans is not recycled. If the unit has to be placed near a wall or an obstacle that may prevent satisfactory air circulation, sufficient distance as recommended by the manufacturer shall be maintained between the unit and the obstacle. The location to install the unit shall be submitted to the Supervising Officer for approval prior to execution of work.

(d) Adequate clearance opposite to the evaporator connections as recommended by the manufacturer shall be allowed so that cleaning of the tubes and maintenance of the evaporator can be carried out. Sufficient space shall be allowed at each end of the unit for opening the fan access panel and the starter door.

(e) All components such as control panels, indicating lights and gauges shall be housed in a weatherproof, watertight, and anti-corrosion metal cabinet with lockable door. The components shall be neatly and tidily arranged within the cabinet with proper labelling in both English and Chinese. A clear and precise circuit diagram, service and safety instructions for the refrigeration

machine separately enclosed in waterproof enclosures shall be provided in a conspicuous position within the cabinet.

(f) Rigid sun/rain shelter in front of the control panel, starter and equipment cabinet of each refrigeration machine unit shall be provided. The shelter shall be constructed of minimum 2 mm thick galvanised sheet steel and reinforcement framework or FRP materials. Rim inclining downward along the edges of the shelter or similar provision shall be provided to prevent water from flowing to the underside of the shelter and dripping onto the control panels or equipment cabinets. All metal work shall be treated with suitable anti-corrosion paintings. The shelter shall be made of adequate sizes to cover the above-mentioned panels and cabinets and extend at least 1 m in depth from the refrigeration machine to provide a protective cover for the panels and cabinets, and for the servicing personnel, to the satisfaction of the Supervising Officer.

6.1.6.4.2 Water Piping Connection

(a) All water piping to the unit shall be thoroughly flushed before making the final piping connections to the unit.

(b) To avoid possible equipment damage, untreated or improperly treated system water shall not be used.

(c) Sufficient vents shall be provided at high points in the piping to bleed air from all water circuits. Necessary pressure gauges shall be installed to monitor the entering and leaving water pressures. Shutoff valves shall be provided between the pressure tapping point and the pressure gauge to enable the gauge to be replaced and the zero point to be checked while the plant is running.

(d) Temperature sensor and flow meter shall be installed in the water circuits to measure the leaving and entering water temperatures of chiller evaporator, chilled water flow rate and decoupler flow etc., for determining potential energy saving opportunities for continuous commissioning of chilled water system. A balancing valve shall be installed in the leaving water line for water flow balancing.

(e) Shutoff valves shall be installed in both the entering and leaving water lines to the evaporator so that the evaporator can be isolated for maintenance when required.

(f) A pipe strainer shall be installed in the entering water line to prevent water-born debris from entering the system.

(g) Vibration eliminator shall be installed in the entering and leaving water lines to the unit.

(h) A shutoff valve shall be installed in the drain line of the evaporator.

(i) A water pressure relief valve shall be installed in the evaporator water system.

6.1.6.4.3 Installation and Connection of Temperature Sensors

(a) To enable the sensor to read a well-mixed leaving and entering water temperature of chiller evaporator, the sensor finger shall be positioned at a substantial distance from the evaporator and avoid placement near elbows.

(b) Thermo-contact paste shall be put on each sensor finger before inserting the sensor to ensure better thermal conductivity. The bottom of the sensor shall be in touch with the sensor finger.

6.1.6.4.4 Installation of Flow Sensing Devices

(a) Flow switch or differential pressure switch with pump interlocks shall be installed to sense system water flow. The flow switch shall be installed in series with the pump interlocks to protect the refrigeration machine.

(b) The flow switch shall be mounted upright, with a minimum of 5 pipe diameters straight, horizontal run on the water circuit. The flow switch shall not be installed close to elbows, orifices or valves.

6.1.6.4.5 Installation of Energy Metering Devices

(a) Electricity meters and thermal energy meters shall be installed to continuous measure, record and monitor the electricity consumption, energy input and output, cooling/heating power, coefficient of performance, and energy performance for each refrigeration machine. Independent electricity meters and thermal energy meters in accordance with ASHRAE Guideline 14-2014 and ASHRAE Guideline 22-2012 shall be provided to measure the energy performance of the whole refrigeration system.

(b) Ambient temperature sensors shall be installed to continuous measure, record and monitor the outside air temperature, outside air dry-bulb, and relative humidity for the whole refrigeration system.

(c) The electricity meters in accordance with ANSI C12.1-2014, and ANSI C12.20-2015 or IEC 62053-22:2020, IEC62058-11:2012, IEC62058-21:2012 and IEC 62058-31:2012 shall be installed with 10 years certified life.

(d) Thermal energy meters in accordance with ANSI C12.20-2015 and IEC 62053-21:2003+A1:2016, IEC62058-11:2012, and IEC62058-21:2012 shall be installed with 10 years certified life.

(e) Type test report of the electricity meters and thermal energy meters shall be submitted to the Supervising Officer for approval prior to execution of work.

(f) The electricity meters and thermal energy meters shall be connected to Central Control Monitoring System, if such system is provided, to optimise the operation of the refrigeration system. The measurement and data collection details shall comply with the Code of Practice for Energy Efficiency of Building Services Installation.

6.1.6.5 WATER-COOLED PACKAGED REFRIGERATION MACHINE

6.1.6.5.1 Installation Requirements

(a) When lifting the unit to position, clevis connectors shall be installed through the lifting plates provided on the unit. Required lifting beam dimensions shall comply with the manufacturer's recommendations. To prevent unit damage, the lifting beam shall be positioned so that cables will not be in contact with the unit or otherwise appropriate protection shall be applied on the unit casing.

(b) Elastomeric isolation pads shall be installed on the foundation for the unit to isolate the vibration of the unit. The strength and mass of the foundation to support the unit operating weight shall be advised.

(c) Sufficient space shall be allowed around the unit for unrestricted free access of the Installations and maintenance personnel to all service points. Adequate clearance as recommended by the manufacturer shall be allowed so that cleaning of the tubes of the evaporator and condenser and maintenance of the various components can be carried out effectively. Sufficient vertical clearance above the unit shall also be allowed. No services such as ductworks and water pipes shall be located over the compressor motor.

6.1.6.5.2 Water Piping Connection

(a) All water piping to the unit shall be thoroughly flushed before making the final piping connections to the unit.

(b) To avoid possible equipment damage, untreated or improperly treated system water shall not be used.

(c) Sufficient vents shall be provided at high points in the piping to bleed air from the water circuits. Necessary pressure gauges shall be installed to monitor the entering and leaving chilled or hot/condensing water pressures. Shutoff valves shall be provided to the gauges to isolate them from the system when required.

(d) Thermometers shall be installed in the lines to monitor entering and leaving chilled and condensing water temperatures. A water balancing valve shall be installed in the leaving chilled or hot/condensing water lines for water flow balancing.

(e) Shutoff valves shall be installed in both the entering and leaving chilled or hot/condensing water lines so that the evaporator and condenser can be isolated for maintenance and servicing when required.

(f) A pipe strainer shall be installed in the entering chilled or hot/condensing water lines to prevent water-born debris from entering the system.

(g) Vibration eliminator shall be installed in the entering and leaving chilled or hot/condensing water lines to the unit.

(h) A shutoff valve shall be installed in the drain line of the evaporator and condenser.

(i) A water pressure relief valve shall be installed in the evaporator and condenser water system.

6.1.6.5.3 Installation and Connection of Temperature Sensors

(a) To enable the sensor to read a well-mixed leaving and entering water temperature of chiller evaporator, the sensor finger shall be positioned at a substantial distance from the evaporator and avoid placement near elbows.

(b) Thermo-contact paste shall be put on each sensor finger before inserting the sensor to ensure better thermal conductivity. The bottom of the sensor shall be in touch with the sensor finger.

6.1.6.5.4 Installation of Flow Sensing Devices

(a) Flow switches or differential pressure switches with pump interlocks shall be installed to sense system water flow. The flow switches shall be installed in series with the pump interlocks for either chilled or hot/condensing water circuits to protect the machine.

(b) The flow switch shall be mounted upright, with a minimum of 5 pipe diameters straight, horizontal run on the water circuit. The flow switch shall not be installed close to elbows, orifices or valves.

6.1.6.5.5 Installation of Energy Metering Devices

(a) Electricity meters and thermal energy meters shall be installed to continuous measure, record and monitor the electricity consumption, energy input and output, cooling/heating power, coefficient of performance, and energy performance for each refrigeration machine. Independent electricity meters and thermal energy meters in accordance with ASHRAE Guideline 14-2014 and ASHRAE Guideline 22-2012 shall be provided to measure the energy performance of the whole refrigeration system.

(b) Ambient temperature sensors shall be installed to continuous measure, record and monitor the outside air temperature, outside air dry-bulb, and relative humidity for the whole refrigeration system.

(c) The electricity meters in accordance with ANSI C12.1-2014, and ANSI C12.20-2015 or IEC 62053-22:2020, IEC62058-11:2012, IEC62058-21:2012 and IEC 62058-31:2012 shall be installed with 10 years certified life.

(d) Thermal energy meters in accordance with ANSI C12.20-2015 and IEC 62053-21:2003+A1:2016, IEC62058-11:2012, and IEC62058-21:2012 shall be installed with 10 years certified life.

(e) Type test report of the electricity meters and thermal energy meters shall be submitted to the Supervising Officer for approval prior to execution of work.

(f) The electricity meters and thermal energy meters shall be connected to Central Control Monitoring System, if such system is provided, to optimise the operation of the refrigeration system. The measurement and data collection details shall comply with the Code of Practice for Energy Efficiency of Building Services Installation.

6.1.6.6 AIR-COOLED CONDENSER

Air cooled condensers mounted outside buildings shall have weatherproof fan motors. The units shall discharge air vertically upwards. If specified to discharge horizontally, they shall be protected by an integral wind deflector or purpose-made baffle. The structure and casing of units shall be constructed of material which is either corrosion resistant or treated against corrosion after manufacture in the factory.

The unit shall be installed on vibration isolation devices as specified in Sections 6.1.8 and 6.2.8. The requirements on strength of the roof curb structure for supporting the unit shall be advised according to the manufacturer's recommendation. Selection of the vibration isolators shall be submitted to the Supervising Officer for approval prior to execution of work.

The unit shall be installed so that air can circulate through the condenser coils without any hindrance, and the air discharged from the condenser fans is not recycled. If the unit has to be placed near a wall or an obstacle that may prevent satisfying air circulation, sufficient distance as recommended by the manufacturer shall be maintained between the unit and the obstacle.

6.1.6.7 AIR-COOLED EVAPORATOR

The cooling unit shall be dehydrated, charged with an inert gas, pressure tested and sealed after manufacture.

6.1.6.8 COOLING TOWER

The fiber-reinforced plastic (FRP) warm water distribution or hot water basin shall be covered by removable FRP covers that keep out sunlight and give a finished appearance to the tower. The cold water basin shall be supported by a structural beam assembly provided by the cooling tower manufacturer. Builder's work supports by the Building Contractor, exact tower orientation and architectural aesthetic consideration shall be submitted in sufficient time according to the building programme to the Supervising Officer for approval.

The make-up water pipe inlet shall be fitted with a strainer and flow meters capable of being used to record the maximum rate of make-up water in m^3/hr, and the make-up water consumption in m^3. Isolation valves, unions, and by-pass valve shall be provided to facilitate meter removal for maintenance and servicing.

A bleed-off pipe with stop valve and flow regulating device shall be provided on each cooling tower to flushing tank for bleed-off water reuse or to the nearest builder's drain for discharging to the public sewerage prior to the approval of discharge license from the Environmental Protection Department.

Water sampling points shall be provided for taking water samples for cooling water and bleed-off water for bacterial test. The water sampling pipe shall be as short as possible to minimise the amount of stagnant water in the pipe. The sampling tap shall be run for at least 30 seconds with cooling water/bleed-off water discharged to drainage system prior to sampling.

Control and chemical or ozone treatment plants shall be located near to the cooling towers and they shall be installed inside a covered plant room/space with proper ventilation.

6.1.6.9 VIBRATION ISOLATION

All plants offered shall have minimum vibration and noise levels during operation, with particular attention to the sound pressure level requirements from different sources while all plants operating in full capacity shall comply with the requirements of the EPD or other statutory noise control requirements issued prior to tendering, whichever is more stringent. Provision of adequate vibration isolation and/or sound attenuation measures for the refrigeration plant to meet the requirements as detailed in Sub-sections regarding

Noise and Vibration Control of this Part and to the satisfaction and acceptance of the Supervising Officer.

6.1.6.10 ELECTRICAL WORK

The works shall include the supply and installation of power cables, cable trays, G.I. supports, starters/motor drives, isolators, control, safety earth bonding and all necessary accessories to connect power from the isolator to each electricity-driven equipment.

SUB-SECTION 6.1.7

ELECTRIC MOTORS AND ELECTRICAL EQUIPMENT

6.1.7.1 LOW VOLTAGE-GENERAL

All low voltage electrical equipment necessary for the completion of the Installations shall be supplied and installed under the Contract. The works shall include all necessary wiring from the points of power supply provided by others as indicated on the Drawings.

Essential electrical equipment, such as motor control cubicle for A/C plant, shall be segregated from water services such as chilled/condensing water pipes and other plumbing/drainage services to avoid accidental breakdown of the main power supply for A/C system due to water damage from pipe bursting or leakage.

All electrical equipment, wiring and installation work, and materials shall comply with Part 7 of this General Specification.

Motor arranged for automatic restart shall have a label of durable material permanently fixed to it and in a prominent position clearly inscribed.

6.1.7.2 LOW VOLTAGE VARIABLE SPEED DRIVES

Variable speed drives shall be either wall mounted or floor mounted in a well ventilated location and in accordance with the manufacturer's standard installation recommendations.

The drives shall be located away from any nearby water pipework to avoid possible damage by water leaking or water pipe bursting. In case that such location could not be identified, necessary protective means to avoid the damage shall be provided.

The distance between the drives and the controlled motors shall be within the range as recommended by the manufacturer. Calculations including the selection of interconnecting cable sizes shall be submitted to the Supervising Officer to substantiate that the overall performance can meet the manufacturer's requirements.

For essential air conditioning services subject to the approval of the Supervising Officer and requiring to meet special building functions and client's operational requirements, all major and essential electric motor drives in the air conditioning systems shall be configured in such a way that there is a minimum chance of serious interruption and/or breakdown of the entire plant operation due to a single point of failure for major and essential electric motor drives in the systems.

Redundancy and/or backup provisions such as installation of alternate variable speed drive or motor starters for maintenance by-pass of the duty variable speed drives in the motor control equipment and ancillaries shall be provided if specified in the Particular Specification or Drawings.

6.1.7.3 LOW VOLTAGE AUTOMATIC POWER FACTOR CORRECTION CAPACITORS

The capacitor bank shall be wall or floor mounting cubicle-type, built up from static primary capacitor unit. The capacitor bank together with its associated equipment shall not be installed inside the switchboard, where practicable. However, if it is not practical due to physical constraint or other justified reasons, the equipment shall be installed in a separate compartment segregated from the rest of the switchboard.

SUB-SECTION 6.1.8

NOISE AND VIBRATION CONTROL

6.1.8.1 GENERAL

Noise and vibration control provisions on plant/equipment, interconnected piping, ductwork and conduit shall be provided so that when the installed plant/equipment are put into operation, the resulting noise and vibration levels at locations within the building and at adjacent or nearby buildings shall not exceed the acceptable limits.

Unless otherwise specified in the Particular Specification, the total noise level in occupied areas within the building, whether it be airborne, structure-borne or ductwork-borne, shall not exceed the specified noise criteria in ASHRAE Handbook – Fundamental to all areas as measured at a level of 1.2 to 1.8 m above the floor. The measuring points shall avoid exact geometric centre of the room and any location within 1m of a wall, floor, or ceiling of the rooms.

The major noise sources include chillers, water cooling towers, fans (duct type and centrifugal) and ducts etc., shall be identified so that when assessed in accordance with the Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites issued by the EPD, the level of the intruding noise at the façade of the nearest sensitive receiver shall be at least 5 dB(A) below the acceptable noise level (ANL) shown in the Technical Memorandum, or in the case of the background being 5 dB(A) lower than the ANL, shall not be higher than the background, in accordance with Chapter 9 of the Hong Kong Planning Standards and Guidelines. Noise prediction /assessment report shall be submitted to prove that the noise level from the major noise sources as mentioned above at identified noise sensitive areas (NSRs) complies with the recommended criteria.

6.1.8.2 EQUIPMENT BASES

6.1.8.2.1 General

Floor mounted equipment shall be installed on 100 mm high concrete housekeeping pads provided by the Building Contractor covering the whole floor area requirements of the equipment bases plus a minimum of 150 mm further on each side or on inverted beams at roof. Vibration isolators are then mounted on this concrete pad or inverted beams.

Unless otherwise specified in the Particular Specification, plant/equipment to be isolated shall either be supported by structural steel bases or concrete inertia bases.

6.1.8.2.2 Welded Structural Steel Bases

Detailed calculation and drawings of the base and its anti-vibration isolator arrangements shall be submitted for approval by the Supervising Officer before manufacture.

6.1.8.2.3 Concrete Inertia Bases

Detailed calculation and drawings of the base and its anti-vibration isolator arrangements shall be submitted for approval by the Supervising Officer before manufacture.

6.1.8.3 VIBRATION ISOLATORS

The following types of vibration isolation mountings or suspensions are not exhaustive but serve to cover the main types that shall be applied as appropriate unless otherwise stated in the Particular Specification.

6.1.8.3.1 Type 'A' - Free Standing Spring Mounts

Springs shall be corrosion-protected and the ends of the springs shall remain parallel.

Submittals for approval shall include spring diameters, "compressed" spring height, "solid" spring height, rated capacities and rated deflections.

6.1.8.3.2 Type 'B' - Restrained Spring Mounts

A minimum of 10 mm clearance shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operations.

6.1.8.3.3 Type 'C' - Double Deflection Neoprene Mounts

These mountings shall have a minimum static deflection of 8.5 mm. Bolt holes shall be provided for applications where bolting down is required. They shall be carefully positioned such that all supporting mounts would be properly loaded and the weight load on each mount would be evenly distributed over the entire surface.

6.1.8.3.4 Type 'D' - Neoprene Pads

Where necessary, pads may be bolted through with bolts isolated from the machine by neoprene grommets. Alternatively, "waffled" neoprene pads can be used without holding down bolts where the vibration is minimal and the weight of machine is such that the resultant friction is adequate and the machine is unlikely ever to move. They shall be carefully positioned such that all supporting pads will be properly loaded and the weight load on each pad will be evenly distributed over the entire surface.

6.1.8.3.5 Type 'E' - Spring Hangers

Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.

Submittals for approval shall include scale drawing of the hanger showing its 30° to 35° swing capability.

Application - See relevant clauses for pipework vibration isolation and ductwork vibration isolation.

6.1.8.3.6 Type 'F' - Spring and Double Deflection Neoprene Hangers

Submittals for approval shall include scale drawing of the hanger showing its 30° to 35° swing capability.

Application - See relevant clauses for pipework vibration isolation and ductwork vibration isolation.

6.1.8.3.7 Type 'G' - Pre-Compressed Spring Hangers

Submittals for approval shall include scale drawing of the hanger showing its 30° to 35° swing capability.

Application - See relevant clauses for pipework vibration isolation and ductwork vibration isolation.

6.1.8.3.8 Type 'H' - All Directional Anchor Units

Submittals for approval shall include rated capacities and rated deflections.

Application – The units may use to provide high frequency noise and vibration isolation for those locations where movement shall be controlled.

6.1.8.3.9 Type 'I' - Pipe Anchors and Guides

Submittals for approval shall include rated capacities and rated deflections.

6.1.8.3.10 Type 'J' - Split Wall/Floor Seals

The seals shall be tightened around the pipes to eliminate clearance between the inner sponge faces and the piping.

Concrete may be packed around the seals to make it integral with the floors, walls or ceilings if the seals are not already in place around the pipes prior to the construction of the building members.

Seals shall project a minimum of 25 mm past either face of the walls.

Application – The seals may be used to prevent noises generated within equipment rooms or plant rooms from leaking through the spaces around piping which pass through walls, ceilings or floors of these rooms.

6.1.8.3.11 Type 'K' - Horizontal Thrust Restrains

The assembly shall be furnished with one threaded rod and two angle brackets for attachment to both the equipment and ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centre line of thrust and symmetrically on either side of the unit.

6.1.8.3.12 Type 'L' - Built in Inertia Block Plant Support

Where specified, plant foundations and housekeeping pads in form of large concrete blocks recessed into the main floor slab shall be provided.

6.1.8.4 PLANT/EQUIPMENT VIBRATION ISOLATION

6.1.8.4.1 General

All rotating or reciprocating equipment shall be mounted on vibration isolation mountings or suspended from vibration isolation hangers.

There shall have no rigid connection in whatever form between the isolated equipment and the building structure which will otherwise short-circuit the vibration isolation system and degrade its performance. This includes the necessary co-ordination with other trades.

All isolators shall operate in the linear portion of their load versus deflection curve. The load versus deflection curves shall be furnished by the manufacturer, and shall be linear over a deflection range of not less than 50% above the design deflection.

All vibration isolators shall have their known undeflected heights or calibration markings so that, after adjustment when carrying their loads, the deflection under load can be verified, thus determining that the load is within the proper range of the device and that correct degree of vibration isolation is achieved according to the design.

The static deflection of the isolator at each support point shall not differ from the design objective for the equipment as a whole by more than ±10%.

The ratio of lateral to vertical stiffness for spring shall be neither less than 0.9 nor greater than 1.5.

The installation of all vibration isolators, hangers and associated equipment bases shall be carried out strictly in accordance with Drawings, the approved manufacturer’s written instructions, and where indicated under the direct supervision of the manufacturer’s representative.

6.1.8.4.2 Method of Installation

The equipment structural steel or concrete inertia base shall be placed in position and supported temporarily by blocks or shims. The machinery

shall then be installed on the base and when that is complete, the isolators are to be installed without raising the machine and frame assembly.

After the entire Installations is complete and under full operational load, the isolators shall be adjusted such that the load, are transferred from the blocks to the isolators. When all isolators are properly adjusted, the blocks or shims will become slightly free and can then be removed.

The springs of vibration isolators shall in general have a loaded working height equal to 1.0 to 1.5 times the outside diameter of the spring and shall be capable of being compressed to approximate 50% of their unloaded height.

Where any vibration isolation system permits equipment motion in all directions, provide where necessary additional resilient restraints shall be provided where necessary to flexibly limit the lateral movement of the equipment to 6 mm at start and stop.

Prior to start-up, remove all foreign matter underneath the equipment base and verify that the vibration isolation system is not short-circuited.

Electrical circuit connections to isolated equipment shall be looped to allow free motion of isolated equipment.

6.1.8.5 PIPEWORK VIBRATION ISOLATION

6.1.8.5.1 General

Unless otherwise indicated, all piping located in mechanical equipment room and having connection to vibrating equipment shall be isolated from the building structure by means of noise and vibration isolation hangers for a distance of at least 15 m or 100 times the pipe diameter from the vibrating equipment, whichever is the greater. At least three of the first hangers from the equipment shall provide the same deflection as the equipment isolators, with a maximum limitation of 50 mm deflection. The first three hangers adjacent to the equipment shall also be of "positioning" or "pre-compressed" type, to prevent load transfer to the equipment flanges when the piping system is filled. This "floated" pipe run shall include, where situation permits, bends in two mutually perpendicular directions in order to give three degrees of freedom of movement, with approximately equal distance between successive elbows or bends.

All piping over 50 mm in diameter and for any piping suspended below or near noise-sensitive areas shall be suspended by vibration isolated hangers. Hangers adjacent to noise-sensitive areas shall be Type ‘F’.

For floor-supported piping in equipment rooms or adjacent to isolated equipment, the vibration isolators shall be selected appropriately. The first two adjacent floor supports shall be Type ‘B’, with a blocking feature

that prevents load transfer to equipment flanges as the piping is filled or drained.

Where specified in the Particular Specification, all horizontal and vertical pipework throughout the building which has connection to vibrating equipment shall also be isolated from the building structure by means of noise and vibration isolation guides and supports.

All piping to be isolated shall freely pass through walls and floors without rigid connections. Penetration points shall be sleeved or otherwise formed to allow passage of piping, and a clearance of 10 to 15 mm around the outside of the piping shall be maintained. This clearance space shall be tightly packed with glass fibre or rock wool and caulked airtight after installation of piping. Alternatively, factory fabricated Type 'J' split wall/floor seals may be used.

The inlet and outlet connections of all vibrating equipment shall be fitted with either flexible connectors or flexible hoses as appropriate.

6.1.8.5.2 Horizontal Pipe Isolation

Where horizontal pipe isolation is required, the first three pipe hangers in the main line near the mechanical equipment shall be of Type 'G' and the hangers for the horizontal run in all other locations shall be of Type 'E' or Type 'F', the latter being used for more sensitive situations where a higher degree of noise and vibration attenuation is required.

Type 'G' hangers shall have the same static deflection as that of the mountings under the connected equipment. Type 'E' and Type 'F' hangers shall have a minimum deflection of 20 mm.

6.1.8.5.3 Pipe Riser Isolation

Where pipe riser isolation is required, the pipe risers to be isolated shall be suspended from Type 'G' hangers or supported by Type 'B' mountings and anchored with Type 'I' pipe anchors or guided by Type 'I' pipe guides. Steel spring deflection shall be a minimum of 20 mm except in those expansion locations where additional deflection is required to limit deflection or load changes to within plus or minus 25% of the initial stress.

6.1.8.5.4 Flexible Connectors

Flexible connectors shall be fitted to the inlet and outlet connections of all pumps, water chillers, refrigeration machine, water towers and other centrifugal or reciprocating vibrating equipment.

Flexible connectors shall be full line size of the equipment connection and fitted as close to the source of vibration as is practicable. Straight connectors shall, where practicable, be installed in a position that is parallel to the equipment shaft as equipment vibration tends to be most severe in a direction radial to the shaft.

All flexible connectors shall be provided with end restraint to counteract the pressure thrust.

Manufacturers' recommendations on restraints, pressure, and temperature limits shall be strictly followed during the installation. The space for installation shall be measured and recorded before installation.

6.1.8.5.5 Flexible Metallic Hose

For higher operating temperatures and pressures, vibrational movement generated by pumps, chillers, refrigeration machine, water towers, air handling units and other centrifugal or reciprocating vibrating equipment shall be accommodated by braided flexible metallic hoses. Allowable stress levels shall be within the units as prescribed in PD 5500: 2018+A1:2018.

The lengths of the flexible metallic hoses shall be in accordance with manufacturer's recommendation.

Since the braid is stretched taut by the pressure in the axial direction, hoses cannot accept axial motion. Therefore, the hoses shall be installed on the equipment side of the shut off valves and be installed parallel to the shaft for best performance so that the vibration movement is perpendicular to the axis of the hose. A Type 'I' pipe anchor capable of withstanding the deflection forces generated by the flexible hose shall be installed immediately after the hose in order to force the hose to flex transversely, otherwise the hose will serve little purpose.

Two hoses at right angles to each other shall be provided when major vibrational motions to be isolated exist in two planes.

6.1.8.6 DUCTWORK VIBRATION ISOLATION

Flexible connections shall be provided between the vibrating equipment and the ductwork. Thrust restraints shall be used to maintain a slack position of the flexible ductwork connections.

Unless otherwise specified, all discharge ductwork which runs for a distance of 15m from the connected vibrating equipment with a discharge pressure of 1kPa or above shall be isolated from the building structure by means of Type 'E' hangers provided with top and bottom eye bolts for flat iron hanger strap and ductwork strap respectively. Spring deflections shall be minimum 20 mm.

Except where the ductwork passing through compartment walls requires a fire damper, all ductwork to be isolated shall freely pass through walls and floors without rigid connections. Penetration points shall be sleeved or otherwise formed to allow passage of ductwork, and a clearance of 20 to 32 mm around the outside surfaces of the ductwork shall be maintained. This clearance space shall be tightly packed with glass fibre, caulked airtight and sealed with approval sealant after installation of ductwork.

In case where fire damper is required, ductwork to be isolated shall be fitted with a flexible joint on the side of the fire damper where the vibration is originated.

6.1.8.7 DUCTWORK ACOUSTIC INSULATION

Acoustic linings shall not be applied to the interior of the ductwork unless otherwise specified.

Transverse joints of the ductwork liner board shall be neatly butted and there shall be no gap in between the board shall be cut to assure tight, overlapped corner joints. Board shall be adhered to the sheet metal ductwork with 100% coverage of adhesive conforming to ASTM C916-20: Standard Specification for Adhesives for Duct Thermal Insulation, and all exposed edges and joints shall also be coated with adhesive. Board shall be additionally secured with mechanical fasteners which shall start with 75 mm of the upstream transverse edges and 75 mm from the longitudinal joints and be spaced at a maximum of 150 mm centres around the perimeter of the ductwork and 100 mm from corner joints. Elsewhere the fasteners shall be spaced at a maximum of 150 mm centres in the direction across width of ductwork and 400 mm centres in the direction along length of ductwork and not more than 75 mm from longitudinal joints and 100 mm from corner joints. Entering and leaving edges of the ductwork liner boards shall be provided with continuous sheet metal edge protectors.

Ductwork internal linings shall not be installed within 1 m of the fire damper.

Dimensions of lined ductwork are to be clear inside dimensions after lining has been installed.

6.1.8.8 ACOUSTIC DUCTLAG

Acoustic duct lag shall be applied, only where indicated, to the exterior of the work to prevent noise break-in or breakout through the duct wall.

The acoustic duct lag shall be installed in such a way that the material is completely decoupled from the vibrating duct wall. Installation details shall be submitted to the Supervising Officer for approval prior to installation.

6.1.8.9 DUCTWORK SILENCERS

Ductwork silencers shall be supplied and installed as indicated in the Particular Specification or Drawings.

Mani folded silencers shall be installed with continuous metallic nosing crimped in place. Nosing pieces and tails shall be provided as per manufacturer’s design.

Before ordering ductwork silencers, the proposed manufacturer’s certified test data for pressure drop and insertion loss ratings shall be submitted for the Supervising Officer’s approval

The silencers shall be located at least three ductwork equivalent diameters from fans, coils, elbows, branch take offs, or other ductwork elements.

6.1.8.10 ACOUSTIC DOORS

Proprietary acoustic doors shall be supplied and installed to plant rooms only where specified in the Particular Specification or Drawings.

6.1.8.11 ACOUSTIC LOUVRES

Acoustic louvres to the external walls of plant rooms shall be supplied and installed only where specified in the Particular Specification or Drawings.

6.1.8.12 ACOUSTIC ENCLOSURES

6.1.8.12.1 General

Where specified for in the Particular Specification or Drawings, double-wall, insulated, and air-pressure-tight acoustic enclosures for housing noisy plant or machinery shall be provided as specified and installed in strict accordance with the installation details and instructions from the specialist manufacturer in order to achieve the published standards of construction and performance.

6.1.8.12.2 Access Doors and Louvres

When required as shown on the Drawings, access doors and louvres forming part of the complete acoustic enclosures shall be of acoustic type and be so fixed and installed without degrading the acoustical performance.

6.1.8.12.3 Openings and Sealing

All openings with dimensions greater than 150 mm shall be factory/workshop cut and framed.

The clearance space between the acoustic enclosure and any ductwork, pipes, or conduits passing through the enclosure shall be tightly packed with glass fibre or rock wool and sealed with approved sealant. Both ends of the opening shall then be covered up by 1.2 mm thick sheet steel and sealed airtight by high pressure ductwork sealer.

6.1.8.13 PLANT ROOM ACOUSTIC LININGS

Where specified in the Particular Specification or Drawings, acoustic linings to walls and / or ceilings of the plant rooms shall be supplied and installed in order to reduce the reverberant noise levels of the plant rooms.

The wall liner board shall be secured by 1.5 mm thick galvanised steel 'z' or channel sections of 50 mm deep which shall be firmly fixed to the wall surfaces at 600 mm intervals. The wall liner boards shall be protected by 0.8 mm thick galvanised perforated metal plates which shall be secured by self-tapping screws to the galvanised steel sections. The perforated metal plates shall be removable to enable future maintenance.

6.1.8.14 FLOATING FLOORS

In cases where machines are adequately mounted to reduce vibration transfer but emit transmittable noise into the air space of the plant room which is above a noise-sensitive area, it may be necessary to mount all the plant in the room on a floating floor.

Unless the situation is one of incorrect plant selection under the Works, the detailed design and construction for the floating floor will be provided by the Supervising Officer. Any Works for the Installation shall not undermine the acoustic performance of the air space formed under the floating floor.

In such situations, it is likely that the walls and ceiling will also be required to be acoustically treated by the specialist or Building Contractor. Again, any Works for the Installations shall not undermine the acoustic performance of the air space formed under the floating floor.

6.1.8.15 SPECIALIST MANUFACTURER'S INSPECTION

On completion of the installation of all noise and vibration control devices, the representative of the acoustic and vibration equipment/materials manufacturer shall inspect the completed system and report in writing concerning any installation errors, improperly selected isolation devices, and/or other faults that could adversely affect the overall performance of the system.

Report shall be submitted to the Supervising Officer in which the report shall include all findings of the manufacturer's representative and confirmation of the satisfaction completion of all isolation work together with any remedial actions proposal.

Where remedial action has to be taken, further inspections shall be carried out until all faults are rectified.

6.1.8.16 INDEPENDENT INSPECTIONS

In addition to the inspection of the Works by the specialist manufacturer's representative, independent parallel inspections and tests may be carried out by others under direct instructions of the Supervising Officer. Any deficiencies revealed by these inspections and tests shall be rectified at no additional cost to the Employer.

SUB-SECTION 6.1.9

PIPEWORK, VALVES, COCKS AND STRAINERS

6.1.9.1 GENERAL

This Sub-section covers pipework for: -

- Chilled or hot water circulation, vent & drain.
- Condensate drainage.
- Condenser cooling - fresh water circulation.
- Condenser cooling - sea or brackish water circulation.
- Make-up cold water supplies.

Pipework fitting and accessories for refrigerant systems shall read in conjunction with Sub-section 6.1.6 of this General Specification.

Pipework and valves for pneumatic control systems will be fully specified in the Particular Specification. When mild steel or malleable iron support and fixing accessories are called for, they shall be hot dip galvanised.

6.1.9.2 AUTOMATIC AIR VENTS

Automatic air vents shall be provided at all high points in the pipework. They shall be installed in the highest points of the sections where they are intended for venting.

If manual air vent to be provided, the air bottles shall be made from 50 mm size pipe, each approximately 230 mm long, fitted with a cap and 8 mm size air cock; they shall be fitted to equal tees or have 50 mm size connections if the main is 50 mm or above. Where an air bottle is fixed out of reach, an 8 mm extension tube shall be run from the cap to within 1.5 m of the floor and terminated with an 8 mm size needle-seated key-operated air cock.

6.1.9.3 BELLOW EXPANSION JOINTS/ANCHORS AND GUIDES

6.1.9.3.1 General

Movements of the pipework due to changes in temperature shall be accommodated by the natural flexibility of the pipework run or by bellow expansion joints, in either case allowable stress levels shall not be exceeded.

Where expansion joints are utilised, they shall be manufactured in accordance with the design philosophy for thin walled bellow membranes as laid down by the Expansion Joint Manufacturers Association (EJMA).

6.1.9.3.2 Axial Movement Pattern

Axial movement bellow expansion joints on all services shall comprise thin wall multi-plied omega formed convoluted bellows of stainless steel material to BS EN 10088-1:2014, BS EN 10029:2010, BS EN 10051:2010 and BS EN ISO 9445-1:2010, BS EN ISO 9445-2:2010of appropriate type. Bellows shall be argon arc welded to carbon steel end fittings utilising a stainless steel seal ring to reinforce the bellow cuff end with carbon steel flange or stainless steel flange.

The bellow expansion joint shall be provided with a close fitting stainless steel internal liner to reduce turbulent flow.

End termination to be carbon steel threaded male to ISO 7-1:1994/cor1:2007 or carbon steel flanges to ISO 7005-1:2011 Standard to suit the line pressures.

For copper or non-ferrous pipework systems expansion joints shall be manufactured in stainless steel throughout. The bellow expansion joints shall be installed with pre-cold setting to their required length to suit the temperature condition at the time of installation. The joints shall be rated suitable for the required amount of designed axial movement and shall be capable of performing the required cycles within the working life of the pipework. Mild steel outer protection sleeves shall be fitted to the bellows only when the units are open to the environment and exposed to risk of damage or when it is necessary to carry lagging over the joint.

Units shall be installed in strict accordance with the manufacturers' recommendations. Manufacturers of expansion joints shall be approved to ISO 9001: 2015.

6.1.9.3.3 Angular or Lateral Movement Pattern

These bellow expansion joints shall generally comply with the requirement as specified in this General Specification. Hinge and shackle or centre joining tube, tie bars and spherical nut arrangement shall be carbon steel to ISO 9692-1:2013 fully designed to contain the pressure thrust. End termination to be flanged to ISO 7005-1:2011 Standard to suit the line pressures.

The joints shall meet the required angular movement or the required movement in all directions perpendicular to the axis of the bellows.

6.1.9.3.4 Provision for Anchors and Guides

Anchors and guides shall be installed according to the recommendations of the expansion joint manufacturer and the details shall be submitted to the Supervising Officer for approval before manufacture commences.

(a) Anchors

Allowances shall be made for anchors capable of withstanding the maximum stresses created within the pipework system, and have

adequate safety margin. These shall be positioned as indicated on the layout drawings or as necessary shop drawing/details.

On steel pipework, the pipe shall be welded to the anchors via heavy steel straps. On copper pipework, the pipe shall be brazed to the anchors via heavy copper straps.

(b) Guides - Axial Movement Pattern

The pipework shall be guided along its length and the guides shall be capable of withstanding not less than 15% of the maximum stresses created within the pipework system and have an adequate safety margin.

Guides shall be adjustable in both directions in the lateral plane, so that pipework can be accurately aligned with the expansion joint.

Each guide shall not be less than 2 pipe diameters long and shall have a minimum manufacturing clearance of the pipe diameter.

The distance from the expansion joint to the first guide shall not be greater than 4 pipe diameters, and the distance between the first guide and the second guide shall not be more than 14 pipe diameters. Guides thereafter shall be spaced in accordance with normal pressure performance requirements as a minimum standard.

(c) Guides - Angular or Lateral Movement Pattern

Directional guiding shall apply, such as side plates, local to the expansion joint, the remainder of the pipework shall be supported in the nominal way, by roller or frictional supports, or pipework hangers.

A combination of axial, angular or lateral movement guides shall not be permitted.

6.1.9.4 CHANGES IN PIPE SIZE

Changes in pipe size can be facilitated at tees by reduction on branch or outlet

Reduction on bend elbows or by bushes is not permitted without prior permission of the Supervising Officer.

Reduction by means of straight through reducing sockets is permitted.

Care shall be taken in carrying out reductions to ensure that air is not entrapped at high points. In such case, it shall be necessary to install eccentric reducing sockets with the "flat" at the top for horizontal pipework and concentric reducer for vertical pipe riser.

6.1.9.5 CONNECTIONS IN PIPEWORK

For non-welded pipework, connections shall be by means of screwed fittings, mechanical couplings, flanges or unions. The use of "long screws" shall not be permitted, unless otherwise approved by the Supervising Officer.

Unless otherwise specified, flanges complete with appropriate gaskets, nuts, bolts and washers shall be used to connect up all plant and equipment such that it can easily be removed for servicing or replacement.

6.1.9.6 FLOW MEASURING

Methods for measuring flow rates in chilled or hot water and/or other liquid circuits shall be in accordance with relevant Sub-section of this General Specification.

6.1.9.7 FLUSHING DOWN AND DRAINAGE

15 mm diameter key-operated drain cocks with hose unions shall be fitted to the lowest accessible points of the system pipework and also on individual items of plant to ensure complete drainage.

20mm or above drain cocks shall be required for rapid flushing down in connection with water treatment and dead legs or stagnant water corners of chilled water or condensing water circulation pipework.

6.1.9.8 JOINTS AND FITTINGS FOR STEEL PIPEWORK

6.1.9.8.1 Joints on all permanently concealed pipework and all pipework over 100 mm size shall be welded unless otherwise agreed by the Supervising Officer. The welded joints shall be to BS EN 10253-2:2007. The other pipework may be of screwed or welded joints. Mechanical coupling joints may be used for joints under the conditions as stated in Clause 6.1.9.8.5. When screwed joints are adopted at least one of the two engaging components shall be taper-threaded to ISO 7-1: 1994/Cor1:2007 or BS EN 10226-1:2004 and the joints between them shall be made with approved jointing material, selected to suit the appropriate type of services. For pipework without anti-rust threaded joints, it shall be patched up with galvanised painting or anti-corrosion paint before making such joints.

6.1.9.8.2 At dismantling points or where the pipework is connected to an appliance, ground-in spherical seated unions shall be used for pipework up to 50 mm size and flanges shall be used for pipework at 65 mm size and above. The flanges shall be to ISO 7005-1:2011 of appropriate type or another acceptable national/international standard, such as BS, EN or BSEN. Flanged joints shall be made with flat ring gaskets suitable for the pressure and temperature and extending to the inside of the bolt circles.

6.1.9.8.3 Screwed fittings, other than sockets, shall be malleable cast iron, banded or beaded pattern. Standard but welding fittings shall be used on welded pipework. Use of mixed joints shall be prohibited.

6.1.9.8.4 Flanges for mild steel pipework shall be forged steel and machined over the raised or flat faces. Headers shall be of flanged mild steel tube with flanged outlets welded on and spare outlets shall be blanked off with bolted flanges.

6.1.9.8.5 Where specified, and/or subject to the Supervising Officer's written agreement, mechanical pipe couplings may be employed for pipe connection (except for connections to units incorporating reciprocating compressors or where the water temperature exceeds 93°C, unless the couplings are suitable for these conditions and acceptable to the Supervising Officer.)

Mechanical pipe couplings shall be self-centred, engaged and locked in place onto the grooved or shouldered pipe and pipe fitting ends. The pipe connection shall result in a positive watertight couple, where flexible types shall provide reasonable allowance for angular pipe deflection, contraction and expansion, and where rigid types shall provide no joint movement, angular pipe deflection, contraction or expansion. The coupling housing clamps shall consist of two or more malleable or ductile iron castings or rolled steel segment holdings with a composition water sealing gasket of suitable working temperatures, so designed that the internal water pressure will increase the water tightness of the seal. The coupling assembly shall be securely held together by two or more oval-neck heat treated carbon steel track head bolts and nuts. All pipe fittings connected to mechanical pipe couplings shall have groove and shouldered ends and shall be malleable or ductile iron castings. Flanged or threaded end valves may be used with grooved adapters.

Before couplings are assembled, pipe ends and outsides of gaskets shall be lightly coated with grease or graphite paste to facilitate installation.

Pipe grooving shall be in accordance with the pipe coupling manufacturer's specifications. Pipes may be cut-grooved or roll-grooved as recommended by the manufacturer. The cut-grooving shall be roll-grooved without the removal of any metal.

The entire coupling installation shall be in accordance with manufacturers' recommendations.

6.1.9.8.6 Couplings or flange adapters for plain ended pipework shall be cast iron or steel, slip-on type as approved by the Supervising Officer: -

Coupling shall consist of: -

- Sleeve (without centre register);
- End flanges;
- Sealing rings; and
- Bolts and nuts.

Flange adapter shall consist of: -

- End flanges/sleeves;
- Sealing rings; and
- Studs and nuts.

To provide hard and durable protection against impact, abrasion, chemicals and low temperature, all couplings and flange adapters shall be coated with Rilsan Nylon 11 by either a dip process giving a coating thickness of 250 - 375 microns or an electrostatic spray process giving a coating thickness of 150 - 250 microns.

6.1.9.9 JOINTS AND FITTINGS FOR COPPER TUBES

Fittings for copper pipework shall be as follows: -

6.1.9.9.1 Size up to and including 65 mm shall be of the capillary fitting type to ISO 2016:1981 or BS EN 1254-1:1998 or compression fitting type to BS EN 1254-2:2021 or push fit type to BS EN 1254-6:2012 or press type to BS 8537:2010for water distribution purpose and ASME B16.22 for refrigeration copper fittings for refrigerant distribution purpose. Size of the 76 mm and 108mm shall be the flanged to ISO 7005-1:2011, ISO 7005-2:1988 or ISO 7005-3:1988 or BS EN 1092. Size for pipework above 108 mm shall be flanged or welded.

6.1.9.9.2 Pipework shall be arranged with adequate connection points to allow easy dismantling. Connection points in copper pipework size up to and including 54 mm size shall be unions or screwed and for pipework of size 67 mm and above shall be flanged or grooved.

6.1.9.9.3 For the pipework connection with the fan coil unit, the inlet and outlet connections of the fan coil unit shall use the flexible connector with the same size as the installation pipework and shall be to BSRIA COP 11/2002 or in accordance with the manufacturer's recommendation. Any flared type connection for the copper pipework shall be to the ASME B16.

6.1.9.10 PIPEWORK GENERAL DETAILS

6.1.9.10.1 Pipework shall follow the contours of walls and shall be suitably graded not less than 1 in 500 to ensure proper venting and draining. Generally, the clearance between pipework (or the lagging) and the wall and any other fixtures shall be not less than 25 mm. Pipework shall not run near to or above electrical appliances, cables, trunkings and conduits.

6.1.9.10.2 Where two or more pipe runs follow the same route, all pipes shall run parallel with one another and to the building structure without prejudice to the necessary allowances for venting, drainage or other reasonable restrictions. Any pipework which requires subsequent insulation shall be adequately spaced to allow for individual finish.

6.1.9.10.3 Purpose-made sets or springs may be used where it is necessary to deviate from a straight run in ungalvanised pipework.

6.1.9.10.4 Sets or springs in tubes of 50 mm size and above shall be heat-treated and the tubes shall remain circular after setting. In galvanised pipework, no deviations shall be formed from standard fittings.

6.1.9.10.5 Tubes shall be reamed after cutting and shall be free from burrs, rust, scale and other defects and shall be thoroughly cleaned before erection. Pipe ends left open during the progress of work shall be temporarily closed with purpose-made metal or plastic plugs or caps, or blank metal flanges and protect from corrosion.

6.1.9.10.6 Joints shall not be made in the thickness of any wall, floor or ceiling and pipework shall not be embedded in the structure of floors unless otherwise instructed by the Supervising Officer. Where pipework passes through walls, floors or ceilings, sleeves shall be provided. Pipework passing through floors shall, where specified, be provided with approved type floor and ceiling plates and fastened securely to the sleeve. Sleeves shall be of the same metal as the pipe, unless otherwise accepted by the Supervising Officer. The space between pipework and sleeve shall be sealed with an approved fire resisting material having FRP of not less than that of the wall and floor and in compliance with relevant regulations and code of practices.

6.1.9.10.7 All entry and exit holes to or from a building for a pipework services shall be sealed and plugged. The sealant shall be a mastic compound or silicone rubber. Where the pipework enters the building through a large hole or duct, a mild steel blanking plate not less than 6 mm thick shall be built into the wall of the hole or duct. The service pipes shall pass through clearance sockets welded to the plate. The space between pipe exterior and socket interior shall be sealed and plugged with rockwool or equivalent material having an FRP of not less than that of the wall and in compliance with the relevant regulations and code of practices, all to the approval of the Supervising Officer.

6.1.9.10.8 All fittings shall, as far as practicable, be the same size as the tubes and pipes connected to them. Bushed outlets will only be accepted if the required outlet size of a fitting is not of standard manufacture. Eccentric bushings and square tees shall be used where concentric bushings and pitcher tees may cause air to be trapped in the system.

6.1.9.10.9 Elbows shall be used, where practicable, in preference to bends. However, square elbows will not be permitted. Unless otherwise specified, long radius elbows shall be used in order to minimise hydraulic resistance.

6.1.9.10.10 In the event of the bends being formed in the lengths of pipe, a hydraulic bender shall be used to have "shoes" of the correct size for the relevant pipe. Flattening or distortion of the bore will not be accepted.

6.1.9.10.11 For forming bends in small bore, copper pipe up to size 25 mm pipe bending springs may be used but again there shall be no distortion of the pipe involved.

6.1.9.10.12 In the case of all bends formed in the pipe, these shall constitute long radius bends.

6.1.9.10.13 All centrifugally cast ductile iron buried mains shall be coated externally with zinc. Metallic zinc shall be used with a zinc content of not less than 99.9% by mass. The zinc shall be applied at the manufacturer's works to the oxide skin of the pipe surface which shall be dry, free from dust, non-adhering particles, oil or grease. The zinc coating shall cover the external surface of the pipe to a mean density of 130 g/m^2. Spiral appearance is permissible only if there is no bare patch.

6.1.9.10.14 On pipework up to and including 50 mm nominal bore, minor type fittings shall be provided to make up to valves, expansion pieces, loops and items of plant.

6.1.9.10.15 Short radius elbows shall only be used at the discretion of the Supervising Officer where long radius elbows will not fit or are not manufactured.

6.1.9.10.16 Where pipes are ordered galvanised, the zinc content shall be not less than 98.5% by weight of zinc and at a temperature suitable to produce a complete uniformly adherent coating of zinc.

6.1.9.10.17 Pipes which are to be screwed shall be galvanised before servicing. Pipes which are to be fitted with welded flanges shall be flanged before galvanising. Galvanised treatment on all welding joints shall be required after welding.

6.1.9.11 PIPEWORK LAYOUT

The Drawings indicate the size and general layout of the required pipework. The exact position may not be indicated on the Drawings as for the purpose of clarity, they are generally shown as separately spaced out from one another as if they were at the same plan level.

6.1.9.12 PIPEWORK SUPPORTS, EXPANSION JOINTS AND ANCHOR POINTS

6.1.9.12.1 Where the Employer's guide drawings and details are provided in the Contract or issued, they are only for general information and shall be adjusted as to the detail in order to suit the particular circumstances. Such adjustments shall be indicated on the Installation/Shop Drawing and loading calculation submissions which to be approved by the Supervising Officer before work commences.

6.1.9.12.2 Pipework shall be supported so as to permit free movement due to expansion and contraction. Pipework supports shall be installed as near as practicably possible to joints and changes in direction. Each support

shall take its due proportion of the load. The spacing of the supports shall in accordance to Clause 6.1.9.17. Where there are two or more pipes, the spacing shall be based on the centres required by the smallest bore pipework.

6.1.9.12.3 Vertical rising pipework shall be supported at the base or, as indicated, to withstand the total weight of the riser. Branches from risers shall not be used as a means of support for the riser. If such base has to be rested on an intermediate floor slab, particular attention shall be drawn to the Supervising Officer for structural reinforcement to the floor slab and allow for additional treatment to the base as required by the Supervising Officer.

6.1.9.12.4 Where pipework up to 50 mm size is fixed to solid wall, brackets may be of the screw-on or long shank built-in type in case the walls are plastered, only the long shank built-in type shall be used. For fixing to woodwork and lightweight partitions or walls, brackets shall be of the screw-on pattern of adjustable two-piece type. Brackets for mild steel and plastic pipework shall be mild steel or malleable iron; brackets for copper pipework shall be brass or gunmetal. The upper half of the pipe clip shall be detachable without disturbing the fixing.

6.1.9.12.5 Brackets screwed to walls shall be secured by expanding plugs. Other purpose designed fixing devices or softwood plugs will not be permitted.

6.1.9.12.6 Pipework of 65 mm size and larger, subjected to expansion and contraction and hung from supports shall be suspended on swivel hangers unless otherwise agreed by the Supervising Officer.

6.1.9.12.7 Unless otherwise specified, hangers for horizontal pipework at high level shall be supported from galvanised mild steel angle or channel sections or approved proprietary devices, suitable for building-in or otherwise securing to the structure by the Building Contractor. Adjustable mild steel hangers shall be used. Pipe rings shall be of malleable cast iron or fabricated steel, made in halves and secured by bolts or screws. Alternatively, malleable iron hinged pipe rings may be used. Calliper type hooks will not be permitted.

6.1.9.12.8 Where pipework is fitted in service duct or trenches or where it is of 65 mm size or greater and supported from walls, the configuration of the pipe supports, guides and anchors shall be in accordance with the Drawings. Otherwise, details and proposal shall be submitted to the Supervising Officer for approval. Where roller supports are required, they shall be of an approved type. The performed insulation shall be kept free of the rolling surface. Load-bearing insulation at supports, where required, shall be fitted at the time of erecting the pipework.

6.1.9.12.9 For copper pipework, the anchors shall be provided by wide copper straps secured to the pipework in such a manner that the pipe is not damaged.

6.1.9.12.10 The works shall include supply and fix in position ready for building-in all cleats, brackets and steelwork required for anchor points. Anchor

steelwork secured to the bottoms of ducts or trenches shall be coated with hot-poured bitumen to inhibit future corrosion.

6.1.9.12.11 Supports for plastics pipework may be of any approved pattern that prevents free axial movement of pipe at all temperatures and have radial edges to prevent cutting into the pipe. The entire bearing surface shall be sufficiently wide to prevent indentation.

Heavy "in-line" equipment shall be supported independently. Valves and meters shall also be supported independently, where necessary.

Supports for pipes carrying water at a maximum temperature of 15°C and covered with lightweight insulation shall be spaced in accordance with Clause 6.1.9.17. Alternatively, the pipework may be continuously supported, provided that the thermal insulation covering the pipework is sufficiently rigid to ensure that no compression or deformation of the insulation occurs.

6.1.9.12.12 Provision for movement due to expansion and contraction shall be generally as indicated and/or shall be by changes in direction of the pipework, by loops or by other approved expansion devices.

6.1.9.12.13 Supports and guides shall be arranged to ensure that all movement is taken up by the change in direction of the pipework or by the loop or device.

6.1.9.12.14 The spacing of supports for steel, copper and plastic pipework shall be in accordance with Clause 6.1.9.17.

6.1.9.12.15 Cold bridge shall be prevented between the insulated pipework and the associated hangers and pipework supports.

6.1.9.12.16 All metal mounting and fixing brackets for water pipework shall be pre-fabricated off-site.

6.1.9.13 PIPEWORK VIBRATION DE-COUPLERS

Pipework connections to the suction and delivery outlets of pumps and other vibrating machines shall be isolated from such sources of vibration by means of anti-vibration couplings as detailed in Sub-sections regarding Noise and Vibration Control of this Part.

The vibration de-couplers shall be capable of attenuating the vibration of the plant such that the bulk of the vibrations are prevented from being transferred to the pipework.

Wherever vibration de-couplers are installed, the adjacent pipework shall be adequately supported by guide type brackets.

6.1.9.14 PLASTIC PIPEWORK

Fittings for plastics pipework shall be as follows: -

6.1.9.14.1 Fittings shall be of the same material as the pipework to which they are joined. They shall be made or approved by the pipe manufacturers and suitable for the solvent welding process. Where screw threads are required (e.g. at connections to metal valves, strainers, etc.), a factory made threaded adapter shall be used. Adapters shall be made from heavy weight tube with an appropriate thread at one end; the other end shall form part of a socket and spigot solvent welded to the plastic pipe. As a general rule UPVC pipe shall only be made threaded and screwed into metal "Female" threaded fittings.

6.1.9.14.2 Joints between pipe and pipe fittings shall be made by the solvent welding process. No cleaning fluid or solvent cement other than that supplied or recommended by the pipe manufacturer shall be used.

6.1.9.14.3 Where it is required to form a spring in the pipe run, the pipe shall be softened by immersion in (or by pouring on) heated brine, glycerine oil or water as recommended by the pipe manufacturer. The use of a naked flame on the pipe surface will not be accepted.

6.1.9.14.4 Unless otherwise specified, connections to items of plant such as pumps or air cooler batteries shall be made by means of flanged joints. The plastic pipe shall terminate with a socket flange of the full face or stub type welded on by the solvent process and having a loose metal backing ring; the ring and the flange shall be drilled to match the mating flange. The joint shall be made with a neoprene or similar gasket.

6.1.9.14.5 Where UPVC is used for condenser cooling circuits and for the inlet and outlet to pumps, it shall be effectively isolated from the vibration of the machine. This shall be achieved by the insertion of flanged synthetic rubber vibration de-couplers installed between UPVC pipework and plant on all connections.

6.1.9.15 SPECIALISED HYDRAULIC SYSTEM BALANCING VALVES

6.1.9.15.1 In addition to those specified, necessary hydraulic valves at all points on the system shall be provided where circulation flow balancing shall be carried out in order that the system balancing can be done.

6.1.9.15.2 These valves shall be: -

(a) Allow measurement of pressure differences across the valve;
(b) Allow measurement of flow through the valve;
(c) Allow for proportional balancing of the system;
(d) Provide shut off;
(e) Provide for venting (where required); and
(f) Provide for draining (where required).

6.1.9.15.3 Construction

10 - 50 mm	Gunmetal/ Bronze/ Brass	Working pressure up to 2 MPa (to BS EN 1982:2017 for Bronze or to BS EN 12163, BS EN 12164 and BS EN 12165 for Brass and Gunmetal)
65 - 300 mm	Cast Iron/ Ductile iron	Working pressure up to 1.6 MPa (to BS EN 1561:2011 / ISO 185:2020 BS EN 1092-2 for cast iron or BS EN 1563:2018 for ductile iron)

The valve will be constructed with angled seat and valve handle complete with two plug type pressures tapping on each side of the valve seat.

Drain or vent plug valve

Valves 10 - 50 mm with screwed ISO 7-1:1994/Cor1:2007 and 7-2:2000 connections or BS EN 10226.

Valves 65 - 300 mm with flanged ISO 7005-1:2011, for cast iron, BS EN 1092-2 for cast iron. .

6.1.9.15.4 Commissioning and Testing Equipment

One set (or more if specified) of electronic measuring equipment for use with hydraulic balancing valves shall be provided for initial balancing and commissioning of the system where hydraulic balancing valves are installed.

At completion of the work, one new set of test equipment shall be handed over to the Supervising Officer for subsequent monitoring and adjustment by the Employer’s operation and maintenance staff.

6.1.9.16 'T' AND 'Y' FITTINGS

Except at vent and drain points, all tees and 'Y' fittings shall be of the swept type. The sweep radius being at least equal to that of the medium bend but where specified as a long sweep it shall then be equal in radius to the long bend.

6.1.9.17 SUPPORTS FOR PIPEWORK

Table 6.1.9.17 (1) Supports for Steel Pipework

Supports with suitable load spreader for the pipework shall be provided.

Size of Tube (mm)	Intervals for Horizontal Runs		Interval for Vertical Runs
	Bare (m)	Lagged (m)	Bare and Lagged (m)
15	1.8	1.8	2.4
20	2.4	2.4	3.0
25	2.4	2.4	3.0
32	2.7	2.4	3.0
40	3.0	2.4	3.7
50	3.0	2.4	3.7
65	3.7	3.0	4.6
80	3.7	3.0	4.6
100	4.0	3.0	4.6
125	4.5	3.7	5.5
150	5.5	4.5	5.5
200	8.5	6.0	8.5
250	9.0	6.5	9.0
300	10.0	10.0	10.0

Table 6.1.9.17 (2) Supports for Copper Pipework

Size of Tube (mm)	Intervals for Horizontal Runs		Interval for Vertical Runs
	Bare (m)	Lagged (m)	Bare and Lagged (m)
15	1.2	1.2	1.8
22	1.2	1.2	1.8
28	1.8	1.5	2.4
35	2.4	1.8	3.0
42	2.4	1.8	3.0
54	2.7	1.8	3.0
65	3.0	2.4	3.7
76	3.0	2.4	3.7
108	3.0	2.4	3.7
133	3.7	3.0	3.7
159	4.5	3.7	3.7

Table 6.1.9.17 (3) Supports for Plastics Pipework

Nominal Bore of Pipe (mm)	Intervals for Horizontal Runs (m)	Interval for Vertical Runs (m)
15	0.75	1.5
22 to 28	1	1.8
28 to 35	1	2
42	1.2	2.4
53 to 65	1.4	2.8
76	1.8	3.5
108 and over	2	4

6.1.9.18 WELDING AND BRAZING

The procedure and the competence of the operative shall be in accordance with the recommendations contained in the following publications: -

(a) AWS D10.12: Guide for Welding Mild Steel Pipe

(b) ISO 9692-1:2013 and ISO 15609-1:2019 - relevant subsections for metal-arc welding (steel pipe)

(c) ISO 9692-1:2013 and ISO 15609-2:2019 - relevant subsections for gas welding (steel pipe)

(d) ISO 5187:1985 - Brazing (copper pipe)

Where the visual inspection and tests reveal those welding joints which are reasonably believed to be unacceptable, the Supervising Officer shall be entitled to have such welding examined by radiography or other approved inspection method and independently assessed. The cost of the tests shall be included under the Works. The Works shall be rectified to the satisfaction of the Supervising Officer if the test results demonstrate non-compliance of the welding joints.

SUB-SECTION 6.1.10

ENERGY OPTIMISATION CONTROL

6.1.10.1 GENERAL

The Installations shall include provisions for energy optimisation and continuous commissioning.

All equipment provided shall conform to the highest energy efficiency rating as per the time of installation and also they shall be able to reset to the suitable operating parameters without sacrifice of thermal comfort.

6.1.10.2 DESIGN FOR ENERGY OPTIMISATION

The setup of the Installations shall have due consideration in circuitry and zoning for the flexibility of operation, with capabilities to tackle seasonal changes, operating hours changes and all factors in related to the ambient and building's changing environment.

Unless otherwise specified, the Installations shall have provisions to perform demand control strategies. All necessary control accessories (e.g. DDC, PLC, control and monitoring modules, etc.) shall be provided for the full automatic operation of the Installations. Sufficient meters and sensing devices shall be provided for the purpose of energy management and continuous commissioning.

The control panel of air handing units, chillers and VSD for the pumping systems shall be connected to the CCMS through the DDC.

Unless otherwise specified, the Installations and the main plant shall equip with the following equipment and/or materials:

6.1.10.2.1 Air-side system / equipment

(a) Variable speed drive (VSD) fan

(b) Motorised control damper

Motorised control exhaust air damper shall be installed at the exhaust air outlet and normally opened at pre-set position. This exhaust damper shall be interlocked with the exhaust air fan.

Motorised control damper shall be provided in the returned air path for isolating the return air side and supply air side under the free air cooling mode. This isolating damper shall be normally opened.

Motorised outdoor air supply damper shall have minimum setting to provide the minimum outdoor air supply to the system.

(c) Temperature and humidity sensing devices

Temperature and humidity sensing devices shall be provided in the outdoor air supply intake to monitor the outdoor air conditions.

Temperature and humidity sensing devices shall also be installed in the downstream of the supply air fan to monitor the supply air conditions.

(d) Thermometers – air immersion

Air immersion thermometers shall be provided for measuring both dry and wet bulb temperatures at the same time in the various locations of each air handling unit.

(e) Static pressure gauges for air distribution systems

System static pressure gauges shall be provided. Two gauges shall be provided for each fan and arranged to indicate system static pressure on the intake and discharge sides.

The gauges shall be connected into the system at fan intake and discharge side at points where the static pressures are steady. Entrance, dock, and other areas where large, sudden static pressure changes may occur shall be avoided. On completion of commissioning, the suction and delivery static pressures indicated by the gauges shall be indelibly marked adjacent to them to serve as system reference points.

(f) Heat recovery condenser for the supply of heat source

Sufficient control provision shall be allowed in the chiller controllers for the proper operation of heat recovery condenser for the supply of heat source and shall be connected to the CCMS through the DDC if applicable and coordinated in operation with the integrated hot water system.

6.1.10.2.2 Water-side system / equipment

(a) Variable speed drive (VSD) pump

(b) Variable speed cooling tower fan

(c) Automatic balancing valves

Automatic self-balancing valves shall be provided for at least branch tee-off from risers for water balancing and commissioning purpose for chilled water system to achieve an accurate and efficient balancing of water distribution for saving energy.

(d) Thermometers – Liquid immersion

Thermometer pockets shall be provided adjacent to the flow and return connections to/from each heating coil and cooling coil. The location and depth of thermometer pockets shall be determined to assure correct reading of liquid temperature. Each pocket shall be filled with sufficient approved heat conducting medium.

(e) Pressure gauges for water systems

Pressure gauges shall be provided at suction and discharge sides of chilled/heated water pumps and condensing water pump. Pressure gauges shall be fitted with lever handle cocks and shall have siphon pipes, pigtail with 2 complete turns minimum or pulsating damper, fitted between them and the system pipework.

(f) Liquid flow rate meters

Appropriate type of flow rate metering instruments shall be provided and installed in the plants for all chilled/heated water circuits and condensing water circuits. Particular attentions shall be paid on factors like system identity, group of users and size of accommodation, sharing mechanism among users.

(iii) Energy and power factor monitoring

Instruments and metering provisions to monitor the supply voltage, and/or current to individual or groups of refrigeration plant shall be provided.

Where indicated elsewhere in this General Specification or in the Contract, instruments and metering provisions to monitor the power factor of the equipment installed shall be provided.

Power Consumption (kWh) metering devices shall be installed for the following plants and all equipment including chilled/ heated water plant, chillers, heat pumps, cooling towers, chilled/ hot water pumps, condensing water pumps, etc.

(iv) Self sealing test points

Self-sealing test plugs suitable for temperature and pressure measurement can be provided to substitute the thermometer pockets and pressure gauges for systems specified in the Particular Specification.

6.1.10.3 ENERGY PERFORMANCE CHARACTERISTICS OF CHILLER PLANT

6.1.10.3.1 Coefficient of Performance (COP) characteristic of individual chiller in the plant shall be determined and provided according to the manufacturer's information. The COP shall base on the instantaneous power input of the chiller, associated pumps and equipment against various cooling capacity output of the chiller (i.e. at 100%, 80%, 60%, 40%, 20% load condition).

6.1.10.3.2 The COP characteristic under various chilled water supply temperature set points (i.e. 7°C, 8°C, 9°C, 10°C, etc.) shall be determined and provided.

6.1.10.3.3 For air-cooled chiller, the COP characteristic under various ambient air temperatures (i.e. at 35°C, 30°C, 25°C, 20°C, etc.) shall be determined and provided.

6.1.10.3.4 For water-cooled chiller, the COP characteristic under various condensing water temperatures (i.e. at 32°C, 30°C, 28°C, 26°C, 24°C, etc.) shall be determined and provided.

6.1.10.3.5 The energy performance characteristic of individual variable speed pump shall be determined and provided according to the manufacturer's information. The characteristic shall base on the instantaneous power input of the variable speed pump against various chilled water flow rate (i.e. at 100%, 80%, 60%, 40%, 20% load condition).

6.1.10.3.6 The energy performance characteristic of individual variable speed fan of cooling tower shall be determined and provided according to the manufacturer's information.

6.1.10.3.7 Computer programme with chiller plant optimisation algorithm shall be provided and commissioned. The optimisation algorithm shall capable to determine the most energy efficient operation combination of the chiller plant in according to their COP characteristics under the specific cooling load demand, chilled water supply temperature set point and ambient /condensing water temperature condition.

6.1.10.3.8 Base on the optimised energy characteristic of the plant under various cooling load, chilled water supply temperature set point, ambient /condensing water temperature conditions and the building cooling load demand, the overall plant energy efficiency characteristic (Plant COP) and optimised control zoning maps shall be determined and built-in into the DDC system controlling the chiller plant. The automatic control shall determine the number of chillers, number of pumps, number of cooling towers, chilled water supply temperature set point, etc. to match with the loading demand with the highest operating energy efficiency.

6.1.10.3.9 The Plant COP, optimisation control strategies and optimisation control zoning maps shall be submitted to the Supervising Officer for approval.

6.1.10.4 CHILLER PLANT OPTIMISATION CONTROL

6.1.10.4.1 General

The chiller plant optimisation control system shall closely monitor the following parameters for determine the optimised chiller plant control operational combination and set points: -

(a) chilled water supply/return flow rate;

(b) chilled water supply/return temperature; and

(c) chilled water control valve position of each AHU/FCU/PAU, each water-side equipment and associated circulation pipework system.

Optimisation control strategy for chiller plant shall base on the characteristics of equipment, Plant COP, cooling load demand and ambient air /condensing water temperature condition as detailed in Clause 6.1.10.3 of this Sub-section.

With collection of the operating status of the control valve positions of AHU/FCU/PAU, water-side equipment and circulation pipework system, the optimisation control shall automatically re-set the supply water temperate and thus the pump speed of the chilled water pumps via the control of variable speed drive.

6.1.10.4.2 Chiller Sequencing Control

Due to the non-linear part load characteristic of chiller, operating more chiller group (i.e. chiller and the associated primary chilled water pump) under the same cooling load demand condition may save energy. The optimisation control system shall determine the optimised chiller sequencing so that the overall energy consumption of chiller group is the minimum.

The sequencing control shall base on the optimisation control zoning map to determine the optimal operating sequence. The control zoning map shall be specific under various chilled water supply temperature and ambient air temperature /condensing water temperature.

6.1.10.4.3 Chilled Water Supply Temperature Reset

Under a specific load condition, rising the chilled water supply temperature in variable flow chilled water distribution system may save chiller energy while increase the energy consumption of variable speed chilled water distribution pump. The optimisation control system shall determine the optimised chilled water supply temperature set point so that the overall combined energy consumption of chillers and variable speed chilled water pumps is the minimum.

The chilled water supply temperature set point shall be automatically reset during low cooling load demand and/or low outdoor air temperature condition.

When any of the chilled water valves of air-side equipment is under fully opened condition, alert shall be provided when recommending the reset and the reset control shall only be manually confirmed.

After reset the chilled water supply temperature, optimisation control zoning maps in associated with the chilled water supply temperatures shall be used by the control system.

For areas requiring humidity control, chilled water supply temperature reset is not recommended.

6.1.10.4.4 Cooling Tower Fan Control

The cooling tower fan group and fan speed shall be controlled to minimise the overall combined energy consumption of chiller and cooling tower fan.

Normally the cooling tower fan group and fan speed are controlled to maintain a constant temperature difference between the condensing water supply temperature and the ambient wet bulb temperature. When the ambient wet bulb temperature decreases, the condensing water supply temperature will decrease and the chiller energy consumption will decrease.

Under a specific ambient wet bulb temperature, lowering the condensing water temperature by controlling the fan group and fan speed may save chiller energy, while the cooling tower fan energy may increase. The optimisation control system shall determine the optimised cooling tower fan group and fan speed so that the overall combined energy consumption of chiller and cooling tower fan is the minimum.

The condensing water supply temperature shall not below the minimum allowable condensing water temperature of the chiller recommended by the manufacturer.

6.1.10.4.5 Condensing Water Flow Rate Reset

There may have energy saving opportunity by lowering the rated condensing water flow rate. Lowering the flow rate may reduce the energy consumption of condensing water pump while the chiller energy may increase. The optimisation control system shall determine the optimised condensing water flow rate set point so that the overall combined energy consumption of chiller and condensing water pump is the minimum.

The control system shall monitor the condensing water system to ensure the following conditions can be met: -

(a) The minimum water flow rate with 10% margin at chiller condenser recommended by the manufacturer shall be kept;

(b) The minimum water flow rate required by the cooling tower with 10% margin to maintain proper distribution over the fill recommended by the manufacturer shall be kept; and

(c) The minimum pump speed with 10% margin to produce the required static lift of the condensing water system shall be kept.

6.1.10.4.6 Other Optimisation Control Strategies

Additional or alternative optimisation control strategies may be offered and shall subject to the approval by the Supervising Officer.

6.1.10.5 ENERGY CONTROL OF AIR SIDE SYSTEM

6.1.10.5.1 Fresh Air Flow Rate Control

Carbon dioxide (CO_2) based demand control for fresh air intake shall be provided for energy saving. The control shall be realised by operating motorised air dampers or direct fan speed control of PAU /fresh air fan as appropriate.

The CO_2 sensors shall be located at strategic locations for proper determination of the fresh air requirement.

Minimum fresh air flow rate as required by specific premise according to ASHRAE Standard 62 shall be maintained.

The control strategy may not be applicable for areas with special pressure control requirements

6.1.10.5.2 Demand Control Ventilation

Ventilation fan shall be demand controlled according to the applications.

Ventilation fan for plant room shall be variable speed controlled base on the room temperature and according to the minimum ventilation set point.

Ventilation fan for toilet shall be variable speed /step controlled base on the odor sensor as specified in the Particular Specification or Drawings.

The control strategy may not be applicable for areas with special pressure control requirements

6.1.10.5.3 Supply Air Temperature Reset for Variable Air Volume Air-Handling Unit

Multi zone variable air volume (VAV) air-handling unit (AHU) shall equip with supply air temperature reset control for energy saving. The

supply air temperature set point being maintained constantly by the chilled water modulating valve shall be automatically reset to higher valve when the control system determine that all VAV box dampers are near the minimum turn down ratio position and to avoid the cut-in of terminal reheat in any VAV box.

Single zone VAV AHU shall also equip with supply air temperature reset control for energy saving. The supply air temperature set point being maintained constantly by the chilled water modulating valve shall be automatically reset to higher valve when the control system determine that the variable speed fan is operating near the minimum turn down ratio position.

6.1.10.5.4 Static Pressure Reset for Variable Air Volume Air-Handling Unit

Multi-zone VAV AHU shall equip with static pressure reset control for energy saving. The static pressure set point for controlling the supply fan speed shall be automatically reset to maintain the critical zone VAV box damper open within predetermined range, i.e.70% to 90%.

Trim and Respond control logic shall be applied. The static pressure set point shall be trimmed slowly and regularly until a VAV box indicates that more pressure is required, in which case the control system responds by bumping the set point up a small amount.

6.1.10.5.5 Supply Flow Rate Reset Control for Constant Air Volume Air-Handling Unit

Constant Air Volume (CAV) AHU shall equip with supply air flow rate reset control for energy saving. The design supply air flow rate shall be automatically reset to lower valve when the control system determine that the return air temperature is still below the set point even the chilled water modulating valve near fully closed.

SUB-SECTION 6.1.11

THERMAL INSULATION

6.1.11.1 GENERAL

The thermal insulation works shall be undertaken by a minimum required percentage of workers who shall have a valid certificate of completing satisfactorily the thermal insulation training courses organised by the recognised association as specified in the contract. Upon request, details and particulars of these workers shall be submitted to the Supervising Officer for approval.

In general, all ductwork and equipment shall be insulated if the air conveyed within the ductwork and the air external to it have a temperature difference which may cause an unwanted condensation or heat loss either on the duct surface or within the ductwork or result in unwanted thermal exchange between the external and inside air of the ductwork.

Thermal insulation shall be applied to chilled or hot water pipework distribution systems and to components within distribution systems such as valves, storage vessels, strainer and accessories.

All insulation shall fit tightly to surfaces to be covered, and all slabs and sections shall be built up close, butting edges being mitred, chamfered or shaped as necessary. Any minor interstices left in insulation shall be filled and sealed with granules embedded in suitable and approved adhesive compound.

Insulated pipes and ducts shall be supported on the outside of the insulation, with load spreading galvanised iron or corrosion treated steel metal plates of suitable size and thickness between the insulation and supports to prevent the insulation being crushed. A higher density load bearing quality insulation or hard wood block shall be used at support points as recommended by the insulation manufacturer and as directed by the Supervising Officer.

At the point of support, specially prepared blocks of hardwood or styrofoam material shall be positioned to ensure the integrity of the vapour barrier and cladding where applicable by bonding the supports to the insulation.

All materials delivered to Site shall be new, and where appropriate, colour coded and labelled at the factory to identify different grades, sizes and types. The insulation shall be protected from damage or deterioration before, during and after fixing. Damaged or compressed insulation shall be replaced.

Immediately before applying insulation, clean all surfaces until these are free of rust, scale and grease, and are thoroughly dry. Under no circumstances should the insulation be applied to wet surfaces.

Any surface to be insulated, which shows any sign of rusting or damage, shall, prior to insulating, be thoroughly scrapped and wire brushed as necessary to remove all rust, scale, etc. Surfaces shall then be cleaned with appropriate solvent to remove all oil, grease and dirt prior to the application of two coats of grey epoxy primer paint and

insulation. Only clean and dry insulation shall be applied in any case, and it shall be free from damage before application.

All materials including the thermal insulation itself, together with adhesives, paint, bands, sheeting, etc. shall be supplied with a reasonable margin for cutting, wastage and making good damage and loss. All materials shall be stored in a suitable manner so as to prevent them from damage or deterioration before fixing.

All insulation shall be applied so as to give a smooth, homogeneous and linear surface. All rigid sections shall be concentric, and accurately matched for thickness. Steps and undulations in the surfaces are not acceptable. Any sections or slabs having damaged ends will be rejected.

Continuous insulation shall be provided through all sleeves and insulation joints shall be staggered with respect to joints on the associated pipework or ductwork systems.

Insulation damaged for whatever reasons will be rejected.

Where thermal insulation is applied to the outside of piped and ducted services, equipment and plant used to convey, store or generate fluids or gases at temperatures lower than the design ambient dew point temperature indicated, a water vapour barrier shall be provided unless it can be demonstrated that the insulation material itself provide adequate barrier throughout its thickness to the approval of the Supervising Officer. The separate type vapour barrier where employed shall not be pierced or otherwise damaged by supports or by the application of external cladding. Any damages on the insulation or barrier or any subsequent wetting of the material due to improper installation shall be made good and replaced as appropriate.

Where relevant, moisture and vapour barriers, whether applied to the ductwork, hangers or projections, shall be continuous and completely provided throughout the surface of the insulation, and the insulation complete with the barrier shall be properly and firmly bound on the duct or pipe surface by appropriate fixing provisions. Such fixing provisions shall in no way impair the insulation or the vapour barrier.

Flexible connections on air conditioning ductwork shall be insulated with flexible blanket made from non-flammable material. The insulated blanket is to be wrapped with vapour barrier. The blanket shall be wrapped around the flexible connection, overlapped and secured in place by metal bands at both ends to the rigid ducts.

6.1.11.2 TYPES OF THERMAL INSULATION MATERIALS

6.1.11.2.1 Type “A” –Phenolic Foam Insulation

For pipe insulation and pipe support, the phenolic foam joint shall be of unique Z-shape slip along the longitudinal joint sealed with adhesive and shall be provided with shiplap joints (male and female joint) at both circumference ends. The shiplap joints shall be a minimum width and depth of 10mm respectively in contact with each other for thermal lock purpose and sealed with adhesive.

Rigid cut sections shall be used with factory applied Class 'O' facing for pipework. "Butt-joints" of slabs shall be sealed with minimum 75 mm

wide matching Class 'O' self-adhesive tape as recommended by the insulation manufacturer. Overlap of factory applied Class 'O' facing for cut pipe sections shall be sealed with manufacturers recommended adhesive tape.

Factory-preformed insulated fittings formed to suit standard radius elbows, long bends and tees shall be used wherever available, otherwise, the Supervising Officer's permission shall be sought to neatly cut and mitre the insulation to fit around fittings. In the latter, great care shall be taken to ensure that all mitred joints are a close fit and the aluminium foil adhesive tape is neatly applied as a finish coating.

Flanges and other protrusions shall be insulated by factory-fabricated oversized sections ordered to suit the diameter of the flange or adjacent pipe insulation whichever is the greatest. The oversized section shall overlap on to the adjacent pipe insulation by a minimum of 75 mm width on each side.

Pipe supports shall fit around the outside of the insulation. The insulation at the support points shall be made of heavy density load bearing phenolic foam in preformed sections of same thickness as the adjacent pipe insulation. This shall be complete with the same external finish to Class 'O' as used on the adjacent standard pipe insulation.

Reference shall be made to the insulation manufacturer recommended support details to ensure the load bearing and dimensions of high density foam and associated galvanised metal plate supports are correctly inserted to spread the point loads involved.

6.1.11.2.2 Type "B" & "Type "C" – Preformed Rigid & Flexible (Semi-Rigid) Fibreglass Insulation

All fibreglass insulation shall be completely sealed by effective vapour barrier and self-adhesive foil tape.

All fibreglass insulation shall be completely sealed at all joints. All holes, tears, punctures, etc. made in the vapour barrier shall be completely sealed with the same specified foil tape. Any damage to the insulation, duct or pipe shall be repaired.

When pins are required to be used to support the fibreglass blanket, all the pins shall be fire resistant and sealed by same specified foil tape after installation.

The material shall be adhered to the ducts with moisture and fire resistant adhesive of an approved type. Where preformed fibreglass sheets are to be adhered to flat surfaces such as ductwork the method of fixing shall be approved by the Supervising Officer before the commencement of work.

6.1.11.2.3 Type “D” - Flexible Closed Cell Elastomeric Insulation

The flexible closed cell elastomeric insulation sheet shall be supplied in rolls in dimensions recommended by the manufacturer for application over ductwork so that the top, adjacent and bottom sheets lapped with adjacent sheets edges and corners. Adhesives shall be applied evenly to the entire contact surfaces if the elastomeric insulation sheet is not a self-adhesive sheet with adjacent sides lapped to maintain a uniform thickness at corners.

When shifting large bore flexible closed cell elastomeric tube which has become elliptical during storage, the slit shall be made in the flattened surface.

If the Flexible Closed Cell Elastomeric Insulation is exposed to weather, inside plant room or services duct, protection finish coating recommended by the insulation manufacturer shall be applied.

All coatings shall be supplied by the original insulation manufacturer and application shall strictly follow the manufacturer’s installation manual to obtain the required result.

6.1.11.2.4 Type “E” - Polystyrene Insulation

Unless otherwise instructed by the Supervising Officer, polystyrene insulation shall be covered with 25 mm square wire netting of 1 mm diameter galvanised steel wire netting reinforcement and coated on the top with 15 mm cement plaster smoothed and finished with painting.

6.1.11.2.5 Type “H” - Polyurethane (PU) Foam Insulation Panel for Pre-insulated Air Ducts

Whenever the foam insulation is used for pre-insulated air duct system without galvanised iron sheet metal, the following guidelines shall be followed: -

Wherever necessary, the air ducts shall be provided with appropriate reinforcements to guarantee sufficient mechanical seal against a maximum internal pressure of 500 Pa during operation. The maximum deformation of the duct shall not exceed 3% of its width or 30 mm in any case.

The joints between ducts shall be performed using flanges with unexposed bayonet coupling and shall be ensured for the appropriate pneumatic and mechanical seal. Elbows shall be provided with turning vanes wherever indicated.

The air ducts shall be supported by appropriate supports at intervals of no more than 4m whenever the greater side of the duct is less than 1 m, and intervals of no more than 2 m whenever the greater side of the duct is more than 1 m.

Accessories such as volume dampers, fire barriers or duct heater/heating coil/cooling coil and etc., shall be provided with independent support in such a way that their weights are not imposed on the air ducts.

The air ducts shall be provided with appropriate test points for the sensors and inspection doors for cleaning and inspection all along the route.

6.1.11.2.6 Type "I" - Polyurethane (PU) Foam Insulation for Pre-insulated Pipes

All pipes and fittings using PU foam insulation shall be done off-site by foaming machine as far as practicable. Straight pipes longer than 1m are not allowed to be insulated in-situ.

All joints between pipes shall be insulated using foam-in-situ (on site foaming) method. Same foaming chemical shall be used for foam-in-situ to ensure the foam is well bonded to the pipe's surface and the cladding/outer jacket.

All pre-insulated pipes shall be supported on the outside of the cladding/ outer jacket and no high-density load bearing or hardwood block is required between the service pipe and cladding/ outer jacket to minimise thermal bridge and enable a seamless foam insulation throughout the whole pre-insulated pipe system.

Manufacturer recommended method statement shall be followed on installation of pre-insulated pipes and in-situ foaming of pipe joints. Details shall be submitted to the Supervising Officer for approval.

PU foam insulation supplier shall be engaged to provide training by recognised trainer to the Supervising Officer's Representative, project installers and inspectors to enable them to understand and familiarise with the installation and to ensure the pre-insulated piping system will be properly installed.

6.1.11.3 PIPEWORK FITTINGS

Unless otherwise specified, all valves, flanges, strainers, expansion joints, etc., are to be insulated in conformity with the pipework in which they are incorporated, and of the same thickness. All such items where proper treatment on pipework connected to the puddle flanges in tunnel and trench is required shall be provided with relevant insulation filled 0.8 mm thick hammered aluminium split boxes, arranged for easy removal, the box to enclose up to valve handle and to have a lid for valve access. The insulation on the pipes immediately adjacent to flanges, etc., shall be neatly swaged off to allow the insulated boxes to be removed without damage to the pipe insulation.

All valves, flanges, strainers, glands, etc. are to be provided with insulation of similar type to that employed on the rest of system (if appropriate to this purpose) fitted into galvanised steel or aluminium sheet split boxes arranged for easy removal so that access to the valves, flanges, etc. can readily be gained without damaging the general run of insulation.

For all chilled water fittings and accessories such as valves, strainers, etc., there shall be external protection of a box constructed with 0.8 mm thick hammer aluminium cladding. The box shall be hinged at a point and fastened together on the other side with a quick action snap catches.

6.1.11.4 CHILLED WATER PUMPS AND ACCESSORIES

All chilled water pumps and their accessories shall be insulated with split box arrangement for easy maintenance without damaging the insulation. Lids of water boxes on chillers and similar places shall be provided so that easy access can be obtained for maintenance without damaging the insulation.

6.1.11.5 DUCT WORK AND AIR HANDLING PLANT - METHODS OF APPLICATION

6.1.11.5.1 Thermal insulation shall be applied to air distribution ductwork and to components within distribution systems such as fans, heater, heating coil, cooling coil casings which convey conditioned air within plant rooms and up to and including all terminal points in the system.

Air distribution systems conveying conditioned, warmed or chilled air through conditioned spaces shall be insulated. Exhaust, ventilation or outdoor air passing any conditioned space shall also be insulated.

All ductwork (including re-circulation ductwork) conveying warmed or chilled air through unconditioned spaces or the open air shall be insulated.

Distribution systems conveying untreated outdoor air and exhaust air need not be insulated unless such air distribution interconnecting with heat recovery system/device or passing through conditioned space.

6.1.11.5.2 Fixing methods for insulation shall minimise direct metal paths which thermally bridge the insulation, particularly when the insulation is metal faced. The full insulating effect shall be maintained at connections and access openings and panels including the edges of such openings, fasteners and stiffeners either by means of purposely made boxes or by increasing the general thickness of insulation. Where insulation is applied in layers, all joints in all layers shall be staggered.

6.1.11.5.3 At all points of support, the insulation and outer covering and vapour seal shall be continuous and shall not be pierced or protruded by the supports. The insulation at supports shall be of the material with sufficient compressive strength to take up the loads transmitted to the supports.

6.1.11.5.4 Pre-formed sheet insulation shall be applied with adjacent sides lapped at joints and corners to maintain a uniform thickness. The insulation shall be fixed securely with adhesives conforming to NFPA-90A:2021 and by impaling on fasteners which shall be galvanised iron metal studs' split prongs, plastics studs or other approved devices fixed to the thickness and weight of the insulating materials and finishes to be applied and shall be spaced at approximately 300 mm centres. Fastenings shall be finished

flush with the surface of the insulation to which they are applied. Adhesives shall be compatible with the insulation and in their dry state be non-flammable. Under no circumstances shall adhesives be used which attack or dissolve the ductwork or insulation.

6.1.11.5.5 Aluminium foil or plastics faced preformed sheet insulation materials shall be placed on the outside of ductwork with adjacent sides lapped to maintain a uniform thickness at joints and corners. All joints shall be sealed with foil tape and held in place with contact adhesive. The adhesive shall be suitable for the range of ambient temperature and humidity encountered.

6.1.11.5.6 Reinforcement of self-setting cement shall be 25 mm spaced wire mesh of 1 mm diameter galvanised steel wire netting reinforcement. Cement finishes applied to thermal insulation shall always be completely dry before the application of any sealing primer and final decorative coating. Cement application shall be planned and executed in sections to avoid joints between wet cement and cement already dried.

6.1.11.5.7 Where thermal insulation is protected against the effects of weather by plastics sheet or roofing felt, particular care shall be taken to ensure a watertight seal at all joints. The sheet material shall be adhered to the external surface of the insulation and all joints shall be lapped, secured and sealed by adhesives or solvent welding. All jointing and sealing materials and methods of application shall be to the recommendations of the sheet supplier. Poly-isobutylene sheet shall be not less than 0.8 mm thick and have a tensile strength not less than $3.4MN/m^2$.

6.1.11.5.8 Where an insulated duct passes through an external building element, adequate precautions shall be taken to prevent the entry of rainwater from the outside into the building. Details shall be submitted to the Supervising Officer for approval well before the construction starts.

6.1.11.5.9 Flexible insulation shall have all circumferential and longitudinal joints sealed with tape of the same material or highly compatible with the main insulation facing. The external surface of the insulation shall be wrapped over with 25 mm mesh spaced wire mesh of 1 mm diameter galvanised steel wire netting reinforcement and the netting joints shall be secured with a lacing of 1 mm galvanised wire. Care shall be taken to ensure that the insulation material is not crushed during this application.

6.1.11.5.10 Thermal insulation and/or acoustic insulation materials shall be applied to the inside of ductwork only where specified by the Particular Specification or Drawing. The insulation material shall be cut to accurately fit the internal duct surfaces. The insulation shall be fastened to the duct using adhesive spread over the entire surface in combination with piercing fasteners finished flush with the insulation surface. Particular care shall be taken to ensure that the edges of all internal insulating materials, whether exposed or butted against similar edges, are sealed and secured to the internal surfaces of the duct. They shall be protected with galvanised iron channel sheet metal of not less than 0.8 mm thickness and 13 mm width. Alternatively, they may be provided

with other approved means of protection to prevent erosion and peeling. All materials shall have adequate strength and ability to resist erosion at the maximum design air velocity and shall not produce dust.

6.1.11.5.11 Unless otherwise specified in Particular Specification, fibreglass insulation with scrim glass fibre cloth face finish or elastomeric insulation shall be used for internal lining material.

6.1.11.6 CHILLED WATER PIPEWORK AND EQUIPMENT - MATERIALS AND FINISHES

6.1.11.6.1 Inside buildings for services concealed from view; the insulation shall be provided as specified above and shall be finished as follows: -

(a) In normally non-accessible situations such as ducts, voids and chases, etc., factory applied aluminium foil or plastic film secured by adhesive self-overlaps or by matching tape preformed sections secured by external vapour seal and left unpainted. Where necessary on site vapour sealing compound shall be applied to ensure a 100% seal; and

(b) In all accessible ducts, voids, chases, etc. and where indicated, self-setting cement not less than 15 mm final thickness applied "in-situ" to preformed sections over 25 mm spaced wire mesh of 1 mm diameter galvanised steel wire netting reinforcement, sealed and left unpainted. Alternatively, the insulation shall be vapour sealed and then protected with neatly applied external aluminium sheet cladding of not less than 0.8 mm thickness with all joints sealed.

6.1.11.6.2 Inside buildings for services exposed to view but not readily accessible; the following shall be applied or as indicated: -

(a) Pliable plastics, elastomeric sheets or rigid plastics, not less than 0.35 mm thick either factory applied to preformed sections and lapped and sealed with adhesive or supplied loose and wrapped on Site with lapped and sealed joints. The sheets shall be either self-coloured or if required by the Supervising Officer finally painted; or

(b) Aluminium foil faced preformed sections secured and sealed by the application of minimum 100 mm wide matching self-adhesive tape over all longitudinal and circumferential joints.

In both of the above cases, the integrity of the required vapour seal shall be maintained.

6.1.11.6.3 Services in plant rooms and elsewhere where specified in the Particular Specification or Drawing, shall receive the following treatment in order to avoid possible mechanical damage or make necessary provision as otherwise indicated: -

(a) Enclosed in fabricated sheet hammer clad aluminium casings. The casing shall be not less than 0.8 mm thick for pipework of 150 mm and above measured over the insulation and not less than 0.6 mm thick on smaller pipework;

(b) Be insulated and covered with aluminium foil or plastics faced preformed sheet and finally painted;

(c) Be treated with an effective high quality water based vapour barrier coating, Class 'O' surface to BS 5422:2009.

The vapour barrier coating shall be non-flammable and safe to transport, store and use. Thixotropic consistency provides easy application with pinhole free, smooth finish, even when bridged over rough substrates. The dried film shall be tough, flexible, washable and resistant to acids and alkalis for a long service life.

Glass fibre reinforcing mesh shall also be applied in between coat. The reinforcing mesh shall incorporate a thread of 10 strands by 10 strands per 650 mm^2 into its construction. When tested according to ASTM D579/D579M-15, the materials shall have a tensile strength warp of 50 g/mm^2 and fill of 50 g/mm^2.

6.1.11.6.4 Outside buildings, services exposed to the weather; either of the following weather-proof covering shall be provided as indicated: -

(a) Enclosed in fabricated sheet hammer clad aluminium casings. The casing shall be not less than 0.8 mm thick for pipework of 150 mm and above measured over the insulation and not less than 0.6 mm thick on smaller pipework;

(b) Enclosed in roofing felt, sealed with adhesive with overlaps of at least 50 mm, wrapped with 25 mm spaced wire mesh of 1 mm thick, galvanised steel wire netting reinforcement, laced with 1 mm thick galvanised wire and painted two coats of bituminous paint or application with 15 mm thick cement plaster and paint;

(c) Enclosed in poly-isobutylene sheet not less than 0.8 mm thick of tensile strength not less than 3.4 MN/m^2, lapped and sealed at all joints; or

(d) Be treated with two coats of elastomeric polymer-based heavy duty mastic with reinforcing membrane to give a weather resistant finish.

The product shall meet the requirement of NFPA-90A:2021. The non-combustible shall be in accordance with NFPA 220:2021. Dry Film Fire Hazard requirements meet GSA and the product shall be tested by ASTM E84-18b (Standard Test Method for Surface Burning Characteristics of Building Materials).

6.1.11.7 CHILLED WATER PIPEWORK AND EQUIPMENT

6.1.11.7.1 Thermal insulation shall be applied to pipework of chilled water or hot water distribution systems, pipework of thermal fluids of heat recovery systems, cold condensate drain pipes, and all components within distribution systems such as valves and storage vessels, etc.

6.1.11.7.2 Pipework insulation shall also be deemed to include all open vents, cold feeds, chilled/hot water tanks, expansion tanks, valves, flanges, fittings, pumps, accessories, other chilled water plant and hot water plant items whether specifically mentioned or not.

6.1.11.7.3 The insulation shall fit closely to the pipework and other surfaces without gaps between joints. Each section of preformed insulation shall be secured to the pipe by means of circumferential bands of non-ferrous metal, plastics fabric, or adhesive tape. Preformed sheet materials shall be secured to chilled water containers and flat surfaces in the same manner as specified for ductwork. Valves, flanges and other fittings shall be insulated with "oversize" sections, around valves fittings shall be filled with fibrous material, pieces of shaped insulation or other approved infill. Covers which are to be removable shall be separately secured. Two vapour barriers shall be provided, one to totally enclose the main insulation and the other to cover the removable insulation.

6.1.11.7.4 At all points of support, both insulation and outer covering shall be continuous and shall not be punctured or fouled by the supports. The insulation at supports shall be material of sufficient compressive strength to take the loads transmitted to the supports. The load-bearing insulation shall be extended on each side of the supports.

6.1.11.7.5 At entries into buildings the weather-proofed insulation shall extend not less than 150mm beyond the inner face of the wall and be sealed to prevent the entry of water from the outside into the building to the satisfaction of the Supervising Officer.

6.1.11.7.6 Pre-fabricated and pre-insulated pipe section shall be used and provided for long straight run pipes, such as riser pipes, headers and pipes in plant rooms, etc. as specified in the Particular Specification.

6.1.11.7.7 Unless otherwise indicated, pre-fabrication and pre-insulation shall include but not limit to pipework, valve, flanges, fittings and all accessories.

6.1.11.7.8 The pre-insulated pipes shall be delivered to site with 100mm exposed ends to facilitate field joining. All joints shall be insulated by the same material using foam injection method on site. All foam-in-situ (on site foaming) shall be limited to pipe length below 1 meter. All pipework longer than 1 meter requiring insulation shall be pre-insulated, no on site foaming is allowed except for pipe joints and other piping accessories approved by the Supervising Officer. The insulation shall be applied following the contour of pipework and adhere tightly and evenly with the pipework surface.

6.1.11.8 PAINTING AND IDENTIFICATION

6.1.11.8.1 All distribution services shall be colour coded and provided with symbols for identification purposes. Identification coding for ductwork, including thermal insulation, shall be in accordance with BESA Standard DW/144:2016. For pipework, including thermal insulation, the basic colour and colour coding shall be in accordance with BS 1710:2014.

6.1.11.8.2 Uninsulated pipework or ductwork and thermal insulation which are painted or unpainted shall be identified by bands at least 25 mm wide or colour triangles of at least 150 mm side. The bands or triangles shall be spaced and located to permit ready identification of the services particularly adjacent to equipment positions and at service junctions and wall penetrations.

6.1.11.8.3 In addition to colour bands or triangles all pipework and ductwork in plant rooms and service areas, whether insulated or not, shall be legibly marked with black or white letters and triangles to show the type of service and the direction of fluid flow.

Services shall be shown as follows: -

Chilled water	CHW
Condensing water	CONDW
Hot water	HW
Supply air	SA
Returned or recirculated air	RA
Outdoor air	OA
Exhaust air	EA

The letters F and R shall be added to piped distribution to show "flow" and "return" respectively.

SUB-SECTION 6.1.12

UNITARY AIR-CONDITIONER

6.1.12.1 GENERAL

6.1.12.1.1 Unitary air-conditioners shall include the following: -

(a) Single package unit;

(b) Packaged unit and remote condenser;

(c) Condensing unit and blower coils;

(d) Condensing unit with variable refrigerant flow control and indoor fan coil units;

(e) Multi-split system; and

(f) Water-cooled package and water pump package.

6.1.12.1.2 Unitary air-conditioners shall be factory fabricated and assembled. The equipment shall be rated and tested in accordance with the International Organisation for Standardisation (ISO) Standards 5151:2017 (non-ducted air-conditioners and heat pumps) or 15042:2017 (multiple split system air-conditioners and air-to-air heat pumps – testing and rating for performance) or 13253:2017 (ducted air-conditioners and air-to-air heat pumps) or 13256-1 & -2:1998 (water-to-air and water-to-water heat pumps) or GB/T 18837-2015 (multi-connected air-condition (heat pump)) unit other internationally recognised quality assurance standards approved by the Supervising Officer.

6.1.12.1.3 Refrigerants adoption shall fulfil the maximum threshold for the combined contributions to ozone depletion and global warming potentials in accordance to the BEAM Plus New Buildings 2.0 and shall provide the required supporting documents to facilitate BEAM Plus submission.

6.1.12.2 INSTALLATION AND SERVICING

Installation and servicing of unitary air-conditioners shall comply with the practice set out in the ISO13261-1:1998 & ISO13261-2:1998 and the manufacturer's recommendation.

6.1.12.3 ANTI-VIBRATION MOUNTING

Vibration mounting shall be installed in accordance with relevant clauses in Sub-section regarding Noise and Vibration Control of this Part of the General Specification.

6.1.12.4 CASING

Removable panel for casings shall be provided to give access to all working components, parts, and connections for installation and service. The casing of condensing unit shall be rigid G.I. Sheets and painted. The compartment housing for the direct-expansion coil and blower shall be adequately insulated to prevent water condensation and shall contain a suitable drip pan with a drain connection. The compartment housing for the compressor shall be treated for effective sound insulation to ensure that the noise emitted is within the limits as specified in the Particular Specification.

6.1.12.5 COMPRESSOR

Each compressor shall form a separate refrigerant circuit with its own condenser, evaporator and controls except multi-split system and VRF.

6.1.12.6 SUPPLY AIR FAN AND MOTOR

All fans shall be statically and dynamically balanced. Fans shall be equipped with permanently lubricated bearings suitable for the installed altitude of the fan. Motors shall be installed in accordance with the relevant clauses of this General Specification.

6.1.12.7 COOLING AND HEATING COILS

Adequate water collecting tray for run off and removal of the condensation shall be provided. Each coil or circuit shall be controlled by a separate thermal expansion device.

6.1.12.8 AIR FILTER

Air filters shall be installed in accordance with the relevant clauses of Sub-sections regarding Air Cleaning Equipment of this General Specification.

6.1.12.9 AIR-COOLED CONDENSERS

Condenser fan shall be of propeller type arranged for either horizontal or vertical discharge that shall be specified in the Particular Specification.

6.1.12.10 CONDENSATE DRAIN PIPE

Condensate drain pipe shall lead to the nearest convenient drain in the building or as indicated on the Drawings or as directed by the Supervising Officer on Site.

6.1.12.11 MINIMUM INSTALLATION REQUIREMENTS OF SAFETY AND OPERATIONAL CONTROL FOR UNITARY AIR-CONDITIONERS

The minimum installation requirements of safety and operational control shall be as Table 6.1.12.11.

Table 6.1.12.11 Safety and Operational Control Requirements

Components /facilities	Unit Cooling Capacity		
	Up to 7kW	7kW-14kW	over 14kW
Self-contained safety and operational components of factory standard	Yes	Yes	Yes
Pressure gauges' c/w stop valves, sight glass	-	Yes*	Yes*
Renewable filter-drier c/w accessories	-	Yes*	Yes*
Externally mounted adjustable Hi-Lo pressure cut out with hand reset for High side*	-	Yes*	Yes*
Anti-recycling device	Yes	Yes	Yes
Emergency Stop Switch	Yes	Yes	Yes
Crankcase Heater	-	Yes	Yes
Pump down function and facilities	-	-	Yes
Mechanical and weather protection to thermal insulation which exposed to view	Yes	Yes	Yes

*Provision of components/facilities are subject to the recommendation of the manufacturer

Requirements for room coolers are not covered in the above and shall refer to relevant clauses in Part 7 of this General Specification.

6.1.12.12 SINGLE PACKAGED AIR-CONDITIONER

The entire single packaged air-conditioner shall be housed in a weather-proof and galvanised iron sheet metal casing of robust construction yet painted with attractive appearance.

6.1.12.13 PACKAGED AIR-CONDITIONER WITH REMOTE CONDENSER

The remote condenser shall be air-cooled/water-cooled and installed outside the building. The interconnecting refrigerant piping shall be field connected.

6.1.12.14 SPLIT CONDENSING UNIT AND AHU

The Split Condensing Unit shall be air-cooled/water-cooled and installed outside the building. The interconnecting refrigerant piping between condensing unit and air handling units (AHU) shall be field connected.

6.1.12.15 VARIABLE REFRIGERANT VOLUME SYSTEM

The entire system completed with all necessary piping and accessories shall be supplied and by a single proprietary manufacturer who has proven record for its product. Calculation to prove the performance of the equipment with the required length and level difference shall be submitted to the Supervising Officer for approval.

6.1.12.16 MAINTENANCE SERVICING PLATFORM

Where unitary air-conditioners are installed at levels that are normally inaccessible from ground, an adequately sized service platform complete with railings and steel cat ladder with safety wings shall be provided. Such platforms shall be of reasonable substantial rigid galvanised metal construction and shall be well protected against corrosion. The configuration shall be approved by the Supervising Officer before installation.

Suitable working platform shall be used when carrying out works at 2 metres or more above the ground, according to the Work-at-Height Safety published by the Labour Department.

SUB-SECTION 6.1.13

WATER HANDLING EQUIPMENT

6.1.13.1 GENERAL PUMP INSTALLATION REQUIREMENTS

The installation details shall be in accordance with the instructions prepared by the manufacturer. Unless otherwise approved by the Supervising Officer, pump set shall be prefabricated and install according to Part 2 of this General Specification.

Pump shall be "Type-tested" in accordance with the requirements of BS EN ISO 9906:2012. Test certificates with performance curves shall be submitted to the Supervising Officer.

Pump and motor drive shall be segregated such that failure of pump seals shall not result in damage to the drive motors.

6.1.13.2 CENTRIFUGAL WATER PUMP

6.1.13.2.1 Common Installations for Boiler Feed-water, Fresh Water and Saline Water Pumps

(a) Driving Arrangements

The pump and motor shall be direct coupled and mounted on a substantial machined bedplate; accurately aligned, and fitted with guards. The whole assembly including the bedplate shall be supplied by the pump manufacturer. Coupling with spacer shall be used for end suction pumps so that the impeller may be dismantled from the motor side for servicing without neither disrupting the pipework nor dismounting the motor.

The pump and motor for vertical multi-stage pump for potable application shall be of close-coupled type.

(b) Stand-By Pumps Arrangement

Where stand-by pumps are specified with automatic changeover provision, the changeover shall be initiated by means of flow sensing devices of an approved pattern. The necessary non-return valves shall be incorporated in the pipework to interconnect such pumps.

6.1.13.2.2 Sump Pump

Sump pump shall be of vertical centrifugal type and suitable for dry sump or wet sump installation. Each pump shall be constructed with double mechanical shaft seal and close-coupled to a submersible electric motor.

Sump pump shall operate automatically under level control with an alarm to alert the operator when high water level is being exceeded.

Each pump shall be equipped with factory built-in suspension device and a factory mounted discharge elbow shall be provided for wet sump installation, and cast iron or steel base for dry sump installation to provide correct pump alignment for wet sump pump installation, the disconnection shall simply consist of easy removal of each pumping unit for inspection, repairs and services. The pumps when lowered into the pits shall automatically be connected to the discharge piping. There shall be no need for the maintenance or operation personnel to enter the wet well to carry out the work. Each pump shall be complete with guide bars, cable supports and lifting chains.

The pump discharge shall be fitted with a resilient seal that provides a positive hydraulic seal for maximum pump efficiency. Each impeller shall be trimmed to meet the specified flow requirements.

For installation in flammable zones, each sliding guide bracket shall have non-sparking material to prevent ignition of explosive wet well gases.

6.1.13.2.3 Bore Well Pump

Bore well pump shall be vertical multi-stage centrifugal construction that is suitable for submersible bore well installation. Each pump shall be of a single shaft and non-shaft coupling type in which a submersible electric motor is coupled at the bottom of the pump. The pump suction shall complete with a perforated strainer located between the submersible motor and the first stage impeller bowl. The pump bearings shall be water lubricated and shall not cause any contamination to the water handled. The submersible motor shall be cooled by water moving around the motor casing.

Each pump shall be equipped with an impact non-return valve located between the pump discharge and rising main to prevent from the flow back of the water in the rising main. A level switch shall be provided for the automatic cut-off of the pump as dry running protection when the water level inside the pit falls below the pump safety suction lift. The level switch shall be maintenance free type.

Bore well pump shall be installed vertically into the pit. No foundation shall be required for the pump on the bottom of the pit. Instead, the pump shall be hung from the pit cover which seals the pit and absorbs all stress resulting from the weight of the bore well pump, cable, rising main and water column. The length of each section of the rising main shall be limited to 3 m long to facilitate the withdrawal of the pump from the pit for maintenance.

6.1.13.3 PUMP INSTALLATION LOCATION

Adequate working space and headroom shall be provided to access for maintenance and lift the parts for repair. For large pump, hoist with travelling crane or other facility shall be provided over the pump location.

For an open loop system, the location of pump shall be sited so that it will use the shortest and most direct suction and smallest vertical lift. Where possible, the pump centreline shall be placed below the level of the liquid in the suction tank.

Precautions against flooding shall be taken when pump is located in pit or other place liable to flooding. The pump shall be of the vertical spindle type with the motor mounted above the potential flooding level. Motor and pump shall form one unit being joined by a common stool. Where shaft extension is required, the pump shall be driven through a flexible shaft that consists of a universal joint at each of the drive and driven end and the slip joined at centre of travel.

6.1.13.4 PUMP FOUNDATION

The foundation for a pump shall be of sufficient size and rigidity to properly support the full area of the base-plate, to absorb any normal strains and to maintain correct alignment. The minimum mass of inertia block of concrete shall be not less than 2.5 times the mass of the pump assembly with at least 100 mm thick and 150mm wider than the pump base-plate.

The space between the pump unit and the foundation bolts shall be allowed in accordance with the manufacturer's recommendation. Each foundation bolt shall be installed in a pipe sleeve type holder and shall be cast before the concrete foundation is being poured.

Unless otherwise specified, pump base shall be mounted on the raised housekeeping plinth using appropriate anti-vibration spring mountings. Each spring shall be individually selected according to load distribution and shall have an additional free travel equal to one half of the rated deflection. Spring mounts shall have a levelling bolt and shall be mounted to the concrete inertia block via height saving brackets that allows a base clearance of 50 mm.

A curb ring or soleplate shall be used as a bearing surface for mounting of a vertical wet-pit pump. The mounting face of the curb ring or soleplate shall be machined for pump alignment. Tie rods shall be installed to secure the pump that is intended to discharge below ground.

6.1.13.5 PUMP ALIGNMENT

Pump unit shall be accurately aligned in accordance with the manufacturer's instructions prior to operation. The unit shall be supported over the foundation by strips of steel plate close to the foundation bolts, allowing a space of 20 to 50 mm between the bottom of the base-plate and the top of the foundation for grouting. The alignment shall be rechecked after the suction and discharge piping have been bolted to the pump to test the effect of piping strains.

The pump and driver alignment shall be rechecked and adjusted correct at the expiry of the Maintenance Period.

6.1.13.6 GROUTING OF PUMP BASE

The base-plate shall be grouted before piping connections are made and pump alignment is finally rechecked. Grouting by Building Contractor shall be properly done with concrete that shall compose of one part of pure cement and two parts building sands or be a proprietary non-shrink grout to the acceptance of the Supervising Officer to prevent lateral shifting of the base-plate. Grout holes shall be allowed in the base-plate to serve as vents for air escape. The expose surface of the grout shall be covered with wet burlap to prevent cracking from drying too rapidly. The pump alignment shall be rechecked thoroughly after the grouting has hardened for a period that shall not be less than 72 hours.

6.1.13.7 SUPPORT FOR PIPING

Suction and delivery pipes shall be supported independently of the pump. The connecting pipes to a pump shall not strain the pump. Pipes installation shall match up to the respective flanges without being strained into position. The faces of the coupling shall be checked with a straight edge to make sure that they are parallel and concentric.

6.1.13.8 CONNECTION PIPING TO PUMP

6.1.13.8.1 Suction Piping

The suction piping shall be properly installed for a satisfactory pump operation. This shall be achieved by keeping as direct and as short as practicably possible with a minimum number of bends. The installations shall be laid out such that a continuous fall can be maintained from the pump to water source to prevent air pockets forming. Concentric reducers shall not be used on suction branch.

The size of the suction pipe shall be larger than the pump inlet and eccentric reducers shall be used. If the source of supply is located below the pump centreline, the reducer shall be installed straight side up. If the source of supply is above the pump, the straight side of the reducer shall be at the bottom.

A straight section piping at least 4 to 6 diameters long at the pump inlet and long radius bend shall be used for suction pipeline installations to create less friction and provide more uniform flow distribution.

6.1.13.8.2 Delivery Piping

Unless otherwise specified, the size of the delivery pipe shall be at least one size larger than the pump delivery and the velocity shall be kept around 2 metre per second for pumping water over long distance. The check valve shall be installed between the pump and the gate valve. The

gate valve shall be installed close to the pump discharge for pump priming and repairing. Provision such as a sprocket rim wheel and chain shall be provided for manually operated valves that are difficult to access.

Air release valves shall be installed at the highest points on each rise to allow accumulated air or vapour or other gases to escape from the pipe.

A 'Y' type branch connection shall be used for distribution of more than one-discharge points.

A taper piece with the included angle between 10-13 degrees shall be used for reduction of pipe diameter.

Adequate support and anchorage shall be provided if the pipes are laid above or below ground. For this purpose, it is acceptable to have thrust blocks in either corner type or puddle flange type to absorb reactions or turning forces to ensure no mechanical and hydraulic forces imposed on the pump.

6.1.13.8.3 Pipe Flange

Pipe flange shall match with the sizes of pump flanges with full-face gaskets.

6.1.13.8.4 Expansion Joint

Expansion joints shall be installed in suction and delivery pipelines to avoid transmitting any piping strains caused by expansion when handling hot liquid. A suitable pipe anchor shall be installed between the expansion joint and the pump.

If expansion joints are not specified, expansion loops that are formed by looping the pipe shall be provided to prevent the transmission of strains to the pump.

6.1.13.8.5 Intake

The installation work shall be carried out properly to prevent air being entrained as bubble within the water. The intake pipe shall run well below the sump tank level to prevent from forming air gulps.

High level entry into the sump shall be avoided as air may be entrained by the falling jet.

Vortex inhibitor shall be installed to prevent air being drawn from bottom of vortex into the intake.

6.1.13.9 SUCTION STRAINER

The suction strainer shall be installed as close as practicably possible to the pump. This suction pipe strainer shall not be used for flushing the pipe. A temporary strainer fitted with a finer mesh than the permanent strainer shall be used for flushing all piping and cleaning thoroughly all possible mill scale and other foreign matter. The temporary strainer shall be removed afterwards.

6.1.13.10 VENTING VALVE FOR PUMP-SET

Venting valve shall be installed at one or more points of the pump-casing waterway to provide a means to escape for air or vapour trapped in the casing. The valve shall be connected so as not to endanger the operation staff in handling toxic, inflammable or corrosive liquid.

6.1.13.11 DRAIN FOR PUMP-SET

All drain and drip connections shall be piped to a point where the leakage can be disposed of or collected for reuse if specified.

6.1.13.12 INSTRUMENTATION

Each pump installation shall include pressure gauges and a gas cock to measure the system pressures and pressure drop.

All measuring and isolation instruments, such as the pressure gauges, check valves, globe valves, gate valves and strainers, etc., or as specified in the Particular Specification shall be installed properly to maintain a close check on control on the performance and condition of the pumps.

Instruments shall be mounted in a suitable location so that they can be easily observed.

6.1.13.13 FEED AND EXPANSION TANK

The tank shall be provided and installed on the roof or other location as specified, on a stand if necessary, to suit the NPSH of the pump being selected.

The tank shall be complete with ball float valve, valve, overflow, drain facilities and quickly fill valve, etc. In addition, hinged access door with gasket and rotating hinged bolt-securing device shall also be provided.

Overflow pipe shall be at least TWICE the diameter of the inlet pipe or 32 mm whichever the greater and shall discharge to a conspicuous location outside the building.

Connections to a mild steel tank shall be made by means of bossed, screwed flanges or pads and studs and shall be welded before galvanising. Openings for connections to steel tank of other material may be made on site complete with back nuts and plastics that are compatible with the liquid being handled.

Unless otherwise specified, the installation shall include the final connection of the main cold water supply to the ball float valve from a valve point.

6.1.13.14 WATER FILTER

Unless otherwise specified, water filter shall be provided for the Installations with details as follows: -

6.1.13.14.1 Suitable and approved coarse and fine filters shall be fitted on all non-re-circulating cooling or flushing water supply water system e.g. sea water system.

6.1.13.14.2 For re-circulating systems of the water tower type, fine filters and sludge traps shall be provided.

6.1.13.14.3 For close re-circulating system, filters need only be provided for the "make-up" water if it is drawn from the well or stream water and likely to be contaminated with sediment.

6.1.13.14.4 For the installation of a seawater pump house, in addition to the intake coarse filter, the strainer or the motorised travelling band screen in the plant room shall be an automatic self-cleaning and approved type. The strainers or the motorised travelling band screen in the plant room shall comprise a motorised continuously rotating inner drum, and have an automatic backwash arrangement. Proper drainage facility shall be provided by the builder.

6.1.13.15 PLATE TYPE HEAT EXCHANGER

The installation shall be in accordance with the manufacturer’s recommendations and shall be easily accessed for maintenance and repair.

6.1.13.16 SEA WATER STRAINER

The installation shall be in accordance with the manufacturer’s recommendations and shall be easily accessed for maintenance and repair.

SUB-SECTION 6.1.14

INDOOR AIR QUALITY EQUIPMENT

6.1.14.1 GENERAL

The requirements stated in this Sub-section shall apply to all buildings or totally enclosed areas provided with air-conditioning and mechanical ventilation installations (ACMV) for human comfort. In any case the requirements as published by the EPD in related to Indoor Air Quality (IAQ) shall be fulfilled.

The fulfillment of the requirements in this General Specification shall not in any way provide exemption from existing legal obligations relating to indoor air quality and the ventilation requirements.

The indoor air quality objectives and levels of achievement shall be in following the Guidance Notes as published by the EPD or other recognised Authority as specified in the Particular Specification. The indoor air quality objectives will not be applicable to any part of the building such as plant rooms and switch rooms or places where only mechanical ventilation is specified.

Unless otherwise specified, net positive pressure shall be maintained inside the building. The exact requirement of pressurisation shall be in according to the specific requirements as stipulate in the Particular Specification. Unless otherwise specified in the Particular Specification, pressure sensors shall be installed on each floor of the building to monitor and control the fan output so as to maintain the specified positive pressure. Such requirements are exempted for those buildings where negative inside pressure is required and specified in the Particular Specification.

All internal surfaces including walls, floors, ceiling and equipment plinth of AHU and fan rooms shall be treated with epoxy paint. All sealing with fibreglass/rock wool for vibration isolation sealing across structural wall/floor/ceiling shall be caulked airtight and properly sealed with approved means.

6.1.14.2 OUTDOOR AIR QUALITY

The outdoor air intakes shall be located where the air induced shall be the cleanest taking into account any sources of contaminants which are close to or at upwind of the intake. No rectification work is required if outdoor air data measured below the latest concentration level as set out in the Hong Kong's Air Quality Objectives in the Air Pollution Control Ordinance (Cap 311).

Suitable air cleaning and air treatment equipment for the control of IAQ shall be selected based on the measured outdoor air quality as stated in the Particular Specification, or as set out in the Hong Kong's Air Quality Objectives in the Air Pollution Control Ordinance (Cap 311), whichever is worse. Prior to the selection of equipment for the Installations as specified in the Particular Specification, the outdoor air quality shall be verified again by an independent party.

6.1.14.3 SELECTION OF AIR TREATMENT FACILITY

Air cleaning equipment intended to meet the IAQ requirements shall be properly selected for the particular pollutants being treated. The following air treatment facility shall be provided and installed as appropriate: -

(a) Particulate Filtration

(b) Electrostatic Precipitation

(c) Electronic Air Cleaner

(d) Activate Carbon Filter

(e) Germicidal Ultraviolet Air Steriliser

(f) Dehumidifier

6.1.14.4 OUTDOOR AIR PRE-CONDITIONER

6.1.14.4.1 Desiccant Type Outdoor Air Pre-conditioner

The pre-conditioner shall comprise a 3Å molecular sieve Potassium Aluminosilicate coated total energy wheel, an exhaust fan, an outdoor air fan and air filters in both fresh and exhaust streams (upstream of the fan). These components shall be housed in a common insulated casing and shall be suitable for mounting in any orientation.

Removable access panel of suitable size shall be provided for replacement of filters and inspection of fans and wheel. The access panels shall be perfectly sealed and hinged to the casing.

Suitably sized flanged collars shall be provided for each of the connection of fresh air, supply air, return air and exhaust ductworks.

A control panel shall be provided in the casing, together with termination blocks, for the connection of electricity supply.

6.1.14.4.2 Paper Plate Type Outdoor Air Pre-conditioner

The pre-conditioner shall comprise supply air fan, exhaust air fan and resin net (washable) filter. Each pre-conditioner shall comprise a non flammable heat exchange element as the media for the enthalpy exchange between outdoor air intake and exhaust air. The pre-conditioner shall be cross flow type with a high durability and reliability, a high performance and low pressure loss type.

The pre-conditioner shall comprise indoor and outdoor temperature sensors to detect indoor and outdoor air temperature in order to determine bypass or enthalpy exchange mode.

The pre-conditioner shall have 3-steps air flow rate changeover.

The ON/OFF operation shall be controlled from the double poles switch installed at the entrance of the room under the electrical work of the Contract. However, the remote controller supplied with the fresh air pre-treated unit shall be installed adjacent to the unit for maintenance use. The unit shall have automatic ventilation mode changeover controlled by the air temperature sensor.

6.1.14.4.3 Polyester Fibre Type Outdoor Air Pre-conditioner

The pre-conditioner shall comprise a rotary wheel as the media for sensible and latent heat transfer between the outdoor air and the exhaust air.

6.1.14.4.4 Desiccant Type Dehumidifier Air Handling Unit

The dehumidifier AHU shall be a combination of desiccant heat recovery rotor and refrigeration dehumidification system. Humid inlet process air shall firstly be cooled and dried by the evaporator and further dried by the desiccant rotor, or alternative arrangement to be specified in the Particular Specification. The rotor shall be regenerated by hot air after the condenser in the heat pump refrigeration circuit, or by room air as to meet the system requirements. The desiccant dehumidifier shall maintain the specified room relative humidity and temperature when cooling system is turned off at night time.

Each dehumidifier AHU shall be a complete unit comprising cabinet, desiccant rotor, heat pump, process air fan, reactivation air fan, air filters, control panel, access panels, etc. with a standard and specification same as the air handling unit. The casing shall be of insulated double skin construction same as the air handling unit.

Heat pump refrigeration system where specified shall be integrated into the dehumidifier AHU to pre-cool the process air and regenerate the rotor.

The fan shall be centrifugal type. Fan motor shall be mounted within the dehumidifier's cabinet. The process air fan and the reactivation air fan shall provide sufficient static pressure for the application.

The compressor, process air fan and reactivation fan shall be cycled on when the outside relative humidity or temperature or the enthalpy is higher than the pre-set values. The speed of rotary desiccant wheel shall be varied to control the room temperature and humidity. Carbon dioxide sensors shall be installed at the return air stream of AHU to determine the state of occupancy. When humidification is specified in the Particular Specification, the humidification process shall be operated by means of steam humidifier.

6.1.14.4.5 Electrostatic Precipitator

Installation of electrostatic precipitators shall comply with the FSD's requirements.

Each section of the galvanised steel housing assembly shall incorporate a pair of hinged, quick opening access doors permitting access for servicing of all internal components; and a watertight, all welded, galvanised steel, drain pan and drain connections. Access doors shall be sealed against air leakage by continuous perimeter gaskets of closed cell neoprene.

The washer supply water solenoid valve, the manifold drive motor, and the manifold limit switch shall be pre-wired to an accessible, internally mounted. Program timer control, with field adjustable timer and a timer bypass switch shall be provided to control the washing cycles. The washer control enclosure access door shall incorporate a status light to indicate when the reconditioning cycles is energised. An internal panel is to be equipped with a combination of LED status lights and display unit to indicate which part of the reconditioning cycle is in operation. The display unit is to be visible through a window in the control cover.

6.1.14.4.6 Electronic Air Cleaner

A stainless steel mounting flange shall be provided for mounting the electronic air cleaner to the air plenum of the air handling equipment. The electronic air cleaner shall be interlocked with the respective blower electrically and mechanically so that it can be safely switched off when the fan of the blower stops. The electronic air cleaner shall be wired so that the units may be unplugged and removed for regular servicing. The electrical wiring shall conform to the relevant safety standards.

6.1.14.4.7 Germicidal UV Air Steriliser

The construction and operation shall refer to Section 6.1.1.16 - UV sterilising light assembly.

6.1.14.4.8 Water Scrubber

The material and equipment specification shall refer to Section 6.2.1.19 – Water Scrubber.

SUB-SECTION 6.1.15

WATER TREATMENT SYSTEM

6.1.15.1 GENERAL

Water treatment for air conditioning water systems as follows shall be carried out to maintain water in proper "balance" condition (pH, hardness, total dissolved solids, total alkalinity, etc.) and to comply with the relevant Code of Practices issued by the EMSD: -

6.1.15.1.1 Treatment of sea water for condenser cooling to kill or inhibit marine growth and to inhibit the formation of scale, slime and foam in the pumps, pipework and condensers;

6.1.15.1.2 Treatment of water being circulated between condensers and cooling towers including the water in the tower;

(a) To inhibit corrosion, scaling, slime and foam formation; and

(b) To sterilise the water to prevent biofouling and the growth of pathological bacteria such as Legionella Pneumophila.

6.1.15.1.3 Treatment of chilled water or low pressure hot water in circulation system to inhibit corrosion, formation of foam, scale and slime in the pipework and evaporator tubes.

The design, installation, commissioning, testing and operation of the water treatment system shall be carried out by a water treatment specialist who has at least five years local water treatment experience in compliance with the Particular Specification, this General Specification, the relevant parts of the Code of Practice for Fresh Water Cooling Towers issued by the EMSD, Code of Practice for Prevention of Legionnaires' Disease issued by Prevention of Legionnaires' Disease Committee, the Government of the HKSAR, other currently in force Legislation and Subsidiary Legislation in Hong Kong and subject to the approval of the Supervising Officer.

To conserve water, the ratio between the concentration of dissolved solids in the cooling tower and the make-up water shall be 7 or more in accordance to the Code of Practice for Fresh Water Cooling Towers issued by the EMSD, in turn fulfilling the requirements under WU6 of the BEAM Plus New Buildings Version 2.0.

6.1.15.2 FORM OF WATER TREATMENT

Water treatment system as specified in the Particular Specification shall be supplied and installed. Where no water treatment system was specified in the Particular Specification or Drawings, the following basic water treatment system in accordance to relevant requirements in this General Specification shall be provided in according to Table 6.1.15.2.

Table 6.1.15.2 Basic Water Treatment

Type of Water	Basic Water Treatment
Sea water for condensing circuit	In accordance to Clause 6.1.15.3
Fresh water being circulated between condensers and cooling towers including the water in the tower	In accordance to Clause 6.1.15.5
Chilled water or low pressure hot water in circulation system	In accordance to Clause 6.1.15.7

Drawings and technical information detailing the set-up of the proposed water treatment equipment, the type of chemicals used and the treatment proposal shall be submitted to the Supervising Officer for approval prior to ordering of the equipment.

The water treatment proposal shall include water specification, method of analysis and testing recommended by water treatment specialist together with the testing report format. Bacteria count and identification of existence of pathological bacteria such as Legionella Pneumophila shall be included in the water analysis for cooling tower.

Necessary labour, testing equipment and chemicals for testing and commissioning, pre-cleaning and operation of the water treatment systems within the Contract Period shall be provided. Operation of water treatment systems including the consumables, water sampling and laboratory tests shall be provided during the Maintenance Period.

Water treatment specialist shall be engaged to carry out on-site water treatment service and water analysis at least once a month up to the end of Maintenance Period to prove that the performance of the water treatment system is satisfactory and conforming to the approved treatment proposal. Monthly report on the details of water treatment service and water analysis including tests, water treatments, consumption of chemicals, etc. shall be forwarded to the Supervising Officer.

6.1.15.3 SEAWATER TREATMENT BY BIOCIDES

6.1.15.3.1 General

The biocides used shall inhibit the growth of marine organisms throughout the system. It shall also inhibit the formation of scale and slime by acting as an efficient dispersant. This shall be achieved by the appropriate biocide treatment being carried out at 2 to 3 day intervals such that on these occasions the whole system shall contain a 6-ppm concentration of biocide solution for approximate 1 hour, which is sufficient to kill all organisms. Continuous dosages shall not be applied at lower ppm levels lest they allow the organisms to build up immunity.

The biocidal and dispersing agents for sea water condenser cooling systems shall have the following properties: -

- Strong biocidal properties;
- Dispersing effect on deposits;
- Filming properties providing a protective film to internal of pipework;

- pH value of 6.8;
- Specific gravity of 0.98;
- Non-flammable;
- Easily dosed by chemical metering pump with or without dilution; and
- Being sufficiently bio-degradable such that they do not cause environmental difficulties for the marine life. In that respect, they shall be of a type acceptable and approved by the HKSAR Environmental Protection Department or relevant Government Authorities.

6.1.15.3.2 System Sizing and Design

Advice of the approved water treatment specialist shall be sought on the dosages required, together with calculation, for a specified system water volume.

In case the cooling system is running with fixed sea water flow rate, the metering pump(s)of the water treatment system can be set for a particular input rate to achieve the appropriate dosage and duration which is usually possible to pump biocide direct from its supply container.

Where the cooling system is running with variable flow rate of sea water, the metering pump(s) concerned shall have the facility to automatically vary the amounts of chemicals dosing in proportion with the actual sea water flow. This can be achieved by metering pump(s) which can respond to the reading of a flow meter measuring the total sea water flow. Arrangement of variable chemical pumping rates shall be required where the sea water pump(s)is/are "stage" controlled or of "variable speed" control.

For "stage" controlled sea water pump(s), each sea water pump can be supplied with fixed biocide input from one metering pump. The inlet point shall be arranged before the pump and as near as possible to the primary inlet sea water gate valve. Such metering pump(s) would be controlled by the individual pump circuit such that they only operate when the respective pump is operated.

As an alternative, the sea water pump set(s) can also be supplied with a single source variable metering pump which is controlled by a flow measuring device placed after the outlet of main header. In such case, the chemical injection shall be distributed to all pump inlets via solenoid valves. Each solenoid valve shall be opened when the respective main sea water pump is switched on.

6.1.15.3.3 Flow Measurement and Control

The flow measuring device shall be of a low flow interference inserted velocity / static differential headed type.

The unit shall be inserted through and across the centre of the pipe in which the fluid flow is to be measured. It shall be inserted with water

tight glands at a position not less than a length of 12 pipe diameters downstream from any bend or any turbulence creating feature. The position chosen shall also be one that best assures an even velocity cross section flow of the fluid to be measured.

6.1.15.3.4 Biocide Storage

Apart from the necessity to periodically replenish the biocide supply, the Installations shall be capable of catering for minimum 4 weeks unmanned automatic operation. Chemical tanks shall be provided.

6.1.15.3.5 Chemical Tanks

Two chemical mixing tanks which made of ultra violet resistant round moulded fibreglass or polyethylene shall be installed. The capacity of each tank shall not be less than 180 litres.

6.1.15.3.6 Chemical Tube Connection to the Circulation System

Unless otherwise instructed by the Supervising Officer, suitable sized PVC valve completed with connectors for attachment of the chemical tubes from the metering pumps to the biocides feed pipe shall be installed at a tap off point near to the sea water intake.

6.1.15.3.7 Make Up Water Supply to Chemical Tanks

Unless otherwise specified, this shall take the form of an 18 mm bib tap situated over each chemical tank. Suitable supply to these bib taps with pipework securely fixed to the walls shall be installed. A 25 mm mains valve supply will be provided by others within a 30 metres pipe run of the tanks. Sufficient lengths of chemical resistant flexible hose from bib taps to the tanks to facilitate the filling operation shall be allowed.

6.1.15.3.8 Chemical Metering Pump

Panel or tank-top mounted high efficiency metering pumps shall be provided for each tank. Each pump shall capable of pumping from 2 litres to 90 litres of solution each in 1 hour. Metering pumps exceeding 90 litres/hour will be considered subject to approval by the Supervising Officer. Chemical pump shall have ON/OFF switch and protection fuse.

The pump suctions shall be mounted into the tank using an UPVC suction tube assembly that will prevent the suction tube becoming wrapped around the agitator shaft. The end of the pump suction tube shall not extend beyond the bottom of the UPVC tube shield.

6.1.15.3.9 Chemical Tank Agitator

One agitator assembly per mixing tank shall be provided. Each agitator shall consist of a fractional motor driving a stainless steel shaft and neoprene with bronze hub impeller. The shaft shall be of suitable length to suit the depth of the solution in the mixing tank.

6.1.15.3.10 Chemical Tank Liquid Level Switch

In order to prevent the metering pump and agitator from running if the chemical solution drops below a pre-set low level, liquid level switch and control system shall be provided at each tank cover. Visual and audio alarm shall also be provided at the control/indication panel.

The level switch shall be contained in a corrosion resistant assembly of glass reinforced polypropylene. It shall have PVC float tube, foamed polypropylene float and encapsulated reed switch.

In each case, there shall be a float protector to prevent false actuation due to turbulence. An extra low voltage transformer shall be incorporated to provide the supply to the reed switch for safety.

6.1.15.3.11 Electricity Supply

Unless otherwise specified, the electricity supply for the metering pumps, agitators and level switch assemblies shall be operated with 220 V single phase 50 Hz supply and connected from the supply point within the plant room to the water treatment equipment.

6.1.15.4 SEAWATER TREATMENT BY ELECTROCHLORINATOR

System for the injection of sodium hypochlorite solution produced on-site by electrochlorinator shall be supplied and installed where specified in the Particular Specification. The system shall take water under pressure upstream of the main sea water pump (usually in pump chamber) and after passing through the electrochlorinator, inject the solution back into the pump inlet side immediately after the first (primary) sea water inlet valve from the sea. The operation of the electrochlorinator shall be interlocked to work or stop as the seawater pumps.

The resulting concentration of free chlorine residue at this point shall be between 1 ppm minimum and 6 ppm maximums. Facilities shall also be provided at the same point to input a supercharge of concentrated liquid sodium hypochlorite or other suitable chemical to achieve periodic "super-chlorination" of the system.

The water to the electrochlorinator equipment shall be passed through coarse and fine strainers installed in its supply pipework, to ensure minimum fouling up of the equipment cells. Duplicate electrochlorinator plant shall be provided to ensure continued treatment when one unit is "off-line" for maintenance.

6.1.15.5 COOLING TOWER/CONDENSER COOLING WATER TREATMENT BY CHEMICAL AGENTS

6.1.15.5.1 Pre-cleaning and Flushing Out Operation

The entire cooling tower/condenser cooling water system shall be flushed out using appropriate chemical dispersant, detergent and de-foamed of type and strength recommended by a reputable chemical water treatment manufacturer and guaranteed in writing by that company as suitable in every respect for the application in question.

The chemicals shall remain in the system for 48-72 hours including a minimum of 24 hours with the pumped circulation in operation, unless otherwise recommended by the supplier with free technical support accepted by the Supervising Officer.

The system shall then be completely drained and flushed until tests at all drain points show that traces of suspended matter have been substantially removed to the Supervising Officer's approval.

The system water shall be completely drained as rapid as possible. Temporary 50 mm dia. valve drain outlets on all points where the main pipework is 50 mm or over shall be provided.

The discharge to the building drainage system and public sewer shall comply with the requirements of the EPD and DSD. Pre-treatment prior to discharge shall be provided if necessary.

Subsequent to the flushing out operations, the large drain down points shall be reduced to 15 mm valves or cocks or the sizes as indicated on the Drawings. The system shall be refilled and flushed as necessary to achieve the required water quality level.

6.1.15.5.2 Chemical Treatment to Prevent Corrosion, Sludge Formation and Microbiological Activity (Open System)

The chemical agent employed shall be a combination of chemicals which will provide corrosion protection, scaling and microbiological inhibition to the metal pipe lines and the construction material within condensers and cooling towers.

The chemical agent shall be non-flammable liquid chemicals such as molybdate or phosphate based agent blended with anti-foulant and amine based biocide. The agent shall be guaranteed by the chemical manufacturer as suitable in every respect for the application.

6.1.15.5.3 Chemical Dosage System

The chemical dosage system shall be a fully automatic system comprising the following minimum equipment: -

(a) Chemical metering pump and control panel constructed to IP 54 to BS EN 60529:1992+A2:2013 completed with system status indication, visual and audio alarm, timer, etc. as required to facilitate ease of operation and maintenance of the water treatment system;

(b) Chemical tanks; and

(c) Chemical tank liquid level switch.

6.1.15.6 COOLING TOWER/CONDENSER COOLING WATER TREATMENT BY OZONE

6.1.15.6.1 Pre-cleaning and Flushing Out Operation

The entire cooling tower/condenser cooling water system shall be flushed out using appropriate chemical dispersant, detergent and de-foamed of type and strength recommended by a reputable chemical water treatment manufacturer and guaranteed in writing by that company as suitable in every respect for the application in question.

The chemicals shall remain in the system for 48-72 hours including a minimum of 24 hours with the pumped circulation in operation, unless otherwise recommended by the supplier with free technical support accepted by the Supervising Officer.

The system shall then be completely drained and flushed until tests at all drain points show that traces of suspended matter have been substantially removed to the Supervising Officer's approval.

The system water shall be completely drained as rapid as possible. Temporary 50 mm dia. valve drain outlets on all points where the main pipework is 50 mm or over shall be provided.

The discharge to the building drainage system and public sewer shall comply with the requirements of the EPD and DSD. Pre-treatment prior to discharge shall be provided if necessary.

Subsequent to the flushing out operations, the large drain down points shall be reduced to 15 mm valves or cocks or the sizes as indicated on the Drawings. The system shall be refilled and flushed as necessary to achieve the required water quality level.

6.1.15.6.2 Ozone Generation System for Cooling Water Treatment

A complete ozone piping system separated from the main cooling tower/condenser cooling water system shall be provided to take water from the recirculating pump discharge side of the cooling water circuit, through the in-line ozone injector /contactor for ozone dosing, a solid separator and then recirculated into the sump of the water cooling tower or tank. The system operation and ozone dosing shall be fully automatic

with programmable direct digital real time control incorporated. Multiple injection points shall be adopted for cooling systems with turnover rate not more than four times per hour.

The ozone generation system shall include all major ozone generating equipment, circulating pumps, interconnecting piping, pipe fittings, enclosure, wiring, accessories, controls and instrumentation to form a compatible and complete working system. Weather-proof enclosure with self-contained lighting and ventilation shall be provided for the system that is susceptible to weather or outdoor conditions.

Unless otherwise specified, the design of the system, selection of equipment and ozone dosage rate for the particular fresh/sea water cooling water system with specific recirculation rate and system volume shall be included in the Works. The ozone dosage rate shall not be less than 0.1 mg/l in any case. The system shall be suitably oversized to satisfy the ozone demand at the initial stage for cleaning and descaling of the cooling water system for a period of not more than two weeks' period. Detailed system design and equipment selection proposal with all relevant design criteria, data, parameter, calculations and system schematic diagrams shall be submitted to the Supervising Officer for approval before placing order and actual commencement of installation works.

The ozone generation system shall be easily connected to ozone-in-air monitor and other control instrument for automatic stopping and control of the entire system. Visual and audio alarm shall be incorporated as specified. Ozone-in-air monitors shall be fixed at locations as indicated in the Drawings if specified in the Particular Specification and properly connected to the ozone generation system.

Unless otherwise specified, water-cooled type ozone generator shall be supplied and installed. Air-cooled type modules shall only be acceptable for low capacity ozone generator unit as specified in the Particular Specification. The cooling water shall be taken from the chilled water system of the building as indicated in the Drawings or at nearest A/C plant room. Pressure reducing valve, regulating valve and connecting chilled water piping shall be provided to maintain the design constant operating conditions of the modules.

6.1.15.6.3 Test Kit and Ozone Monitoring Equipment

Sampling points in the system together with a complete set of test kit for residual ozone testing shall be provided to facilitate daily inspection and assessment of ozone content.

A portable ozone-in-air monitor with range 0 - 9.5 ppm and 4-digit LCD shall also be provided.

The above test kit and monitor shall be handed over to the operating staff prior to the expiry of Maintenance Period.

6.1.15.7 CLOSE CIRCUIT CHILLED WATER OR LOW PRESSURE HOT WATER HEATING SYSTEMS TREATMENT BY CHEMICAL AGENTS

6.1.15.7.1 Pre-cleaning and Flushing Out Operation

The entire cooling tower/condenser cooling water system shall be flushed out using appropriate chemical dispersant, detergent and de-foamed of type and strength recommended by a reputable chemical water treatment manufacturer and guaranteed in writing by that company as suitable in every respect for the application in question.

The chemicals shall remain in the system for 48-72 hours including a minimum of 24 hours with the pumped circulation in operation, unless otherwise recommended by the supplier with free technical support accepted by the Supervising Officer.

The system shall then be completely drained and flushed until tests at all drain points show that traces of suspended matter have been substantially removed to the Supervising Officer's approval.

The system water shall be completely drained as rapid as possible. Temporary 50 mm dia. valve drain outlets on all points where the main pipework is 50 mm or over shall be provided.

The discharge to the building drainage system and public sewer shall comply with the requirements of the EPD and DSD. Pre-treatment prior to discharge shall be provided if necessary.

Subsequent to the flushing out operations, the large drain down points shall be reduced to 15 mm valves or cocks or the sizes as indicated on the Drawings. The system shall be refilled and flushed as necessary to achieve the required water quality level.

6.1.15.7.2 Chemical Treatment to Prevent Corrosion, Scaling and Sludge Formation

The chemical agent shall be a combination of chemicals guaranteed by the manufacturer as appropriate in every respect to prevent corrosion, scaling and sludge formation.

The agent shall be liquid chemicals such as molybdate or nitrite based agent blended with corrosion inhibitor which can provide such protection to the metal of closed circuit pipe lines, system and equipment.

Chemicals used within chilled water or low pressure hot water (LPHW) heating system shall, unless otherwise recommended by the supplier with full technical support and accepted by the Supervising Officer, have the following characteristics: -

(a) Suitable for the application, system operation conditions and fluid;

(b) Non-flammable; and

(c) Low toxicity.

6.1.15.7.3 Chemical Dosage System

The chemical dosage system shall be a fully automatic system comprising the following minimum equipment: -

(a) Chemical metering pump and control panel constructed to IP 54 to BS EN 60529:1992+A2:2013 completed with system status indication, visual and audio alarm, timer, etc. as required to facilitate ease of operation and maintenance of the water treatment system;

(b) Chemical tanks; and

(c) Chemical tank liquid level switch.

6.1.15.8 PRE-TREATMENT FOR DUMPING OF CHEMICAL WASTES

All chemical wastes generated during the Works, including the routine maintenance, repair, system flush-out etc. during the Maintenance Period, shall be handled, collected and disposed of in accordance with the Waste Disposal (Chemical Waste) (General) Regulation. The wastes shall be collected by a licensed Chemical Waste Collector for disposal at EPD approved facility.

6.1.15.9 WATER TESTING EQUIPMENT

Unless otherwise specified in the Particular Specification, water testing equipment corresponding to the type of water treatment system and chemical used shall be provided to monitor and verify the performance of the water treatment system offered and shall be handed over to the operation and maintenance staff prior to the expiry of Maintenance Period.

The equipment shall be of portable type suitable for field sampling and testing. For chlorine residual concentration testing, plain tablets and colour disc shall be provided. For pH value testing, pH meter or phenol red solution and colour disc shall be provided. Other relevant test kits shall include but not limited to total dissolved solid and corrosion inhibitor level tester.

6.1.15.10 PROVISION FOR OPERATION, MAINTENANCE AND SAMPLING

Prominent warning notices, safety goggles, gloves and necessary accessories for handling the chemicals shall be provided and handed over.

Sufficient number of sampling points in the pipework or equipment for water analysis, routine inspection and testing shall be provided.

SECTION 6.2

MATERIAL AND EQUIPMENT SPECIFICATION

SUB-SECTION 6.2.1

AIR CLEANING EQUIPMENT

6.2.1.1 GENERAL

Filter shall be of proprietary product and have the specified performance and fire property in accordance with the test methods of one or more of the standards stated hereinafter.

For filter used in corrosion resistant ductwork, the associated housing, holding frames, enclosures and all metal surfaces in contact with the air stream shall be applied with the same coating as the ductwork. Accessories, of which the operation will be affected by corrosive, shall be of AISI 316 stainless steel with the coating omitted.

Unless otherwise stated, the design air velocity at the face of filters shall not exceed 2.5 m/s. Product test reports for the listed efficiency including all details as prescribed in the testing methods of one or more of the standards shall be provided.

To improve indoor air quality and protect air conditioning equipment, outdoor air and re-circulated indoor air shall be filtered to remove dust, bacteria, pollens, insects, soot and dirt particles before it enters the air conditioning system. The following air cleaning devices, dependent on their compatibility with the general air conditioning system, shall be incorporated into the system as in-duct devices or stand-alone devices.

6.2.1.1.1 Particulate Filter

Particulate filters are the most commonly used air cleaning devices in buildings. They are classified into two general categories, pre-filters and final filters, according to the size of the particulate, which they catch and the energy required to circulate air through them. One or a combination of the filters shall be selected depending on the physical characteristics and levels of the dust to be removed, the capacity of the system to overcome the associated pressure drop across the filter and the degree of indoor air cleanliness required: -

Table 6.2.1.1.1 (1) Types of Filters

Stage	Nature	Filter Type
Pre-filters	Washable	Washable Panel Filters
		Automatic Viscous Filters
	Disposable	Disposable Panel Filters
		Disposable Pleated Panel Filters
	Renewable	Renewable Panel Filters
		Automatic Fabric Roll Filters
Final Filters	Disposable	Bay Filters
		Cartridge Filters
		High Efficiency Particular Arrestance (HEPA) Filters
	Renewable	Automatic Recleanable Filters
		Automatic Recleanable HEPA Filters

Filter shall be cleaned or replaced on a regular basis according to the manufacturer's recommendations or when the specified maximum pressure drop is reached. To prolong service life, two stages of filtration with the minimum efficiency reporting value (MERV) by ANSI/ASHRAE Standard 52.2-2017 as shown in Table 6.2.1.1.1 (2) are recommended for buildings with a central air handling system to prevent premature clogging and frequent replacement of the high efficiency filter: -

Table 6.2.1.1.1 (2) Filter Efficiency

Conditions	Pre-filters	Final filters
General occupied areas	Required	MERV 11 – 12
Heavy dirt loading areas	Required	MERV 13
Sensitive areas	Required	MERV 14

For critical clean air requirements, such as health care facilities, three filtration stages may be employed with High Efficiency Particulate Arrestance (HEPA) Filter as the third stage.

6.2.1.1.2 Electrostatic Filter

For conditions where low pressure drop, energy saving and minimum servicing are concerned, electrostatic filters shall be used which can also deal with odour of low concentration level.

6.2.1.1.3 Gas Filter

Gas filters are to remove gaseous pollutants from the air. Solid sorbents including activated carbons, molecular sieves, silica gel and activated alumina, each of which has a different adsorbing characteristic, shall be used to remove various gaseous pollutants.

6.2.1.2 STANDARDS

6.2.1.2.1 Performance of Air Filter

The performance of air filter shall comply with one or more of the following standards: -

(a) ANSI/ASHRAE Standard 52.2-2017 – Method of Testing General Ventilation Air Cleaning Device for Removal Efficiency by Particle Size;

(b) Underwriters Laboratories UL 586:2009 – High Efficiency, Particulate, Air Filter Units;

(c) European Standard BS EN 16798-3:2017 - Energy Performance of Buildings – Ventilation for Buildings;

(d) European Standard BS EN1822-1:2019 – High Efficiency Air Filters (EPA, HEPA and ULPA) and BS EN ISO 29463-2:2018 to BS EN ISO 29463-5:2018 – High-Efficiency Filters and Filter Media for Removing Particles in Air; or

(e) European Standard BS EN ISO 16890-1:2016 to BS EN ISO 16890-4:2016 – Air filters for general ventilation; or

(f) Any other standards equivalent to the standards above and approved by the Supervising Officer to suit particular project requirements.

6.2.1.2.2 Fire Property of Air Filter

The fire property of air filters and its associated accessories shall comply with one of the following standards as well as the requirements of the FSD: -

(a) British Standard Institution BS 476-4:1970 - Non-Combustibility Test for Materials;

(b) British Standard Institution BS 476-6:1989+A1:2009 - Fire tests on building materials and structures. Method of Test for Fire Propagation for Products, with Indices "I" ≤ 12 and "i1" ≤ 6;

(c) Underwriters Laboratories UL 900:2015 - Standard for Air Filter Units; or

(d) European Standard DIN 53438-3:1984 - Response to Ignition by A Small Flame, Surface Ignition, Class F1.

6.2.1.3 WASHABLE PANEL FILTER

This type of filter shall be constructed of aluminium to withstand washing by water or steam. The filter panel shall be constructed from multiple layers of expanded aluminium mesh or glass, natural or synthetic fibre, with the layers being corrugated or plain and arranged alternately at right angle at one another. Filter media shall be supported on both sides with a rigid and thicker aluminium expanded metal mesh.

Filters shall be 50, 25 or 12.5 mm thick with a rolled or extruded aluminium frame. The frame section shall be ribbed for stiffness and its inner edges treated to prevent sharpness and increase strength. Corners shall be mitred and riveted where it is necessary. Folding handles shall be applied to the short side of all washable filter panels for easy removal and cleaning. The filter support frame shall be suitable for the installation of either side.

It shall have the minimum efficiency reporting value (MERV) by ANSI/ASHRAE Standard 52.2-2017 and initial resistance at 2.5 m/s face velocity as shown in Table 6.2.1.3(1) below, unless otherwise specified in the Particular Specification. The filter shall operate to a final resistance of 150, 100 or 75 Pa for 50, 25 or 12.5 mm thick panels respectively.

Table 6.2.1.3 (1) MERV and Initial resistance of washable panel filter

Nominal thickness	MERV Not Less Than	Initial Resistance Not Exceeding
50 mm	5	50 Pa
25 mm	4	30 Pa
12.5 mm	3	25 Pa

Where coated filtration media is specified, each layer of expanded aluminium shall be furnished with a thixotropic flame resistant filter coating before assembly into a pack. The adhesive shall have a flash point exceeding 180 ºC Performance data for expanded aluminium filter panels oiled with a thixotropic adhesive shall have the minimum efficiency reporting value by ANSI/ASHRAE Standard 52.2-2017 and initial resistance at 2.5 m/s face velocity as shown in Table 6.2.1.3(2) below, unless otherwise specified in the Particular Specification. The filter shall operate to a final resistance of 150, 100 or 75 Pa for 50, 25 or 12.5 mm thick panels respectively.

Table 6.2.1.3 (2) MERV and Initial resistance of coated washable panel filters

Nominal thickness	MERV Not Less Than	Initial Resistance Not Exceeding
50 mm	6	55 Pa
25 mm	5	35 Pa
12.5 mm	4	30 Pa

6.2.1.4 AUTOMATIC VISCOUS FILTER

The filter shall comprise a frame or enclosure, filter plates, motor, drive and fluid tank. There shall be access to the tank containing the fluid to facilitate maintenance and the tools and containers required for the removal of sludge shall also be provided. It shall have the MERV of not less than 7 by ANSI/ASHRAE Standard 52.2-2017, unless otherwise specified in the Particular Specification. The design air velocity at the face of

the filter shall not exceed 2.5 m/s and operating resistance shall not exceed 125 Pa at the design air volume flow rate. To ensure that there is no carry-over of fluid from freshly wetted surfaces the rate of drive shall be suitably adjusted and set or otherwise the filter shall incorporate shielding devices.

6.2.1.5 DISPOSABLE PANEL FILTER

The filter shall be of glass or synthetic fibres media panel type. It shall have MERV of not less than 6 by ANSI/ASHRAE Standard 52.2-2017 and initial resistance not exceeding 75 Pa at 2.5 m/s face velocity, unless otherwise specified in the Particular Specification. The filter shall operate to 250 Pa final resistance.

The glass or synthetic filter media shall be supported between two media retainers inside a reinforced cardboard retaining frame. The media retainers shall be suitably fabricated to provide adequate support, such as combined metal mesh and grilles, throughout its whole working life, the filter element shall be bonded together with a cured resin, with a light adhesive coating, and suitably treated such that the filter media are not affected by air moisture, vermin proof and resistant to fungal growth.

6.2.1.6 DISPOSABLE PLEATED PANEL FILTER

The extended surface pleated filter shall be of similar design for disposal panel filter but it shall be used when higher air cleaning efficiency and higher air flow rate are required. It shall have the MERV of not less than 7 by ANSI/ASHRAE Standard 52.2-2017 and initial resistance not exceeding 75 Pa at 2.5 m/s face velocity, unless otherwise specified in the Particular Specification. The filter shall operate to 250 Pa final resistance. The pleated media shall be bonded to the expanded wire mesh to maintain its high efficiency and constant air flow rate.

6.2.1.7 RENEWABLE PANEL FILTER

It shall be used for heavy dust loading condition when the maintenance cost is the main decision factor. The filter media shall be of glass or synthetic fibre with a thickness of 50 mm unless otherwise specified. The filter media shall be replaceable and held in position in permanent wire basket for easy filter element replacement. It shall have the MERV of not less than 6 by ANSI/ASHRAE Standard 52.2-2017 and initial resistance not exceeding 75 Pa at 2.5 m/s face velocity, unless otherwise specified in the Particular Specification. The filter shall operate to 250 Pa final resistance.

6.2.1.8 AUTOMATIC FABRIC ROLL FILTER

The filter shall comprise the complete assembly of filter frame, motor, drive, filter blockage sensor and filter media. All sheet metal parts shall be of corrosion resistant galvanised steel construction. The filter media, supplied in roll form and 50 mm in thickness, shall be automatically across the face of the filter, while the used dirty media shall be rewound onto a roll drum at the other end. Each media roll shall not be less than 20 m long for sufficient service life before replacement is required. The filter shall operate automatically to maintain the design operating resistance of the filter media and

the required operating efficiency. The filter shall advance the filter media automatically on the command from a pressure switch, timer, or light-transmission control device. The control circuit shall operate to ensure uniform feeding of the filter media for constant dirt condition and loading. It shall not require re-calibration if the actual working condition differs from design or if the system is of variable air volume type. Visual or audible warning to notify filter media replacement shall be provided. The driving motor shall be automatically switched off when the filter media end is reached and a filter stop alarm shall be generated to alert maintenance personnel for filter replacement. The controls shall be factory wired and arranged to insure fail safe operation. The filter shall be constructed to enable continuous operation during routine servicing and maintenance of the filter. The filter media shall be provided with an effective seal to minimise air bypass. A spare roll of filter media shall be provided for each unit.

The initial resistance of the filter shall not exceed 45 Pa and a mean of 85 Pa under designed operating conditions. The air velocity through the filter media shall not exceed 2.5 m/s. It shall have the MERV of not less than 6 by ANSI/ASHRAE Standard 52.2-2017, unless otherwise specified in the Particular Specification.

6.2.1.9 BAG FILTER

The air filter shall be of high efficiency, extended area, deep pleated, disposable type. The media shall be of microfine glass fibre and reinforced by a laminated synthetic backing. It shall have a nominal thickness of 600 mm and the MERV shall not less than 13 by ANSI/ASHRAE Standard 52.2-2017 and initial resistance not exceeding 100 Pa at 2.5 m/s face velocity, unless otherwise specified in the Particular Specification. The air filter shall be rated for air velocity of 1.0 to 3.5 m/s and shall operate to 250 Pa final resistance.

The filter package shall be factory assembled as a complete set readily for site installation. The filter assembly shall consist of a holding frame, sealer frame, media retainer, and the disposable element.

The sealer frame shall be constructed of galvanised steel of sufficient thickness and equipped with suitable airtight sealing gasket and sealing mechanism on the sealer frame flange. The media retainer shall match the filter elements to provide sufficient support for the multiple pleats of the filter element against the direction of the airflow. The media retainer shall be suitably coated to totally eliminate the possibility of oscillation and sagging. The bag or packer shall inflate fully, shall not sag or flutter or be obstructed by contact with other filter faces or ductwork surfaces when operating between 60 - 110% of design air volume flow rate for constant volume system.

6.2.1.10 CARTRIDGE FILTER

This type of filter shall work reliably in the range of medium and high cleaning efficiency. It shall have the MERV of not less than 13 by ANSI/ASHRAE Standard 52.2-2017 and initial resistance not exceeding 100 Pa at 2.5 m/s face velocity, unless otherwise specified in the Particular Specification. The filter shall operate to 250 Pa final resistance and shall consist of water-resistant media of ultra-fine glass fibres. The media shall be pleated and have suitable separators to maintain the uniform spacing between pleats. The filter assembly shall be of rigid cartridge type, which shall consist of a steel

header and cell box to form a supported pleat media pack for various difficult operating conditions. The filter set shall be, unless otherwise specified, of 300 mm nominal thickness disposable extended surface cartridge type. The media shall be water resistant and shall be made of ultra-fine glass fibres formed into thin mate, which shall be supported by suitable corrugated separators and sturdy enough to operate in a VAV system. The filter panel shall be constructed of galvanised steel sheet folded and reverted to form a rigid frame.

6.2.1.11 HIGH EFFICIENCY PARTICULATE ARRESTANCE (HEPA) FILTER

The HEPA filter shall have minimum efficiency of 99.97% in removing small particles of sizes larger than 0.3 micrometre from air by Underwriters Laboratories UL 586:2009 or shall have most penetrating particle size (MPPS) of 99.995% tested to EN 1822-1:2019 – High Efficiency Air Filters (EPA, HEPA and ULPA) or equivalent. This makes use of a high efficiency glass paper medium and great surface area of medium per cross-sectional area of the filter. It shall reach this rated efficiency when the velocity of the air passing through the media is 2.5 m/s. Unless otherwise specified in the Particular Specification, a normal HEPA filter of a size 600 mm square with 300 mm thickness, shall have a rated flow of 0.75 m^3/s, at a pressure drop not exceeding 250 Pa, and about 23 m^2 of filtering media surface area. The filter shall operate to 600 Pa final resistance.

Filter shall be constructed with the media pack folded over separators to form closely spaced pleats, the whole being sealed into a casing with hard setting synthetic resin cement. This shall enable slower media velocity and increased efficiency. The media of space filter paper produced wholly from glass micro fibres, shall be inert, non-hygroscopic, vermin proof and shall not support bacteria growth. The filter media shall be treated with organic binder materials to provide binder, fungicidal and waterproofing properties.

For clean rooms and clean zones, the HEPA filter shall be selected to meet class 5 of air cleanliness by ISO Standard 14644-1:2015 – Cleanrooms and Associated Controlled Environments - Classification of Air Cleanliness by Particle Concentration, unless otherwise specified in the Particular Specification.

6.2.1.12 AUTOMATIC RECLEANABLE FILTER

The filter system shall include filter media, air compressor unit, air jet nozzles, controller, automatic dust collection unit, etc.

Filter media shall be made of reinforced fibre-glass or other suitable synthetic medium mounted on a rotary tube or a fixed drum. When the pre-set differential pressure between dirty and clean airsides of the filter is exceeded, the cleaning operation shall be initiated. For the rotary tube type, the carrier tube shall rotate and suction nozzle with vibrator motor shall move along the filtering surfaces. For the fixed drum type, an air valve installed at the downstream of the filter shall induce compressed air pulse-jets opposite to normal air flow direction. As a result, dirt particles will be pulsed away from the filter and collected in concentrated form inside a collection chamber, or an external vacuum cleaner, or a central vacuum cleaning system connected outside the filter chamber.

Cleaning shall be carried out both during downtimes of the air-conditioning/ventilation system and during plant operation. It shall have the minimum efficiency reporting value not less than 14 by ANSI/ASHRAE Standard 52.2-2017. The initial resistance across the whole unit shall not exceed 250 Pa at design air flow volume rate and the final resistance shall not be more than 500 Pa, unless otherwise specified in the Particular Specification.

The internal surfaces of the filter set shall be absolutely smooth and the bottom shall be in trough form with drain so that water can be drained away in case of wet cleaning.

The construction of the service door shall be identical to the casing panel. Non-aging steel-inlaid labyrinth seal shall be integrated into the door leaf. Each door shall be fitted with at least two double lever locks with bolts. Safety cams or chains shall be provided for pressure side doors. All the surfaces of the casing shall be protected against atmospheric corrosion by plastic powder coating.

The whole cleaning cycle shall be activated and controlled by a sequence controller with the following basic operations: -

(a) Reverse blowing by air pulses;

(b) Allow a few minutes' time interval for the dust and other contaminant particles to settle at the collector trap;

(c) Operation of the vacuum cleaner/central vacuum cleaning system for a few minutes; and

(d) Actuate alarm for disposal of the contaminant particles when the collecting bag is 80% full.

The filter media shall be selected to suit wet conditions such as market areas and poultry areas.

The controller shall be provided with two operation modes, "Auto" and "Manual". Under the "Auto" mode, the filter media shall be auto-cleaned by the compressor air from the air jet nozzles whenever the pressure difference across the filter media is in excess of the pre-set value. The filter system shall be arranged to connect to CCMS system and operated in accordance with a time schedule which can be set from the CCMS.

An automatic dust collection unit shall be provided to collect dust inside the filter section after each auto cleaning operation.

All of the operation status and fault signals shall be monitored by the CCMS.

The air compressor shall be tested and certified by the laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved in accordance with relevant statutory requirements.

6.2.1.13 AUTOMATIC RECLEANABLE HEPA FILTER

The whole unit shall be of heavy duty proprietary made air-tight construction. It shall be coated with polyester powder to protect from atmospheric corrosion and to minimise internal friction. By modular construction, each filter chamber of the unit shall be able to be isolated from the air stream without affecting the operation of the unit while cleaning or replacing the filter cartridges within a particular filter chamber. The filter cartridge shall be constructed as drawers by sliding in or pulling out for replacement and repairing services from the front panel and entirely from the clean air side. There shall be no contamination on the filter unit and the environment during the replacement. At the bottom, dust collection containers shall be mounted to each filter chamber by clamps via inter-connecting funnel sections.

Automatic cleaning is conducted by using a counter-current compressed air purge sequence. Filter shall be cleaned periodically by compressed air, which is blown in counter-flow direction to the filter cells from nozzles actuated by pneumatic system from the clean air side. A digital measuring and indication device shall be provided to show the differential pressure of all filter cells in one filter chamber.

The controller shall provide two operation modes, "Auto" and "Manual". Under the "Auto" mode, the filter media shall be auto cleaned by the compressor air from the air jet nozzles whenever the pressure difference across the filter media is in excess of the pre-set value. The filter system shall be arranged to connect to CCMS system and operated in accordance with a time schedule which can be set from the CCMS.

An automatic dust collection unit shall be provided to collect dust inside the filter section after each auto cleaning operation.

All of the operation status and fault signals shall be monitored by the CCMS.

The air compressor shall be tested and certified by the laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved in accordance with relevant statutory requirements.

Filter media shall be made of reinforced fibre-glass or other suitable synthetic medium with minimum efficiency of 99.97% in removing small particles of sizes larger than 0.3 micrometre from air by Underwriters Laboratories UL 586:2009. It shall reach the rated efficiency when the velocity of the air passing through the media is 2.5 m/s. For a nominal HEPA filter of a size 600 mm square with 300 mm thickness, it shall have a rated flow of 0.75 m^3/s and about 23 m^2 of filtering media.

The initial resistance across the whole unit shall not exceed 1500 Pa at design air flow volume rate and the final resistance shall not be more than 2400 Pa, unless otherwise specified in the Particular Specification.

6.2.1.14 AUTOMATIC RECLEANABLE HIGH VOLTAGE ELECTROSTATIC FILTER

The automatic recleanable high voltage electrostatic filter shall be able to control odours in the conditioned space and reduce the permanent deposition of contaminants in the space served. It shall have the minimum efficiency reporting value not less than MERV

14 by ANSI/ASHRAE Standard 52.2-2017 and an initial resistance not exceeding 120 Pa at design air flow volume rate, unless otherwise specified in the Particular Specification. The whole unit shall be tested to meet Underwriters Laboratories UL867:2011 - Electrostatic Air Cleaners and of a type approved by the Director of Fire Services. It shall not be used in hazardous locations or for handling hazardous gases/mixtures.

For kitchen applications, it shall comply with the requirements of the Environmental Protection Department on the treatment of gas fired kitchen exhaust air and the unit shall be leakage proof to avoid oil dripping. It shall have oil mist removal efficiency not less than 90%, odour removal efficiency not less than 50% and an initial resistance not exceeding 120 Pa at design air flow volume rate, unless otherwise specified in the Particular Specification. Oil mist removal performance shall be verified by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved. The whole unit shall be tested to meet Underwriters Laboratories UL710:2012 - Exhaust Hoods for Commercial Cooking Equipment (for Fire and Burnout Test only). Filter performance shall be tested according to ANSI/ASHRAE Standard 52.2-2017 and equipment shall be tested to meet Underwriters Laboratories UL867:2011 - Electrostatic Air Cleaners.

The unit shall consist of an ioniser-collector section power generator, an aluminium washable panel filters section against over-spray and a washer and adhesive applicator section. All parts shall be factory assembled into a sectioned housing having an overall depth not greater than 1000 mm in direction of airflow. Each section of the galvanised steel housing assembly shall incorporate a pair of hinged, quick opening access doors permitting access for servicing of all internal components; and a watertight, all welded, galvanised steel, drain pan having drain connections. Access doors shall be sealed against leakage by continuous perimeter gaskets of closed cell neoprene.

6.2.1.14.1 Each ioniser-collector section shall be furnished with the required number of one-piece or multi-piece cells of all aluminium construction. Each cell shall be fitted with stainless steel slides for mounting on the tracks, which form an integral component of the side access housing and to facilitate removal of cells for servicing. Cell support framework shall be completely open beneath the ioniser-collector cells to ensure complete drainage of wash water and excess adhesive, minimising the possibility of short circuits when high voltage power is restored following completion of the wash cycle. Cells shall be constructed so that high voltage input terminals and their high volt rated insulators are located completely out of contact with the moving air-stream to avoid build-up of dirt which could permit dissipation of high voltage charge and reduce air cleaning efficiency. The high voltage bus bars and contactors shall be inherent to each cell and shall permit cell removal without disconnecting any high voltage wiring. Insulators shall be fully exposed, for ease of cleaning, when cells are removed for service. Cells shall be full-face ionisation and shall have completely flat collector plates to prevent build-up of residual, inaccessible dirt accumulations.

6.2.1.14.2 Dual voltage power packs which are to provide high voltage to the ioniser circuit and to the plate circuit respectively shall be connected to each ioniser-collector section. The power packs shall be of solid state to include "fail-safe" low voltage relays to interrupt power to the ioniser

circuit in the event of a malfunction in the plate circuit. High voltage connections between the high voltage output terminals and the bus bar terminals mounted on the ioniser collector section access door shall be adequately installed. Each power pack covers shall include a circuit breaker, a manual reset button and / or automatic reset. Safety type door interlock switches, with suitable length of safety chain and wiring in series circuit for the power pack, shall be furnished to cut-off the power supply whenever the door is opened.

6.2.1.14.3 Each washer and adhesive applicator section shall incorporate slide-in type, perforated, galvanised steel air distribution baffles and a swing or fixed header assembly. The header assembly shall be connected to the inlet water solenoid valve and to the adhesive pump. Washer arms shall be equipped with 360^{o} fixed washer spray nozzles against reactive force to the high inlet water pressure. The removable brass adhesive nozzles shall be mounted on a separate, fixed, vertical header forming an integral component of the assembly. The filter adhesive shall be cold water soluble and non-flammable. A rotary gear adhesive pump with bronze impeller and sufficient adhesive for at least four reconditioning cycles shall be furnished.

6.2.1.14.4 The washer supply water solenoid valve, manifold drive motor, manifold limit switch and adhesive pump shall be pre-wired to an accessible, internally mounted terminal box. The washer control panel shall incorporate a status light to indicate when the reconditioning cycle is energised and the reconditioning cycle is in operation. The complete automatic cleaning by reversing the polarity of the filter element, wet washing by water spray and adhesive application shall be initiated manually or automatically through a push button actuated, internally fused, all solid state and program timer control. The controller shall be provided with two operation modes, "Auto" and "Manual". Under the "Auto" mode, the electrostatic filter shall be automatically cleaned on the timer of pre-set value and cleaning operations shall not be energised when the exhaust fan is in running status. The filter system shall be arranged to connect to CCMS and operated in accordance with a time schedule set from the CCMS.

All of the operation status and fault signals shall be monitored by the CCMS.

6.2.1.15 GAS FILTER

The gas filters shall remove gas pollutants from the air by absorption or adsorption. It shall comprise a robust enclosure inserted with module banks which contain evenly disposed chemical media. The complete unit is to be factory assembled and manufactured by the same manufacturer. All joints between the robust enclosure and the module banks shall be effectively sealed to eliminate air bypass and to ensure the optimum removal efficiency. Their supports shall be constructed from steel protected against corrosion and to provide mechanical protection to the module banks. The chemical media shall be of uniform thickness packed to ensure that compacting does not occur in use.

The chemical media shall consist of solid sorbents including activated carbons for common volatile organic compounds in indoor air and activated alumina suitably impregnated with potassium permanganate for formaldehyde and other gaseous contaminants. The combined media shall be able to operate normally at temperatures 0°C to 45°C and relative humidity 10 to 95%. It shall be inorganic, non-toxic, non-flammable and shall not support bacterial or fungal growth.

The gas filters shall be selected to give the removal efficiency not less than the following value and an initial resistance not exceeding 140 Pa at 2.5 m/s face velocity, unless otherwise specified in the Particular Specification: -

With 0.0283 cubic metre of media per and 0.472 cubic metre per second of air, media shall have a scrubbing efficiency of not less than 99.95% at 0.5 ppm hydrogen sulphide or ammonia inlet challenge concentration for a period of 3600 hours.

Impregnated alumina media shall meet the following removal capacities: -

Hydrogen Sulphide	-	8% min. by weight
Sulphur Dioxide	-	3.5% min. by weight
Nitric Dioxide	-	2.5% min. by weight
Nitrogen Dioxide	-	1.0% min. by weight

Impregnated carbon media shall meet the below removal capacity: -

Ammonia Gas	-	5% min. by weight

Media in the modules shall be manufactured from a combination of activated alumina impregnated with 4% potassium permanganate by weight in such a manner that the impregnate is available for reaction. The media shall be inorganic, non-toxic, non-flammable and shall not support bacterial or fungal growth.

Laboratory analysis report on media samples to establish life cycles and remaining life shall be submitted to the Supervising Officer for approval.

6.2.1.16 ACTIVATED OXYGEN AIR PURIFIER

The air purifier shall be capable of reducing odours of bacterial, organic and chemical origin and shall also be capable of reducing airborne bacteria and particulates in the treated areas.

All components of the air purifier, which are within the air stream, shall comply with the requirement of the Fire Services Department. The air purifier shall conform to BS EN 61000-6-1:2019, BS EN 61000-6-2:2019, BS EN 61000-6-3:2020 and BS EN 61000-6-4:2019 or similar international standards on Electro-Magnetic Compatibility (EMC) compliance.

The air purifier shall have removal efficiency of not less than 95% of Total Bacteria Count (TBC) Test, 95% of airborne particulates of 0.5 micron to 2.0 micron, 95% of cigarette smoke particles, 80% of odours, and 95% of hydrogen sulphide, unless otherwise specified in the Particular Specification. Test reports and certificates by

independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved to show the removal efficiency of the unit shall be submitted to the Supervising Officer for approval.

The air purifier shall not generate ozone in the treated areas in excess of the safety standards as specified by the Occupational Safety and Hygienic Association (OSHA), USA or other recognised international standards. A proper control device to shut off part or the whole unit is required when excessive ozone is detected over the limit of OSHA. A site test shall be carried out to verify that the ozone level in the occupied zone does not exceed the specified level.

The air purifier shall be suitable for ductwork mounting and shall consist of a power generator and screw-in or snap-on electrodes. The power generator shall be able to operate at 220 V 50 Hz single phase supply, equipped with on/off switch, on/off indicator lamps, over load circuit breaker (fuses) and electrode tube sockets. Indication lamp for individual ionisation tube shall be provided. The side in contact to air stream of the power generator housing shall be insulated by double skin panel with proper means of thermal insulation in order to prevent condensation.

There shall be a minimum of 1 transformer for every 2 tubes. The output of the transformer shall be at 2800V whenever ionisation is being called for.

For air purifier installed in the exhaust air plenum, the plenum shall be of min. 300 mm length after the exhaust fan and using a stainless steel mounting flange provided by the manufacturer. It shall be interlocked with the respective ventilation fan so that it switches on/off with the air handling unit or ventilation fan.

Energy of each electrode tube shall be good enough for ionising 0.045 litre/s/W oxygen.

The electrode tubes shall consist of screw-in base and a glass tube. The electrode tube shall be covered with a stainless steel mesh and shall be electrically earthed by means of an earth clip or an earth screw securely connected to the power generator. The required number of electrode tubes shall be in accordance with the manufacturers' recommendation.

A control unit shall be supplied to guarantee stable and situation referred ionisation process without generating excessive ozone for this application. Ozone monitoring device shall be provided. The unit shall be able to control several purifiers by either Auto or Manual mode.

Under Auto mode, the control unit shall moderate the output intensity of the purifiers in accordance with the information concerning adaptation, total power consumption, air flow, relative humidity, VOC concentration and also ozone level for human safety. Adaptation values are depending on the application. Control signals shall be provided by relevant duct mounted sensors. Ionisation intensity can be moderated in the range of 0 to 99% in steps of 1%.

The control unit shall be able to switch off the air purifier when the air flow is below the pre-set value in the control unit in order to prevent the accumulation of ozone inside the system.

The control unit shall be able to reduce 50% and 10% intensity of the computed value when the ozone level of supply air is exceeded 30 ppb and 50 ppb, respectively. It shall stop the unit if the ozone level detected in the first supply air outlet is greater than 61 ppb.

Under Manual mode, the intensity of the purifiers shall be in accordance with the pre-set (adaptation) value at the control unit and independent of the sensor values.

The control unit shall include a LCD display or other display device as approved by the Supervising Officer for sensing values, hour counter and an error / alarm logger record of malfunction. All configuration setting shall be adjustable by using keypads and further protected by a password against unauthorised access of untrained staff.

For purposes of monitoring and remote control, the received signals from the sensors, system parameters and alarm status shall be able to be monitored and set by using the CCMS via a RS232 or Ethernet interface. The time interval of signals is at least 2 seconds. A dry contract for system alarm shall be provided for local / remote monitoring of system operation. Causes of the alarm shall include the failure of sensors and the air flow & humidity exceeding the pre-set values.

The air purifier shall be UL listed and tested to comply with Underwriters Laboratories UL 867:2011 – Electrostatic Air Cleaners.

6.2.1.17 ULTRA-VIOLET (UV) STERILISING LIGHT

The UV sterilising light shall be provided to disinfect the supply air and eliminate any health hazard from the mechanical ventilation and air-conditioning system. It shall be installed inside the UV sterilizing light assembly that is mounted within the air handling unit, return air duct or other appropriate locations as specified in the Particular Specification.

Each lamp of the UV sterilizing light shall consume not more than 40W but emit pure UV-C irradiation at wavelength 253.7nm (or wavelength range that proved to be effectively germicidal) of not less than 120μW/cm^2 measured at 1 m distances from the source after 100 hours under 25 ºC. The total UV light intensity shall not be less than 360120μW/cm^2 per 1.0m^3/s air flow measured at 1 m from source.

Life span shall be not less than 12,000 hours with residual output of 75 ±5% of the original output, measured after 100 hours under 25 ºC.

The UV output of the lamps shall be highly stable over an air temperature range of 5 ºC – 25 ºC and in no case the output fluctuation shall be greater than 30% of its nominal value within this temperature range. The UV output reduction shall not be any higher than 10 ±5% of its nominal value after 2000 hrs of burning in air.

6.2.1.18 CATALYTIC AIR PURIFIER/STERILISER

Catalytic process, i.e. increase the rate of chemical reaction such as oxidation, by means of the use of catalyst can be applied in the air purification or sterilisation process. The catalyst used in the catalytic process can utilise chemical compound, precious metal,

physical processes such as plasma generator, bipolar ionisation, light excitation, etc. In case of chemical compound, it can utilise special manufacturing or treatment processes such as nano technology so that a special form or structure of the chemical compound can be obtained. In case of plasma generator it shall contain plasma generator which creates plasma by using dielectric electrodes with electric-powered source and the catalytic coating is applied inside the generator for effective plasma discharge.

When contaminated or untreated air enters the purifier or steriliser, contaminants and/or germs in the air stream shall be removed through the catalytic process in meeting the IAQ objectives. The by-products of the catalytic process shall also be specifically removed by other effective and proven means that shall not affect the IAQ objectives. The purifier or steriliser shall produce no ozone or very low ozone in concentration during operation.

It can be integrated in the AHU of central air-conditioning system or used for standalone air purifier or steriliser as wall-mounted installation.

Relevant selection, independent laboratory test reports and certificates to show the removal efficiency of the purifier or steriliser shall be submitted to the Supervising Officer for approval.

6.2.1.19 WATER SCRUBBER

The water scrubber shall be provided for applications such as Refuse Collection Point (RCP), Cooked Food Centre (CFC), Poultry Stalls, serving as the exhaust systems for central air treatment of odour, gas, liquid and solid contaminants prior to discharge to the atmosphere. Three of the major components of contaminants in the RCP application are hydrogen sulphide, mercaptans and aldehydes. Whereas oil mist will be present in the foul air source of the CFC or poultry stalls.

All components of the water scrubber shall be compatible to each other in all aspect and wholly imported, factory built and assembled as complete units before shipping. The only field connections required on site shall comprise only external control circuitry, pipework, fan and ductwork connections. For very big unit or due to site constraint that on site assembly is necessary, prior approval shall be obtained and installation method statement shall be submitted to the Supervising Officer for approval and as required per the Part 7 of this General Specification.

The manufacturer shall have at least five years' experience and proven record in the design and manufacturing of water scrubber equipment and has considerable amount of job references and installations for similar applications.

Certificates and documentary evidence of excellent chemical resistance of all materials, components and equipment adopted for operation with the selected chemicals and specified application shall be submitted to the Supervising Officer for approval. In addition, the following detailed information and calculations shall be provided: -

(a) Chemical reaction formulation and design criteria;

(b) Selection of the type and depth of packing, mist eliminators, nozzles, etc. with manufacturer's test data or recognised standards;

(c) Scrubber overall height & dimensions, packing depth, mist eliminators depth, etc.;

(d) Selection of water recycle pump head and flow rate in accordance with the system design and configuration to meet specified performance;

(e) Design of maximum air velocity at specified air flow rate and selection of fan duties with respect to the design flow and pressure drop in ductworks, fittings, silencers, scrubber section, etc.;

(f) Dosing rate of chemicals required and feed-in water /bleed-off rate; and

(g) Equipment sound level calculation and acoustic treatment offered for compliance with the specified acceptable noise levels.

All materials, fabrication procedures, manufacturing tolerances, workmanship, tests and product quality shall conform to the U.S. National Bureau of Standards PS 15-69:1969 - Custom Contact Moulded Reinforced Polyester Chemical-Resistant Process Equipment. Product Standard for Custom Contact Moulded Reinforced Polyester Chemical Resistant Process Equipment or equivalent recognised standards as approved by the Supervising Officer.

Before the scrubber is despatched from the factory, the manufacturer shall obtain a certificate from a reputable independent inspection company such as Bureau Veritas, Lloyd or SGS United States Testing Company Inc., etc. The certificate shall state whether the scrubber assembly is standard manufactured product, list the major equipment and materials for construction and advise whether they comply with our specification.

Each complete scrubbing system shall comprise a scrubber housing, a scrubber section with knockdown baffles/packing, mist eliminator, scrubbing liquid distribution system, chemical feed pumps, fan, chemical tanks, silencers, instrumentation, acoustic enclosure and all necessary controls as well as any other accessories required to build up a functional plant to the satisfaction of the Supervising Officer.

All material and components adopted in the scrubbing system shall be suitable for operation with the selected chemicals including sodium hypochlorite, sodium hydroxide and the resulting by-products of scrubbing.

Those items specified to be constructed of FRP shall be fire retardant grade to Class 1 of BS 476- 7:1997 – Method of Test to Determine the Classification of the Surface Spread of Flame of Products and shall be stabilised against ultraviolet degradation. The type of resin to be used shall be approved by the Supervising Officer.

Acoustic treatment shall be provided to ensure the sound level at site boundaries complies with the latest requirements of the Environmental Protection Department.

6.2.1.19.1 Performance Requirement

(a) Application

Removal of odour, gas, liquid and solid contaminants of foul air source at the RCP, CFC, Poultry Stalls or other specified areas through water scrubbing, absorption and chemical oxidation of malodorous compounds in the exhausted air.

(b) Odour Removal Efficiency

- Not less than 99% based on hydrogen sulphide at 25 ppm, mercaptans, aldehydes and other airborne contaminants; or

- Not less than 60% for kitchen exhaust.

(c) Oil Mist Removal Efficiency

Not less than 99% for 4μm oil particles.

(d) Chemical Selected for Operation

Sodium hydroxide, sodium hypochlorite, or other chemicals as specified in the Particular Specification.

6.2.1.19.2 Construction

The scrubber shell shall be constructed of fibreglass reinforced polyester resin (FRP).

Scrubber section of horizontal draw-through non-clogging venturi type shall be used for exhaust air treatment from kitchens of CFC. A series of knockdown baffles of FRP or other approved equivalent type shall be placed directly following the venturi section. The knockdown baffles shall remove 90% liquid coming from the venturi section and entering the mist eliminator.

Scrubber section of horizontal draw through cross-flow packed tower bed type shall be used for exhaust air treatment from RCP or Poultry Stalls. The packing shall have a free volume of 95% and minimum 100 square metres of surface area per cubic metre of packing. Pressure drop per metre of packing shall not exceed 165 Pa. The packing shall be made of polypropylene or other approved equivalent type. All packing support shall be made from heavy duty FRP construction. The packing depth, recirculation rate, and recirculation solution shall meet the required performance and efficiency.

Each scrubber shall include a scrubber housing, internal structural members, scrubber section with knockdown baffles/packing, mist eliminator, scrubbing liquid distribution system, chemical feed pumps, fan, chemical tanks, silencers, instrumentation, acoustic enclosure, lifting and hold down lugs, etc. All components and accessories shall have sufficient mechanical strength to withstand the extremely corrosive continuous operating environment and pressure even with the absence of chemical dosing.

Sufficient access manholes/panels and facilities shall be provided for inspection, removal and maintenance of all internal parts. Panels shall be completed with handles and neoprene gaskets secured with wing nuts to avoid spill out of water from the scrubber. The whole assembly shall be supported on structural members made of FRP or other approved equivalent material with mechanical strength and properties compatible with conventional steel members.

The mist eliminator section shall be replaceable, corrosion resistant, mesh type or other approved type fabricated of FRP or equivalent as approved and capable of removing not less than 90% of the entrained moisture in the air exhausting through the scrubber. The eliminator section shall be in modular form of adequate surface area and strength to withstand the handling air flow rate and pressure and placed in last section of the scrubber.

The scrubbing liquid distribution system shall be of the spray type or other approved type, sized for the flow rate to suit the design of the scrubber system to meet specified performance. No liquid distributors shall be permitted. Material of construction shall be polypropylene or FRP of same material as the shell.

Spray nozzles shall be constructed of polypropylene or other approved equivalent material.

Each scrubber shall have a sump for collecting the recirculated scrubbing liquid. It shall be finished with three nos. of recycle pumps, one of which as standby. Manual selection switch shall be provided to enable selection of either one of them as standby pump. The pumps shall be direct coupled to TEFC motors, self-priming, horizontal end suction, corrosive resistant, centrifugal type. Accessories such as pressure gauges, stop and vent cocks shall be provided for each pump. The flow rate shall be determined to suit the performance specification with adequate flow rate and pump heads to cater for the piping and scrubber plant friction losses. The pump casing, impeller shall be of rigid PVC and the impeller shaft shall be of stainless steel or equivalent corrosion resistance materials approved by the Supervising Officer.

Corrosive resistant flexible connectors shall be provided between all ductwork joints of the water scrubber.

All pipework, fittings and valves shall be made of UPVC or other approved equivalent material. All internal and external bolts and fasteners, including anchor bolts and flange bolts shall be of high grade 316 stainless steel.

The scrubber shall be suitable for application involving hot gas streams containing relatively high particulate loadings.

6.2.1.19.3 Chemical Feed System

Each scrubber system shall be provided with a complete chemical feed system for storing and feeding the chemicals required. Adequate provisions for the storage, installation and operation of the chemical solutions shall be provided in compliance with the Fire Services Ordinances and relevant regulations as the scrubbing chemical solutions used are in the list of Dangerous Goods Category. The Chemical feed system shall comprise chemical storage tank and feed pump for each scrubbing chemical solution, piping and valves, and all necessary controls.

Chemical storage tanks shall be vertical flat bottom type made of FRP with scale and lockable screw lid and shall be suitable for storing the scrubbing chemical solution. Each tank shall have a minimum effective capacity of holding the exempted quantity at specified concentration allowable by the FSD, typically of 250 litres. One set of protective goggles, gloves and overalls shall be provided for each scrubber.

Chemical metering pumps shall be solenoid operated diaphragm pump for the type of weatherproof protection. The pumps shall be operated on 220 V/single phase/50 cycles. Housing and liquid end shall be corrosion proof as well as dust and waterproof to protection Class IP65. Housing shall be die cast light-metal alloy. Solenoid shall be proofed against overload and excessive counter pressure such that it will not result in failure. Pumping capacity shall be adjusted in ratio of 1:10 through stroke length and 1:25 through stoke frequency, accessories shall include PVC dosing valve and foot valve.

6.2.1.19.4 pH and ORP Control

Each scrubber shall be provided with pH and ORP probes suitably located for analysing the contents in the scrubber sump. Probes shall meet the following specifications: -

	pH Probe	ORP Probe
Range	0 to 14 pH	0 to 990 mV
Stability	0.03 pH units	0.5 MV per 24 hr. per day, non-cumulative
Temperature	0 ºC to 40 ºC	0 ºC to 40 ºC
Pressure Rating	4.83 kPa	4.83 kPa
Wetted Materials	Glass	Glass
Accuracy Sensitivity	0.1 pH unit	5 HV

Each probe shall be supplied with analyser and level alarm at the local and remote control panels and they shall be actuated when the chemical levels at chemical tanks are lower than the pre-set values.

6.2.1.19.5 Fan

Motor driven fans shall be provided for each scrubber unit and shall be of sufficient capacity and horsepower, as indicated in the Equipment Schedule to deliver the required volume of air against the total pressure losses in the air intake, duct pickup systems, packed bed, mist eliminator, silencers and exit ducting, etc.

Fans shall be of high efficiency and low speed backward curved aerofoil types with lowest noise level suitable for outdoor application. Sound power level spectrum shall be submitted for approval and the data shall be verified on Site as specified.

Fan housings, flanges and impellers shall be constructed of FRP laminate as approved by the Supervising Officer.

Inlet connections shall be Neoprene slip type flex connector with stainless steel draw-bands. Outlet connection shall be a rectangular undrilled flange.

Each of the blowers shall have V-belt drive with a minimum service factor of 1.5 times the rated brake horsepower of the fan motor and shall be equipped with heavy-duty, self-aligning sealed ball bearings.

Fan shafts shall be carbon steel and sized to run below critical speed. A steel hub encapsulated with FRP shall be provided to a point flush with the housing. Wheel and shaft assemblies shall be statically and dynamically balanced in 2 directions according to recognised international standards.

The fan base shall be made of corrosion resistant material of sufficient strength or carbon steel treated with anti-corrosion coatings as approved by the Supervising Officer. No metal parts shall be exposed to the corrosive air stream.

Fan shall be completed with motor, drive, belt, FRP motor and drive canopy, housing drains, access doors and flexible connectors for inlet and outlet, etc.

6.2.1.19.6 Motor

Unless otherwise specified in the Equipment Schedule each fan shall be provided with a horizontal squirrel cage induction type motor of sufficient power such that no point on the fan curve requires more than the horsepower of the motor plus a 15% spare capacity.

Each electric motor shall be suitable for 380 V, 3 phase, 50 Hz and 24 hours' continuous operation.

The motor enclosure shall be totally enclosed, fan cooled and suitable for outdoor application.

The motors shall constructed and tested in conformance with all the requirements of the applicable standards of the IET, NEMA and ANSI and as required in Part 7 this General Specification.

Acoustic treatment, such as silencers and acoustic enclosures shall be provided to ensure the noise break out to adjacent areas is at an acceptable level complying with Government Authorities' regulations.

Silencers shall be of pack less type or be completed with adequate coating and shall be suitable for the chemical corrosive environment.

6.2.1.19.7 Control

The water scrubber system shall be capable of both automatic and manual operation. In "DDC/auto" mode, the central exhaust fan shall be started or stopped automatically by the DDC system. The scrubber exhaust fan shall be interlocked with the recycle pumps' operation such that it will not be operative unless the pumps are operating. A 2-way motorised valve and flow regulating valve at water feed-in pipe shall be provided and interlocked with the fan.

Chemical feed pumps shall dose proportionately to maintain the desired concentration of the scrubbing liquid. NaOH shall be controlled with pH analyser to maintain a pH value of 8 to 9 while NaOCl shall be controlled with oxidation-reduction-potential (ORP) analyser to maintain an ORP value of 300 to 400 mV or to values as recommended by the manufacturer in order to comply with the specification.

Low level sensors in the water scrubber chamber shall be provided and installed to give audio and visual warning signals at the local & remote control panels and to stop the circulating pumps when the pre-set extra low water level condition is reached.

Corrosion resistance low level sensors shall be provided and installed for each of the chemical tanks to give audio and visual warning signals at the local & remote control panels during low chemical level condition.

Flow switch shall be provided and installed at the feed-in water pipe to give audio and visual warning signals at the local & remote panels during "no flow" condition.

In "manual" mode, the fan and pumps shall be operated by means of start/stop buttons at the water scrubber control panel.

Emergency stops shall be provided adjacent to each of the pump and fan unit.

Local and remote control panels shall be provided for the water scrubber systems at location as shown on the Drawings. Local/remote selector switch shall be provided at the local panels for choice of control mode. In "remote" mode, the water scrubber system shall be started or stopped via manual push buttons at the remote control panel. The scrubber exhaust

fan shall be interlocked with the recycle pumps' operation such that it will not be operative unless the recycle pumps are operating.

In "Local" mode, the fan and pumps shall be operated by means of start/stop buttons at the local control panel.

The following minimum facilities shall be provided at the local control/starter panel: -

- Power on indication – green;
- Local/remote selector;
- Recycle pumps sequence selector;
- Start and stop push buttons for fan and pumps;
- Hour run meters for fan;
- Running (blue) and fault (red) indication for fan and pumps;
- Ammeters for fan;
- Low level alarms (red) for each chemical tank;
- Low level alarm (red) for the water scrubber chamber; and
- No flow alarm (red) for the feed-in water pipe section.

6.2.1.20 WASHING FACILITIES FOR WASHABLE FILTER

Where washable filters are provided, at least one set of duplicate cleaning tanks (one to wash, one to rinse) shall be provided. These tanks shall be big enough to accommodate the various filters sizes provided, subject to the approval of the Supervising Officer.

The filter cleaning tanks shall be constructed of at least 1 mm thick stainless steel of AISI 316 and suitably stiffened around the top edges by continuous external turned over inverted "U" sections. The tanks shall be 0.4 m deep. They shall be supplied with 18 mm drain down cock for emptying but shall also have external handles to facilitate turning over to clear sludge.

6.2.1.21 FILTER PRESSURE DIFFERENTIAL MEASUREMENT AND INDICATION

A differential pressure gauge of the inclined manometer type shall be provided for each filter bank.

The gauge shall incorporate a graduated scale on which the reading of maximum pressure drop shall occur in not less than 75% of the total scale length.

6.2.1.22 ADDITIONAL REQUIREMENTS (SPARE FILTER MEDIA)

All filters used during testing and commissioning stage shall be replaced with new filters. In addition, the following shall be for use by Employer's operation staff during Maintenance Period: -

(a) For disposable type filters, one complete set of unused filter cells;

(b) For washable type filters, 20% in number of each size of filter cells provided. These shall be new and in good condition. Besides, 10 litres of the approved cleaning detergent per filter installation shall be provided. Regarding filters of viscous type, a drum or drums of fluid amounting to one complete change or 10 litres per filter installation where thixotropic coatings are used shall be provided;

(c) For renewable type filters, one complete set of unused filter media; or

(d) For gas filters, one complete set of unused filter cells.

Within one month before expiry of the Maintenance Period, all the filter cells/media shall be replaced with new ones. In addition, 10 litres of the approved cleaning detergent per washable filter installation shall be provided. Regarding filters of viscous type, a drum or drums of fluid amounting to one complete change or l0 litres per filter installation where thixotropic coatings are used shall be provided.

SUB-SECTION 6.2.2

DUCTWORK AND ACCESSORIES

6.2.2.1 GENERAL

Ductwork shall be off site pre-fabricated according to the requirement as specified in the Particular Specification. The ductwork shall be fabricated from good quality full sized zinc coated hot dipped galvanised flat steel sheet to BS EN 10346:2015, UL 181:2013, Grade DX51D+Z, coating type Z275 unless otherwise specified in the Particular Specification or the Drawings.

6.2.2.2 OFF SITE PRE-FABRICATION

The development of components for round, oval and rectangular ductwork shall be carried out by a computer software which can produce all development plans from the proposed ductwork layouts including all type of ductwork fittings and accessories. The software shall be able to work out the development plans with utilisation factor not less than 94%.

The above utilisation factor is based on a ratio of the Standard Size Straight Ductwork: Ductwork Fittings, which is 7 : 3. For standard straight ductwork, the utilisation factor is about 100% and that for fittings is about 80%. If the ratio of Ductwork to Fittings is not 7 : 3, the overall utilisation factor shall be submitted to the approval of the Supervising Officer.

The remaining materials that cannot be used for fabrication of ductwork shall be used for other purpose or at least to be recycled instead of being disposed of as scraps. The software used shall also be linked to the Numerical Control Cutting Machines, such as the Plasma Cutting System for the cutting, development and forming of the required ductwork components and accessories.

Automatic or semi-automatic machines shall be employed for the bending, folding and assembly of ductwork from sheet metal components developed. Proper machines are required for the manufacturing of all ductwork accessories including flanges, stiffeners, splitter dampers, etc. in order to enhance quality.

Construction and materials used for ductwork, fittings and accessories shall be inert, non-hygroscopic, vermin and moisture proof, asbestos and CFC free, and shall not support growth of bacteria.

Bends and branch vanes, dampers, etc. shall be of the same material as used for the ductwork and/or of heavier gauge, securely mounted.

6.2.2.3 SPECIFICATION AND STANDARDS

Ductwork shall comply with the following BESA publications with additions or amendments as required by this General Specification and/or elsewhere in the Contract: -

(a) DW/144:2016
Specification for sheet metal ductwork;

(b) DW/154:2000
Specification for plastics ductwork;

(c) DW/191:1973
Code of practice for resin-bonded glass fibre ductwork;

(d) TR 19:2019
Guide to Good Practice - Internal Cleanliness of Ventilation Systems

Where any part of the Installations is not covered by the above, the recommendations of the "HVAC Duct Construction Standards-Metal and Flexible" issued by the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) of USA shall be applied.

6.2.2.4 FLEXIBLE DUCTWORK

Flexible ductwork shall be provided as connections between vibration generating equipment and/or ductwork and, where air duct passing across building expansion joint. Flexible connection shall be fitted with acceptable alignment and effective length suitable for the elimination of vibration transmission.

The flexible ductwork shall have a liner and a cover of tough tear-resistant fabric equal in durability and flexibility to glass fibre fabric. The fabric shall be impregnated and coated with plastics. It shall be reinforced with a bonded galvanised spring of stainless steel or other approved wire helix between the liner and the cover. An outer helix of glass fibre cord or equal shall be bonded to the cover to ensure regular convolutions. Flexible ductwork without a liner may not be used.

In no cases shall material containing asbestos fabric be used.

Alternatively, flexible ductwork shall consist of flexible corrugated metal tubing of stainless steel, aluminium, tin plated steel or aluminium coated steel. The metal surface(s) may be coated with a plastics material.

The leakage from any section of flexible ductwork shall not exceed 1% of the local design air flow rate at the local maximum static pressure.

Flexible ductwork shall be suitable for the air velocity, pressure and an operating temperature range of -5°C to 90°C and shall comply with BS 476-12:1991, Rating Class N; BS 476-6:1989+A1:2009 having an index of performance not exceeding 12 of which not more than 6 shall derive from the initial period of test; Part 7 Class 1 (surface of very low flame spread) and current requirements of the FSD unless otherwise indicated.

6.2.2.5 DUCTWORK FOR CORROSIVE FUMES

Ductwork used to carry corrosive fumes shall be of non-corrosive material. Where PVC material is used, the minimum thickness shall be 1.8mm.

Plastic ductwork and all associated moulded or extruded sections, angles and fittings shall be unaffected by the range of substances conveyed and under the conditions indicated. Unless otherwise indicated, and providing the requirements above can be met, sheet material shall be pressed unplasticised PVC sheet complying with ISO 6453:1985.

Where PVC ductwork is thermally insulated or is not readily visible, Type A3 sheet shall be used; elsewhere Type Al shall be used.

Any plastic ductwork system incorporating a heater battery shall be installed such that no part of the system is impaired by the heating effects of the battery or its casing.

Circular ductwork shall preferably be fabricated from unplasticised PVC pipe or Polypropylene (PPs) pipe complying with relevant ISO and BS EN standards. Unless otherwise indicated, the colour of sheet and pipe shall be grey. Ductwork shall be constructed (thickness, angles, stiffness, etc.) in accordance with Specification DW/154:2000. Pipes shall be flame-retardant DIN 4102 B1 and chemical resistance. Where PVC material is used, the minimum thickness shall be 1.8mm. Where PPs material is used, the minimum thickness shall be 3mm according to DIN4741. For circular ductwork over 600mm or whenever the required diameter pipes or fittings are not available, PPs sheet shall be used to fabricate the required pipes and fittings. The sheets, pipes and fittings shall be of the same plastic materials, and preferably in same colour.

Where any part of the Installations is not covered by "DW/154", then the recommendations of the "Thermoplastic Ductwork (PVC) Construction Manual" issued by the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) of USA shall apply.

The methods of construction recommended in BESA Specification DW/154:2000 shall be used, i.e. cemented joints shall be used for circular (pipe) jointing and hot gas/filler rod, welding shall be used for all other fabrication. For circular ductwork constructed from pipe, sufficient angle joints shall be provided to enable the ductwork to be dismantled in the space available. Where so directed by the Supervising Officer, all welders shall carry out the test detailed in BESA Specification DW/154:2000.

The requirements of BESA Specification DW/154:2000 with regard to expansion joints, ductwork supports, access doors and gaskets shall be met.

Extruded or moulded sections, angles and fittings shall be of the same plastic materials and colour as the sheet or tube.

PVC ductwork shall not be used in situations where it will be subjected to temperatures of 50°C and above. Where heater batteries are required in the system, the PVC ductwork shall be isolated from these by a suitable length of stainless steel ductwork, generally as described for glass fibre ductwork in Clause 6.2.2.6.

6.2.2.6 GLASS FIBRE DUCTWORK

6.2.2.6.1 General

Where specified in the Particular Specification or the Drawings, glass fibre ductwork made from 25 mm/38 mm thick resin bonded glass fibre in rigid board form may be used. The board shall have an integral external vapour barrier of hard grade, flame retardant, damage-resistant reinforced aluminium foil and an internal smooth, durable acrylic coating that isolates the glass fibre substrate from the air stream and inhibits penetration of the insulation by dirt, dust, microorganisms and other pollutants.

Special attention shall be paid to ensure that the material itself/fabrication/erection of the ductwork does not contribute towards suspected health hazard.

Thickness of the ductwork board to be used shall be selected in accordance with manufacturer's ductwork sizes, static pressure and reinforcement schedule and recommendation.

6.2.2.6.2 Specification and Standards

Specification and Standards for glass fibre ductwork shall comply with the recommendations of the BESA Publication DW/191:1973 Code of practice for resin-bonded glass fibre ductwork, or the "Fibrous glass Ductwork Construction Standards" issued by the Sheet Metal and Air Conditioning Contractors' National Association, Inc. USA. The flexural rigidity rating of the rigid glass fibre board shall be 8OOE1 (33.7 kg/m^2) as defined in the above Standards. Glass fibre ductwork shall meet with the requirements of NFPA-90A:2021 and 90B:2021 by complying with the requirements of Under-writer's Laboratories Standard for safety UL 181:2013 for Class 0 ductwork.

Glass fibre ductwork to be used shall resist fungal or bacterial growth when subjected to microbial attack described in Standard Practices ASTM G21-15(fungus test).

Glass fibre ductwork shall be easily cleanable using methods and equipment described in North American Insulation Manufacturers Association (NAIMA) Publication AH-122, Cleaning Fibrous Glass Insulated Duct Systems.

6.2.2.6.3 Mounting Fittings

Where the following items are installed in a ductwork, a suitably sized section of galvanised sheet ductwork shall be installed completed with independent supports and insulation: -

(a) Electric or hot water, etc. ductwork heaters and access panels;

(b) Volume control dampers;

(c) Fire dampers and access panel; and

(d) Fan and access panel.

6.2.2.6.4 Mountings of Instruments

All control/metering probes, etc. which requires mounting in fibreglass ductwork shall be adequately supported by a sheet metal panel securely fixed to the internal face of the ductwork. a removable insulated cover over the complete probe shall be fixed to ensure condensation will not occur on any exposed metal surfaces.

6.2.2.6.5 Special Tools and Manufacturers Fabrication Instructions

The construction and installation including all cutting tools employed to fabricate the ductwork shall be strictly in accordance with the recommendations of the fibreglass ductwork manufacturer's instructions issued for the correct installation of their product. Fabrication and installation by any method other than that endorsed by the fibreglass ductwork manufacturer may be rejected by the Supervising Officer.

6.2.2.7 FOAM DUCTBOARD DUCTWORK

6.2.2.7.1 Phenolic Foam Duct Board Ductwork

Where specified in the Particular Specification or the Drawings, pre-insulated ductwork made from 20 mm thick rigid closed cell phenolic foam in rigid board form may be used and shall be approved or accepted by the FSD.

The ductwork material shall be covered with a layer of vapour barrier on both board facing. The vapour barrier shall be of minimum 20 micron thick aluminium foil. The circumferential and longitudinal seams of the vapour barrier foils shall be sealed with self-adhesive foil tape.

All material shall have a class 'O' fire rating and approved or accepted by the FSD. Low smoke emission shall comply with BS EN ISO 5659-2:2017 and shall be CFC free.

The flange system for the phenolic foam ductwork shall be constructed to eliminate the effect of "Cold Bridge" and for the purpose of sealing, the flanges shall be coated with fire resistant gaskets and securely mounted with sufficient bolts, nuts and clips. An established joining system shall be employed in connecting the ductwork and accessories such as air outlets and dampers. The joining system shall be approved by the Supervising Officer.

Where the following items are installed in the ductwork, they shall be adequately supported by a sheet metal panel securely fixed to the internal

face of the ductwork with due consideration to ensure that condensation will not occur on any exposed metal surface: -

(a) Ductwork heaters;

(b) Volume control dampers;

(c) Fire dampers; and

(d) Fans & access panels.

The construction and installation including all cutting tools, adhesives, flange system shall be strictly in accordance with the recommendations of the phenolic foam duct board manufacturer's instruction.

Unless specified in the Particular Specification or the Drawings, the width and length of pre-insulated ductwork made from phenolic foam in rigid board form shall not exceed 500 mm.

6.2.2.7.2 Polyurethane Foam Duct Board Ductwork

General - Where specified in the Particular Specification or the Drawings, pre-insulated ductwork made from 20 mm thick rigid polyurethane foam in rigid board form may be used and shall be approved or accepted by the FSD.

The ductwork material shall be covered with a layer of vapour barrier on both board facing. The vapour barrier shall be of minimum 60 micron thick aluminium foil. The circumferential and longitudinal seams of the vapour barrier foils shall be sealed with self-adhesive foil tape.

All material shall have a class 'O' fire rating and approved or accepted by the FSD. Low smoke emission shall comply with BS EN ISO 5659-2:2017 and shall be CFC free.

The flange system for the polyurethane foam ductwork shall be constructed to eliminate the effect of "Cold Bridge" and for the purpose of sealing, the flanges shall be coated with fire resistant gaskets and securely mounted with sufficient bolts, nuts and clips. An established joining system shall be employed in connecting the ductwork and accessories such as air outlets and dampers. The joining system shall be approved by the Supervising Officer.

Where the following items are installed in the ductwork, they shall be adequately supported by a sheet metal panel securely fixed to the internal face of the ductwork with due consideration to ensure that condensation will not occur on any exposed metal surface: -

(a) Ductwork heaters;

(b) Volume control dampers;

(c) Fire dampers; and

(d) Fans & access panels.

The construction and installation including all cutting tools, adhesives, flange system shall be strictly in accordance with the recommendations of the polyurethane foam duct board manufacturer's instruction.

Unless specified in the Particular Specification or the Drawings, the width and length of pre-insulated ductwork made from polyurethane foam in rigid board form shall not exceed 500 mm.

6.2.2.8 DAMPERS - GENERAL

The respective functions, types and general constructional requirements of dampers shall be in accordance with the BESA ductwork specification DW/144:2016 CIBSE Commissioning Code Series A and BSRIA Application Guide where appropriate unless otherwise indicated, sufficient dampers shall be provided to regulate and balance the system. Dampers on grilles or diffusers shall be used for fine control only.

All dampers shall be of flanged type with independent housing and control mechanism for connection to ductwork and shall be sufficiently rigid to prevent fluttering and comply with BS EN 1751:2014.

Air volume control dampers shall be of the aerofoil, double skin, opposed blade low leakage type with seals on blade edges and casing jambs, low pressure drop and noise regeneration characteristics. Damper blades in rectangular ductwork shall not exceed 225 mm in width and 1500 mm in length. Blades shall be of hollow section constructed from the same material of the ductwork or of stainless steel encapsulating an internal double contoured steel longitudinal reinforcing bar, mounted on square section steel spindles. The units shall be of low-leakage type by incorporation of synthetic trailing edge seals and a peripheral gasket which shall be tested according to BS 476-6:1989+A1:2009 and BS 476-7:1997 and shall be approved or accepted by the FSD. All manually and automatically operated dampers shall be fitted with position indicators provided externally and the final setting position shall be permanently marked. Manual dampers shall include a device for positioning and locking the damper blades. Damper handles shall be equipped with device for padlocking in the final balanced position.

Each air volume control damper in the ductwork shall be fitted with a non-corrodible label stating the actual air flow in m^3/s when in the fully open position, its overall cross sectional area, and the degree to which the damper has been closed in order to achieve the design or actual air flow.

Unless otherwise indicated, quadrants and operating handles shall be of die-cast aluminium or other material approved by the Supervising Officer with the words "OPEN" and "SHUT" cast on the quadrant.

Quadrants shall be securely fixed and the damper spindles shall be closely fitted in the quadrant hubs to prevent any damper movement when the damper levers are locked.

Access openings with readily removable air sealed covers shall be provided adjacent to all dampers except the volume control dampers of which the adjustment can be made outside the ductwork. Subject to limitations of ductwork size the dimensions of access openings shall not be less than 300 mm x 300 mm and they shall be located within 300 mm of each damper so as to afford easy access for inspection and maintenance.

6.2.2.9 BUTTERFLY, BIFURCATING AND MULTILEAF DAMPERS

Butterfly dampers shall each consist of 2 plates, edge seamed, of at least the same thickness as the material from which the associated ductwork is made, and rigidly fixed to each side of a mild steel operating spindle, the ends of which shall be turned and housed in non-ferrous bearings.

Bifurcating dampers shall be of 2 mm thick sheet for sizes up to 450 mm square, for larger sizes the thickness shall be as specified. The damper blades shall be rigidly fixed to square section mild steel spindles, the ends of which shall be turned and housed in non-ferrous bearings.

Each leaf of a multi leaf damper shall consist of 2 plates of material of the same thickness as the associated ductwork and rigidly fixed to each side of an operation spindle, the ends of which shall be housed in brass, nylon, oil impregnated sintered metal, PTEE impregnated or ball bearings. The ends of the spindles shall be linked so that one movement of the operating handle shall move each leaf for an equal amount. The mechanism shall be located outside the air stream.

For system, static pressure below 1000 Pa or ductwork velocity below 12 m/s, blade of at least 50 mm wide shall be used. For static pressure at or above 1000 Pa, at least 100 mm wide blade shall be used. Central blade reinforcement bar shall be provided for damper span longer than 1500 mm. Single module of a damper shall not exceed 2000 mm width and 1000 mm height.

Alternatively, multi leaf damper blades may be of a single plate, at least 1.6 mm thick and suitably stiffened, and the blade linkages may be within the ductwork. These dampers shall have bearings and inspection doors.

6.2.2.10 SELF-CLOSING (NON-RETURN) DAMPERS

Self-closing dampers shall present a minimum resistance to air flow under running conditions and take up a stable position in operation. Maximum resistance shall be presented under reverse air flow conditions such that they will be forced to close and remain so. Resilient strips or other purpose made devices shall be provided to prevent the damper from rattling and as an aid to air sealing under reverse flow conditions.

Blades shall be rigidly constructed of steel or aluminium sheet of not less than 0.8 mm (22 gauge) and shall be free of all buckles. Blades of less than 300 mm in height shall be fitted with a 3 mm (10 gauge) bright steel spindle at each end. Blades of 300 mm and over in height shall be fitted with an 8 mm bright steel spindle at each end. Spindles shall be carried by sealed ball bearings. Bearing shall be accessible for cleaning and lubrication and shall be mounted in a rigid galvanised steel frame. The maximum length of each blade without a central bearing shall be 1000 mm.

6.2.2.11 FIRE, SMOKE AND COMBINED FIRE AND SMOKE STOP DAMPERS

6.2.2.11.1 Fire and Smoke Stop Dampers

Fire or Smoke dampers shall be provided in ductwork in the following locations: -

(a) Wherever a ductwork passes through a floor slab or a fire resisting wall which is expressly built for the purpose of preventing the spread of fire;

(b) Other locations where requirements of compartmentalisation are stipulated in the Code of Practice for Fire Safety in Buildings 2011 under the Buildings Ordinance of HKSAR; and

(c) Other locations as required by the Particular Specification and the Drawings.

Fire or Smoke dampers used singly or in combination shall have an overall fire resistance rating not less than that indicated and certainly not less than that for the wall or floor slab in which they are situated.

In all cases, evidence of fire rating in accordance with ISO 21925-1:2018 Classification E (BS 476-20:1987) or NFPA-90A:2021 with 2-hour UL fire damper label shall be provided by organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS approved by the Supervising Officer. All Fire or Smoke dampers shall also be approved or accepted by the FSD.

Fire or Smoke damper blades of proprietary made shall be constructed to the approved organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS and possess a rating equivalent to the fire resistance of the structure it protects.

Local made fire or smoke damper blades shall comply with the requirements of the Circular Letters issued by the FSD and the Buildings Ordinance of HKSAR. These blades shall be housed in a corrosion resistant casing constructed to avoid distortion due to stress in fire conditions. Stainless steel spring tempered flexible gasket shall be inserted between the blade and the casing for elimination of closing friction and retardation of smoke. Provision shall be made to accommodate expansion of the damper blades within the casing in fire conditions to prevent jamming and to retard the spread of smoke. A Fire or Smoke damper installation frame supplied by the same manufacturer shall also incorporate provision for expansion within the surrounding structure together with masking flange for building into the structure.

Fire or Smoke damper assemblies for installations in corrosive environments shall be fabricated from suitable materials resistant to the corrosive substances and environments indicated. Alternatively, the material may be coated with a protective finish to produce the same effect.

Power fail-safe remote electromagnet release or electro thermal link (ETL) shall be provided to explosion hazardous areas. The electromagnet shall normally not consume more than 10 mA by 220 V AC supply or 200 mA by 24 V AC/DC supply.

Each Fire or Smoke damper casing shall be air tight, continuously welded and clearly marked with a permanent indication of the direction of air flow and the side at which the access/maintenance opening is located.

The folded continuous interlocked blade type of damper may be used for vertical or horizontal ductwork applications. The closing force for these types of dampers shall be provided by stainless steel spring or springs. Locking device shall be provided to ensure that the blades are held in the closed position after release.

Spring actuated pivoted single-bladed or multi-bladed dampers may be used for vertical or horizontal ductwork applications.

Multi-bladed dampers shall be provided with a means to ensure that all the blades close simultaneously.

Gravity operated multi-bladed fire dampers shall not be used in vertical ductwork.

Gravity operated single bladed dampers may be used for horizontal ductwork provided means are incorporated which ensure reliable and positive closure when operating in maximum air flow rate conditions.

Locally fabricated gravity fire dampers shall be provided with a coaming or casing of the same material and shall be physically bolted to the structure through which the ductwork penetrates.

Fire or Smoke dampers shall be rated in accordance with the fire resistance rating of the wall, ceiling or floor, etc. as shown in the drawings and the Particular Specification, to the requirements of the FSD and approved by the Supervising Officer.

For locally fabricated fire dampers, the thickness of metal for the dampers shall comply with the Circular Letters issued by the FSD and the Buildings Ordinance of HKSAR.

Where gravity acting, off-centre pivoted dampers incorporate spindle bearings long term corrosion effects shall be minimised by the choice of suitable materials. Bearings shall be sealed or capped to exclude dirt and dust. Damper blades shall close to comply with the stability and integrity requirements of ISO 21925-1:2018 Classification E (BS 476- 20:1987).

For high velocity air systems, fire/smoke dampers shall provide 100% free area when damper blades are in the open position to give minimum interference to the air flow.

Unless otherwise indicated, each Fire or Smoke damper shall be held in the open position by a corrosion resistant retaining device incorporating a fusible element which shall operate at a temperature of 69^{o}C, unless otherwise indicated.

Fire or Smoke dampers shall be located in a position and be of a type which could facilitate periodic 1 handed manual release and re-setting for test purpose.

Proprietary access doors shall be installed adjacent to each Fire or Smoke damper and, in the case of conditioned air or kitchen exhaust ductwork, the access doors shall be encapsulated and pre-insulated.

6.2.2.11.2 Combined Fire and Smoke Stop Dampers

Combined fire and smoke stop dampers shall be tested to BS 476-20: 1987 for fire resistance and UL 555S for operation cycles and leakage rate and shall be approved or accepted by the FSD. Test report shall be submitted to the Supervising Officer for reference.

The dampers shall be of galvanised steel or stainless steel, aerofoil bladed construction with galvanised steel or stainless steel blades and steel/brass or bronze for bearing.. The blades shall have trailing edges forming an interlocking metal to metal seal when the blades are closed, providing tight, low leakage closure of the air path and maximum impedance to the passage of smoke and products of combustion from either flow direction.

The blades shall be driven by externally mounted and totally enclosed stainless steel gearbox and drive mechanism providing accurate blade control with minimum torque and without accumulative backlash.

The damper casing shall be of double-skin galvanised steel construction with continuously welded corners and integral spigot connections. The dampers shall be supplied completed with the manufacturer-installed frames.

Each damper shall have an externally replaceable combination thermal actuator completely exposed to the air stream.

In addition to the thermal actuation/fusible link, the damper shall be normally held by actuator. The damper shall be released to the closed or fail-safe position by a closure spring on loss of power supply, either by genuine power failure or by the zone fire signal actuated by the smoke detection system. The time for closing the damper shall meet the requirements laid down by the FSD.

The damper shall be automatically reset on resumption of power supply by built-in motor of 220 V AC or 24 V AC/DC.

The whole control mechanism and actuation shall be of the same manufacturer and mounted inside a totally enclosed casing for protection against airborne contamination and to ensure unique reliability.

For smoke extraction at 250 ^{o}C for 1 hour application, damper control actuator shall be totally shielded by a proprietary thermal insulation jacket. The whole damper assembly shall have undergone a high temperature operation test followed by a leakage test at 1500 Pa differential pressure and ultimately approved by the FSD.

6.2.2.12 MOTORISED SHUT-OFF DAMPERS

Motorised shut-off dampers shall be similar to fire/smoke dampers and shall be open or close by motorised mechanism. Each of the dampers shall be in "Open" position normally, but shall be closed when there is a fire or the air handling unit is shut off. The motorised mechanism shall be actuated by associated automatic fire control. Air leakage rate for motorised shut-off dampers shall be tested according to BS EN 1751:2014.

6.2.2.13 TERMINAL DAMPERS

Grilles and air diffusers with rectangular neck connections shall be provided with an opposed blade damper, screwed or riveted to the neck connection to facilitate final balancing of the system.

Damper frames, blades and operating mechanism shall be constructed from an aluminium alloy or, alternatively, formed mild steel suitably finished to give protection to the material during the design working life.

Blades shall be made of solid section material and shall be firmly held in position by a spring steel retaining mechanism. The blade setting mechanism shall be accessible through the grille or diffuser blades and shall be suitable for operation with an "Allen" key. Where dampers are visible through the grille or diffuser they shall be finished with a matt black paint.

6.2.2.14 ACCESS DOORS AND PANELS TO DUCTWORK, CABINETS, COLD STORES

Unless otherwise indicated, locally fabricated Access Doors or Panels shall be constructed of marine plywood on hardwood in accordance with the Supervising Officer’s issued Standard Details, suitably insulated where necessary and finished with at least three coats of shellac, lacquered and polished.

The insulation in the door shall be equal to that of the ductwork or cabinet into which it is installed. When closed, the door shall be effectively vapour sealed.

On doors through which a man can pass, the opening handle shall also be operable from the inside of the door.

Access doors and panels on factory made equipment shall be approved by the Supervising Officer.

All fittings and screws shall be made of brass.

Access doors or panels to ductwork heaters shall be constructed in accordance with the Supervising Officer's issued Standard Details for ductwork heaters.

Access doors shall be of proprietary manufacture, double-skin, 25 mm sandwich G.I. construction with fibreglass or CFC-free foam insulation infill. Access doors shall be of lift off type having a minimum of 4 cam-lock action retaining locks for fixing to ductwork frame. Gaskets shall conform to DW/144:2016 &DW/143:2013. Access doors shall be supplied and fitted with retaining chain tied back to the frame. Multiple screw fixings shall not be allowed.

6.2.2.15 DUCTWORK FLANGES

All rectangular ductwork shall be flange joints. Flanges shall be of a proprietary type, tested and certified for air leakage and deflection to DW/144:2016. Certificates shall be submitted during the equipment submission period.

The proprietary ductwork flanges shall be roll-formed from zinc coated hot-dipped galvanised sheet metal to BS EN 10346: 2015 – TC Grade DX51D+Z, coating type ZF180. Flanges shall be constructed with prefabricated flange profile consisting of manufacturer provided integral sealant with corner joints inserted into the end of the flange profiles and the whole frame shall be firmly secured including the corner component. The already established ductwork flange shall be fastened into the associated ductwork with spot welding. Gaskets strip to BS 476-7:1997, Class 1 and ductwork sealant to BS 476-7:1997, Class 2 shall be applied at the flange joints and corner joints respectively to ensure maximum leakage-proof. All sealant used shall be fire proof and vermin proof, non-toxic and acceptable to the FSD.

Sealant and gaskets shall be provided as recommended by the flange manufacturer.

6.2.2.16 DUCTWORK CLEANING POINTS AND ACCESS PANELS

All ductwork shall be constructed to facilitate maintenance, inspection and cleaning. The ductwork cleaning point shall generally be of a type consisting of a 50 mm diameter metal flange with a 20 mm diameter hole closed with an air-tight screwed plug through which inspection, cleaning and disinfection of the ductwork can be carried out. Size of access panels be provided according to BESA TR/19.

The ductwork cleaning point and access panels shall be of proprietary product, so constructed and installed that no cold bridge which causes condensation will occur.

Ductwork fixings shall not intrude within the ductwork and all sharp edges shall be provided with protective finishing to the approval of the Supervising Officer.

When specified in the particular specification, ductwork support shall capable to support the weight of a person and industrial vacuum cleaner. Similarly, provisions for injecting steam or detergent cleaning devices shall be provided wherever specified.

6.2.2.17 TEST HOLES

Test holes shall be provided according to BESA ductwork specification DW/144:2016, CIBSE Commissioning Code Series A, BSRIA Application Guide, etc. wherever necessary for effective balancing and testing, whether these provisions are shown in the Drawings or not. Test holes shall be of 25 mm diameter and fitted with an effective removable sealed cap made of plastic plugs or die cast metal cupped blanking plates. Test points shall be provided for all dampers and items of equipment to enable fan duties and items to be assessed and for the commissioning of the system.

Test holes shall be positioned at points with stable air flow and not affected by upstream and downstream fittings or obstructions. Test holes shall be located at the inlet and discharge of all fans and air handling units to measure static pressure, before and after air heaters and cooling coils, filters to measure temperature and pressure differentials and other points required for regulating and commissioning of the air distribution system.

6.2.2.18 TRANSFER DUCTWORK

The internal lining material shall be in accordance with Clause 6.2.8.7 of this General Specification.

6.2.2.19 DUCTWORK WITH ANTI-BACTERIA, ANTI-MOULD AND/OR ANTI-DUST COATING

If anti-microbial and/or anti-dust coating is applied to the internal surface of ductwork to inhibit the growth of bacteria, mold and/or to prevent dust aggregation, the performance of the coating shall fulfill the requirement in accordance with Section 6.3 of this General Specification.

SUB-SECTION 6.2.3

AIR HANDLING AND TREATMENT EQUIPMENT

6.2.3.1 GENERAL

6.2.3.1.1 All fans shall be constructed to withstand the pressures and stresses developed during continuous operation at the selected duty. Additionally, all belt driven fans shall be capable of running continuously at the range of 10% to 15% in excess of the required duty speed.

6.2.3.1.2 Fans shall be selected to give the air volume flow rates and sound power levels specified in the Contract. Fan performance curves giving values of sound power levels and fan efficiency at the selected duty shall be submitted to the Supervising Officer for approval.

6.2.3.1.3 Fan Construction

(a) Centrifugal fans having dimensions over 1000 mm in any direction shall have split casing or by other means for easy removal and repair.

(b) The shaft and impeller assembly of all centrifugal, axial flow and mixed flow fans shall be statically and dynamically balanced. All propeller fans shall be statically and dynamically balanced. Limits of vibration severity shall be in accordance with BS ISO 20816-1:2016 or another acceptable standard, such as AMCA, as appropriate.

(c) Fan shall be equipped with self-aligning bearings suitable for the installed altitude of the fan. They shall be of the grease/oil ball and/or roller type or alternatively oil lubricated sleeve type. All bearing housings shall be precisely located in position and arranged so that bearings may be replaced without the need for realignment. Bearing housings shall be protected against the ingress of dust and, where fitted with greasing points, they shall be constructed to prevent damage from over-greasing. For grease lubricated systems the bearings shall be provided with grease of the amount and quality as recommended by the bearing manufacturer. For oil lubricated systems the housings shall provide an adequate reservoir of oil and shall include a filling plug and be oil tight and dust proof. Systems other than total loss types shall include an accessible drain plug. All bearing lubricators shall be located to facilitate maintenance. Extended lubricators outside the fan casing shall only be required if sealed for life bearings are not incorporated.

6.2.3.1.4 Fan and motor for smoke extraction and staircase pressurisation ventilation system shall be suitable for continuous operation at 250 ^{o}C for at least 1 hour. All control and power cables shall be of the fire resistance type complying with BS 6387:2013 or IEC 60331-21:1999 Category

CWZ or AWX where appropriate. The requirements specified by the FSD shall also be complied.

6.2.3.2 AIR HANDLING UNITS (AHUs)

6.2.3.2.1 General

Air handling unit manufacturer shall have ISO 9001:2015 certification in respect of design and manufacturing. The manufacturer shall have made similar product for a period of at least five years.

Individual components forming part of the air handling unit shall, in addition to this section, comply with the appropriate sections contained elsewhere in this General Specification.

Air handling unit shall be tested in accordance to EN 13053:2019 and EN1886:2007 or equivalent, and shall be certified by the Eurovent or AHRI or other recognised certification programme approved by the Supervising Officer. Test certificate together with technical information shall be submitted for the Supervising Officer's approval.

The entire construction of the AHU shall have following mechanical characteristics, as minimum requirements, in accordance with the BS EN 1886:2007.

Table 6.2.3.2.1 Minimum Mechanical Requirements for AHU casing

Characteristics	Class
Casing strength	D2
Casing air leakage under -400 Pa	L2
Casing air leakage under +700 Pa	L2
Filter bypass leakage	F9
Thermal transmittance	T2
Thermal bridging factor	TB2

6.2.3.2.2 Construction

AHU assemblies shall be of rigid double skin fully modular construction with each section having matching cross sectional dimensions and same construction type. All individual components and sections shall be assembled using proprietary and approved fastening techniques. Locking devices shall be used with all fastenings which are subject to vibration.

Each module shall be supported by rigid galvanised steel post frame or extruded aluminium alloy framework or other composite material frame as specified with thermal break and flush mounted with dismountable sandwich panel, corrosion resistant treated and strengthened where necessary to prevent minimum deflection and drumming even at 2500 Pa differential pressure. The post frame and corner pieces shall be fixed

together to provide strength equal to welding. The removal of the side panel shall not affect the structural integrity of the unit.

The double skin or sandwich panel shall be no less than 50 mm thick with injected expanded polyurethane foam insulation or other approved insulation encapsulated by epoxy or approved coated finishing solid sheet steel. Non-hydroscopic sealing shall be provided between the panel and the framework. The width of the frame member & corner piece shall be the same as the thickness of the panel.

The whole construction shall be hygienically configurated and the internal surface shall be smooth to avoid any framework protrusion inside the casing.

Casing material shall not be less than the thickness as shown in Table 6.2.3.2.2 unless otherwise specified in the Particular Specification.

Table 6.2.3.2.2 Minimum material thickness for AHU casing

Component	Minimum material thickness (mm)
Casing framework	2.0
Cooling coil casing	1.5
Panel for polyurethane insulation (each face)	0.8
Other	1.2

For sections with UV equipment installed, the casing material of the internal surface shall be aluminium alloy, stainless steel 304 or better.

6.2.3.2.3 Fan

All fans shall be Electronically Commutated (EC) plug fans or centrifugal fans, double inlet, double width, or single inlet, single width unless alternative requirement is specified in the particular specification and/or equipment schedule. Backward curved centrifugal fans shall be mounted together with their motors on a galvanised steel base frame isolated from the main casing by means of 98% efficient spring vibration isolators. The vibration isolators shall have a minimum deflection of 25 mm.

For backward curved centrifugal fans, fan discharge shall be isolated from the casing by a flexible connection. Fan shall be direct driven or driven by at least two-belt arrangement for motor rated higher than 4kW. Selection of fan and motor shall be at their peak operating efficiency. Motor efficiency shall be of minimum IE4 under International Efficiency (IE) classes according to IEC60034-30-1. Fan motor shall be supplied and installed by the AHU manufacturer unless otherwise specified.

6.2.3.2.4 Access Doors

These shall generally be as detailed for acoustically treated doors described in the relevant content of Sub-section 6.2.8. The access doors shall be no less than 400 mm wide and vertically sized for the full height

of the unit or no less than 400 mm wide by no less than 1550 mm high where the unit height exceeds 1900 mm. Quick access doors shall be provided for filter section, coil section, transfer section, humidifying section and damper section, etc. Heavy duty double hinges and two quick release fasteners shall be provided for all quick access doors.

Where return or fresh air ductwork connects to air handling units, access to the filters shall be through side access panels at the filter chambers.

6.2.3.2.5 Access Sections

Access section shall be provided between heating and cooling coils to allow air blasting or steam blasting of coils for cleaning and/or sterilising purposes. Adequate access shall be provided both upstream and downstream of coils to facilitate cleaning and sterilising.

6.2.3.2.6 Anti-Corrosion Treatment

For outdoor or other specified applications, all metal surfaces shall be properly treated and suitably painted. Galvanised sheet metal finish is not acceptable. All external metallic surfaces of the units shall be painted with two coats of undercoat, and two coats of anti-corrosion epoxy based paint with each layer dry film thickness of 150 microns; or other approved finishing applied in the factory. Field painting after the installation is not accepted. Finishing coating shall be non-toxic. For indoor applications, all metal surfaces shall be suitably painted with anti-corrosion paint.

6.2.3.2.7 Thermal and Acoustic Insulation

The unit shall be cold bridge free without sweating as per the specified Thermal Bridging Factor on Table 6.2.3.2.1. Thermal insulation shall be expanded polyurethane foam or other approved material meeting the thermal transmittance factor as specified on Table 6.2.3.2.1. The insulation shall provide a high degree of noise attenuation. Sound reduction index through panels at 125 Hz and 250 Hz shall be better than 8 dB and 14 dB respectively.

Thermal insulation shall be securely fixed to or built into all sections of plant and equipment handling heated or cooled air.

Special surface protection shall be provided as specified to avoid damage in sections having walk-in access. Adequate lighting completed with door operated switch equipped at the factory shall be provided for AHUs with handling capacity greater than 5 m^3/s.

6.2.3.2.8 Air Filters

The filter section shall be provided by the air handling unit manufacturer or specialist manufacturer of filter holding frame approved by the Supervising Officer. The construction of filter section shall be such that there will not be bypass of un-filtered air. The filter section consisting of

the filter elements and the filter fixing frames shall have a positive means of sealing off the unfiltered air by-passing the filter elements.

Bag filter or cartridge filter or HEPA filter with 50 mm thick permanent washable pre-filter shall be provided as specified. Final filter shall be mounted on non-corrosive aluminium or coated G.I. steel or stainless steel tightness proof holding frame for side service or front release depending on the restriction of access. Neoprene gaskets shall be provided along the contact surfaces of the filter element and the holding frame. Filter cartridges shall be clamped against the slide rails with spring type clamping devices.

Each individual filter section in the AHU shall be completed with a dedicated pair of copper tuber pressure tapings, adequately sealed for filed connection of differential pressure sensor. Each individual filter section shall also be connected to a dedicated manometer mounted on outside for local indication.

The filter section shall not be located closer than 500 mm to any electric heaters or water heating battery.

The following air filters shall be provided to the air handling units for special applications: -

Table 6.2.3.2.8 (1) Final filter for special applications

Application	Minimum Efficiency Reporting Value (MERV) ANSI/ASHRAE Standard 52.2-2017 or equivalent
General ventilation system suitable for museum/art gallery, computer room, archives	MERV 14 E3≥95% & E2≥90% & E1≥75%
General ventilation system suitable for hospital, research laboratory	MERV 15-16 E3≥95% & E2≥90% or 95% & E1≥85% or 95%

Remarks:
- E1 is Composite Average Particle Size Efficiency (E) % in Size Range, 0.3um-1.0um
- E2 is Composite Average Particle Size Efficiency (E) % in Size Range, 1.0um-3.0um
- E3 is Composite Average Particle Size Efficiency (E) % in Size Range, 3.0um-10.0um

Table 6.2.3.2.8 (2) High efficiency and HEPA filter

Application	Efficiency % (E) BS 3928:1969 (or EUROVENT 4/4 & 4/5)

Special ventilation systems for hospital, clean room, research laboratory	99.999 > E ≥ 95

Special air by-pass prevention devices and testing facilities with the following components and requirements shall be provided where specified in the Particular Specification.

(a) Volumetric flow meters to measure leakage flow rates;

(b) Hand-pump;

(c) Connection for external compressed air system (max. 1.1 bar);

(d) Pressure gauge for hand-pump and external system;

(e) Connection tube linking the testing device and the tightness proof frame;

(f) Throttle valve; and

(g) A test groove shall be provided on the filter seat of the holding frame of each filter element with a testing port for the connection to the above portable tightness testing device.

6.2.3.2.9 Identification Plate

All AHU shall bear the manufacturer's nameplate giving manufacturer's name, serial and model number, and date of manufacturing; and an identification plate showing the AHU equipment number and essential performance data as indicated on the Equipment Schedule.

6.2.3.2.10 Air Cooling Coil

(a) General

Cooling coil shall be mounted on non-corrosive aluminium or stainless steel slide rails. Coil sections shall be arranged to provide removal of coils from the access side of the section. Cooling coil casing shall equip with flanged ends drilled and corrosion treated to receive counter flanges on connecting ductwork or other associated equipment.

Cooling coil shall utilise the full unit available cross sectional area. Cooling coils shall be constructed from one of the following combinations:-

- Copper tubes expanded into aluminium fins;
- Copper tubes expanded into copper fins;
- Copper tubes expanded into tinned copper fins; and
- Copper tubes expanded into epoxy coated aluminium fins.

Tube thickness shall not be less than 0.34 mm. Fin thickness shall not be less than 0.12 mm with suitable fin spacing.

(b) The resistance to airflow through a coil section shall not exceed 125 Pa taking into account the wet air condition. The face velocity of airflow shall not exceed 2.5 m/s. for primary air handling unit, the face velocity shall not exceed 2.2 m/s.

(c) Access doors with air seals shall be provided on both the upstream and downstream of the cooling coils.

(d) Cooling coils shall be factory tested and certified to at least one and a half times the working pressure.

(e) The number of rows of coil for primary air handling unit and other air handling units shall be optimised. Detail calculations to determine the number of rows required to meet the performance with safety margin shall be submitted for Supervising Officer's approval.

(f) All coil capacities, pressure drops and selection procedures shall be rated in accordance with AHRI 410:2001.

(g) The pressure drop of waterflow through a coil selection shall not exceed 50kPa or otherwise approved by the Supervising Officer.

6.2.3.2.11 Drain Pan

(a) Drain pan shall be made of insulated 1.2 mm thick AISI 304 stainless steel. Water shall not be carried over from a cooling coil into the remainder of the system and an eliminator section shall be provided, wherever necessary or indicated. The eliminator shall be readily removable for cleaning.

(b) The drain pan serving the cooling coil shall be extended or a separate tray be provided to collect water from the eliminator. Drain pan shall be sloped towards a bottom drain connection and pipework shall be installed from each connection to the nearest sump or gully. The drain pan shall be accessible for cleaning and disinfecting without the coil having to be removed.

(c) The drain pipework shall include a water trap of minimum 50 mm deep depends on the maximum fan pressure at the rated speed to prevent entry or exit of air to or from the system. On stacked coil, intermediate drain troughs shall be provided. All drain pans shall be adequately insulated with durable, non-smell and non-peeling under cooling/heating and air flow design conditions. Sealing devices shall be provided at tops and bottoms of coils to minimise air by-pass and water carry-over.

6.2.3.2.12 Chilled Water Connection to Cooling Coil

The flow and return connections and headers shall be made of heavy gauge seamless flanged copper tube or steel tube with external coating. Provision shall be made for thermal expansion of the tubes, for effective venting of the coils and their connections and for the draining of the headers and tubes.

Coil connections shall be arranged so as to enable same side connections to the flow and return pipework, and to have the supply and return connections to headers to give counter flow of air and water. Equal flow of water shall be through all the tubes in the coils.

(a) Up to and including 50 mm bore connections may be made using ground-in spherical seated unions. Pipework of 65 mm bore and above shall be connected using flanged joints. Isolating valves shall be provided on flow and return connections and arranged so as to facilitate easy removal of the coils.

(b) For the connection between the coil header and the external G.I. or black steel pipework, suitable fitting/device or methodology approved by the Supervising Officer to prevent galvanic corrosion effect of different pipe materials jointing together shall be provided.

6.2.3.2.13 Hot Water Air Heating Coil

The construction of coil sections, mounting method, materials, performance, access door and testing requirements, and the coils connection shall be the same as air cooling coils.

The performance of heating coil shall be as specified and the method of testing for rating of the coils shall be in accordance with BS 5141-2:1977 or AHRI 410:2001.

6.2.3.2.14 Electric Type Air Heater

(a) Electric air heater shall consist of a number of sheathed heating elements of the enclosed type mounted in a sheet steel casing. The elements shall be so installed that they can be removed for cleaning or renewal without dismantling ductwork. The surface temperature of the elements shall not exceed 400°C when measured in an air flow of 2.5 m/s at ambient temperature. A high temperature limit cut-out device with hand reset button shall be incorporated such that the limit device sensor is nearest to and above the heating elements which are energised by the first control step. The device shall operate within two minutes at a temperature of 68.5°C.

(b) The control of electric air heaters, except for remote boosters, shall be interlocked with the fan motor starters and an air flow control of the pressure or sail switch type so that the heaters cannot operate unless the fan is running.

(c) Electric air heaters which are installed as boosters in branch ducts remote from the fans shall have an air flow control of the pressure or sail switch type which shall isolate the heating elements from the electricity supply in the event of the failure of air flow.

(d) The number of elements in the heater shall be the same as or a multiple of the number of steps in the controller, or using modulating power controller alternatively. All heaters and heater sections of more than 3 kW loading shall be balanced over 3-phases and the complete heater bank shall be arranged for balanced operation on a 3-phase 4-wire system.

(e) The connections from each element shall be taken to a readily accessible terminal box arranged for conduit entry. Each heater section shall be separately fused and the neutral point of all 3-phase star-connected sections shall be brought out to a link in the terminal box. Near hot areas the wiring insulation shall be of a quality suitable for the maximum working temperature.

(f) The total resistance of the heaters to airflow shall not exceed 15 Pa and the face velocity shall not exceed 6 m/s.

Note for energy efficiency design: - Heating by hot water from waste heat reclaim or from heat pump system aiming for high operating efficiency shall be considered.

6.2.3.2.15 Humidification Equipment

Steam humidifiers shall be used. They shall be of the steam injection type using electric elements/electrodes or be of the evaporative pan type with a minimum efficiency of 95%. Steam available from a central plant may also be used.

It shall be possible to isolate the electrical supply from the elements/electrodes and they shall be arranged to facilitate removal for maintenance and replacement. Electric heating elements shall incorporate a high temperature cut-out and shall be interlocked to break the electrical circuit on low water level. Steam injection distribution pipes shall be provided for condensate return and be so installed that free moisture is not carried over into the air stream. Steam generating equipment, other than remote central plant, shall be an integral part of a purpose-made humidifying unit and shall incorporate automatic water-level control, overflow protection and drain connections. Automatic intermittent or continuous blowdown shall be incorporated as appropriate.

The evaporative pan type humidifier shall be positioned so that it is not affected by the radiant heat from heater batteries.

6.2.3.2.16 Additional Modular Sections

Additional modular sections shall be provided with ease for the accommodation of ultra-violet steriliser, heat wheel or other devices as specified for the improvement of air quality and energy efficiency.

6.2.3.3 AXIAL FLOW FAN

6.2.3.3.1 Axial flow fans shall be of either the single-stage type or the multi-stage contra-rotating type with each impeller mounted on an independent motor.

6.2.3.3.2 Fans shall be tested for air performance and sound ratings in accordance with ANSI/AMCA Standards 210-16 and 300-14, ISO 5801:2017 or equivalent recognised standards as approved by the Supervising Officer.

6.2.3.3.3 Casing shall be rigidly constructed of mild steel stiffened and braced to obviate drumming and vibration. Cast iron or fabricated steel feet shall be provided where necessary for bolting to the base or supports. Inlet and outlet ducts shall terminate in flanged rings for easy removal.

6.2.3.3.4 The length of the duct casing shall be greater than the length of the fan(s) and motor(s) in order that the complete section may be removed without disturbing adjacent ductwork.

6.2.3.3.5 Electrical connections to the motor(s) shall be through an external terminal box secured to the casing.

6.2.3.3.6 Impellers shall be of galvanised steel or aluminium alloy; the blades shall be secured to the hub or the blades and the hub shall be formed in one piece. The hub shall be keyed to a substantial mild steel shaft carried in two bearings and the whole statically balanced. Unless otherwise indicated blades shall be of aerofoil section.

6.2.3.3.7 Where axial flow fans are driven by a motor external to the fan casing the requirements of the relevant content in this General Specification for pulleys and for V-belt drives and guards shall be met. An access door of adequate size to facilitate inspection, cleaning and other maintenance shall be provided.

6.2.3.3.8 Axial flow fans of the bifurcated type shall be used on application for greasy gases, hot gases or vapours. Motors shall be out of the air-stream and shall normally be placed between the two halves of the bifurcated casing in the external air. The motor and the bearings shall be suitable for operation at the temperature they may experience. The bifurcated section containing the motor shall be mounted vertically in order to maximise convection air flow over the motor.

6.2.3.3.9 Special design multi vanes to reduce turbulence and increase fan efficiency shall be provided as specified in the Particular Specification.

6.2.3.4 CEILING FAN

6.2.3.4.1 Dimensions

The sweep diameter of the units shall be 1200 mm or as otherwise indicated.

6.2.3.4.2 Capacity

The 1200 mm unit shall be capable of an air delivery of 3.9 m^3/s or as otherwise stated.

6.2.3.4.3 Duty

(a) The unit shall be suitable in all respects for operation under ambient air conditions of 40°C and 95% RH.

(b) The unit shall be suitable for operation in 220 V, 50 Hz single phase AC mains.

(c) The unit shall be suitable for heavy duty commercial and domestic usage.

(d) The fan shall operate without generating unnecessary noise at all speeds.

6.2.3.4.4 Motor

(a) The motor shall be a totally enclosed, capacitor run induction motor, with internal stator and external squirrel cage rotor.

(b) The rotor shall be mounted in grease lubricated ball bearings.

(c) The power factor shall not be less than 0.85 at any speed.

(d) The motor shall be rated for continuous operation under ambient air conditions of 40°C and 95% RH and the temperature of the windings shall not exceed 50°C after 2 hours of continuous operation.

(e) All electrical components, cables, etc. shall conform to the appropriate specifications or shall be of fully equivalent quality and capacity.

6.2.3.4.5 Blades

(a) The fan shall be fitted with three blades. "Twisted" blades are preferred.

(b) The blade assemblies shall consist of blades manufactured from heavy gauge aluminium securely riveted to steel blade carriers.

(c) The blade carriers shall be manufactured from mild steel plate of not less than 3 mm in thickness and of not less than 40 mm width at the narrowest point, pressed to shape.

(d) Where the blade carriers are twisted to give the required angle of incidence to the blades, there shall be large radius bends to prevent stress concentrations in the blade carriers.

(e) Anti-vibration bushes shall be installed between the blades and blade carriers.

(f) The blade carriers shall be securely fastened to the frame of the motor by machine screws and spring washers, the whole assembly shall be constructed to ensure that there is no possibility of a blade becoming detached during operation.

6.2.3.4.6 Terminals and Capacitor

(a) The plastic terminal block and capacitor shall be mounted in a ferrous metal connecting piece, located between the fan and the down-rod. The leads from the stator windings shall be connected to the terminal block. An earthing terminal, consisting of a round head brass, screw and washer, shall be provided on the connecting piece. All exposed metal parts of the fan unit shall be connected to this earthing terminal.

(b) The bottom portion of the connecting piece shall be screwed on to the shaft of the motor. The connecting piece shall be tightened onto a shoulder formed on the motor shaft. A 4 mm minimum thickness steel hexagonal lock-nut with lock bracket underneath shall then be fitted and tightened in position. The connecting piece shall additionally be screwed in the fully tightened position by two hardened steel grub screws. These screws shall engage in shallow depressions drilled in the shaft after the connecting piece has been tightened in place to ensure positive locking.

6.2.3.4.7 Down-Rod Assembly

(a) The down-rod assembly shall consist of a down rod and a steel shaft with a hard rubber roller for suspension of the fan. The down rod shall be supplied to the length indicated for the job which shall be measured from the top of the connecting piece to the centre of the pin in the shackle at the top.

(b) The down-rod shall be manufactured from 12 mm bore standard mild steel pipe of not less than 3 mm wall thickness, having an external diameter of approximately 20 mm. It shall be accurately threaded at one end and shall be screwed into the top portion of the fan connecting piece (capacitor housing) from which it shall protrude by a minimum of 2 mm.

(c) It shall be locked in position by two hexagonal steel lock nuts, having a minimum thickness of 6 mm, tightened onto the upper machined surface of the fan connecting piece.

(d) The down-rod shall also be locked to the fan connecting piece by means of a steel split-pin, of not less than 5 mm diameter, passing through both the fan connecting piece and the down-rod.

(e) The split-pin holes in the fan connecting piece shall be of such a diameter that the split-pin is a light push fit there-in. The matching split-pin holes in the down-rod shall be just sufficiently large so that the split-pin shall be a light push fit, when the hole is in its worst position relative to the threading. All burrs and sharp edges shall be removed from the split-pin holes both in the fan connecting piece and the down-rod.

(f) The steel suspension shackle shall be welded to the down-rod. Welding shall be of good quality and to the satisfaction of the Supervising Officer. The rubber roller shall be mounted on an 8 mm diameter steel clevis pin secured by a split-pin.

(g) The ends of the down-rod shall be rounded off and free from burrs. There shall be no sharp edges which could cause damage to the insulation of the wiring.

6.2.3.4.8 Suspension Joints and Threaded Parts

(a) Joints along the suspension rod shall be of double-locking type, i.e. at least two independent positive locking devices shall be employed to prevent a joint from loosening itself.

(b) The maximum clearance between threaded mating parts shall not exceed 1% of their mean diameter.

(c) The direction of rotation of the fan shall be such that all screw joints tend to be tightened when the fan is in operation.

6.2.3.4.9 Canopies

Two canopies manufactured from plastic or pressed steel sheet shall be provided and fitted over the upper and lower ends of the down-rod. They shall be fixed to the down-rod grub screws.

6.2.3.4.10 Balance

(a) All fans shall be fully balanced after assembly, with any necessary adjustment being made to ensure that they shall not oscillate due to out-of-balance forces.

(b) All blades shall be given a single identification number, or letter, permanently stamped on the supply side, with a corresponding

mark stamped on the motor body so that the fan blades may be reassembled in the correct position.

6.2.3.4.11 Finish

The whole fan shall be finished in high quality stove-enamel, white, ivory or other colour where required by the Supervising Officer.

6.2.3.4.12 Speed Regulator

(a) Solid-state speed regulator shall be with five speeds and an "OFF" position in white or ivory or another colour to match the fan.

(b) An earth terminal shall be provided on the base with an earth wire permanently connected to the steel core of the choke unit.

(c) The speed regulator shall move smoothly and easily between positions.

6.2.3.4.13 Inspection

At least one typical unit for those to be supplied for a given Contract shall be provided for acceptance test carried out for the Supervising Officer before delivery of any quantity is made to the Site.

6.2.3.5 HIGH VOLUME LOW SPEED FAN

High volume low speed fan shall be manufactured to efficiently move air with quiet operation of less than 50dB(A). The sweep diameter shall be up to 7200 mm.

Fan frame shall be powder coated or galvanised steel and blades shall be extruded aluminium with high impact end caps. The blades shall be interlocked with one another and the impeller hub via a heavy duty steel airfoil retaining ring for safety.

Fan speed shall be variable continuously with range from 20% to 100%.

Protection system shall be provided to protect from failures caused by over-current, over-temperature, over speed and fan impact.

6.2.3.6 CENTRIFUGAL FAN

6.2.3.6.1 Centrifugal fans for high-velocity high-pressure systems as defined within BESA Standard DW/144:2016 shall be of the backward bladed type.

6.2.3.6.2 Centrifugal fans with motor brake power of 5 kW or more shall be of the backward bladed type having a fan total efficiency not less than 75%.

6.2.3.6.3 Fans shall be tested for air performance and sound ratings in accordance with ANSI/AMCA Standards 210-16 and 300-14, ISO 5801:2017 or equivalent recognised standards as approved by the Supervising Officer.

6.2.3.6.4 Fan casings shall be constructed to permit withdrawal of the fan impeller after fan installation. Fans other than those in factory constructed air handling units (AHUs) shall be provided with flanged outlet connections and spigot inlet connections suitable for flexible joint connections except those for use with negative pressures greater than 500 Pa in which case inlet connections shall be flanged.

6.2.3.6.5 Except for factory constructed AHUs, all fan casings of 900 mm diameter or greater shall be provided with removable access panels which shall incorporate purpose-made air seals. The sizes of access panels shall be such as to facilitate cleaning and maintenance of the impeller and shall not be less than 300 mm x 300 mm.

6.2.3.6.6 For all kitchen extract ventilation fans an access door, for inspection and cleaning, shall be fitted to the scroll casing in an accessible position; it shall be of full width of the impeller. A plugged drain point shall be fitted at the lowest point of the fan.

6.2.3.6.7 Permanent indication shall be provided to show the correct direction of rotation of the fan impeller.

6.2.3.6.8 Impellers shall be of mild steel with protection coating, galvanised steel or aluminium alloy where indicated, of riveted or welded construction, with spiders or hubs, and shall be capable of running continuously at 10% in excess of normal speed. Impellers shall be keyed to a substantial mild steel shaft and the impeller completed with shaft shall be statically and dynamically balanced and tested for satisfactory overspeed performance before leaving the maker's works.

6.2.3.6.9 Fan shaft shall enable pulley to be mounted at both ends. Shaft bearings of belt driven single inlet fans shall be truly aligned and rigidly mounted on a pedestal common to both bearings. Double inlet, double width fans shall have a pedestal mounted bearing at each side of the fan. Fan bearings shall be of the ring oiling sleeve type, or the ball or roller type. Where silence is important the bearing pedestal shall not be attached to the fan casing, instead ring oiling sleeve type bearings shall be supplied.

6.2.3.6.10 Centrifugal fans shall be driven by electric motors through V-belt drives complying with the relevant content in Sections 6.1.7 and 6.2.7.

6.2.3.6.11 Three phase powered variable flow centrifugal fans where specified shall be variable speed driven. Variable speed drive shall be in accordance with Sections 6.1.7 and 6.2.7 of this General Specification.

6.2.3.7 FAN COIL UNIT

6.2.3.7.1 General

Fan coil unit shall comply with the manufacturer's own ISO 9001:2015 quality standard in respect of design and manufacturing and be type-tested

to BS 4856-2:1975 or, ANSI/AHRI 440:2019 or GB/T 19232:2003 or other acceptable standards, such as Eurovent, etc., for thermal volumetric and acoustic performance.

Fans, filters, cooling coils, heating coils, motors, thermal and acoustic insulation shall comply with the appropriate sections of this General Specification and the following requirements: -

(a) Fans shall be of the Double Inlet Double Width (DIDW) forward curved centrifugal or tangential flow types and shall be of galvanised/mild steel, aluminium, reinforced glass fibres or rigid plastic material as specified in Particular Specification;

(b) Air filters shall be washable panel type.

(c) Motors shall be quiet running and have sleeve or ball bearings factory lubricated for life. Motor windings and electrical components shall be impregnated or protected to avoid trouble from condensation;

(d) Stepless controlled motor shall comply with the following requirements:

(i) A variable speed controller shall be equipped for modulating speed of FCU over a specified range of 30% to 100% continuously and smoothly;

(ii) The motor shall be insulated with class B (or above) with built-in thermal cut-out protection; and

(iii) The power factor shall have performance not less than permanent split capacitor type.

(f) Fan coil unit capacity and air flow rate shall be selected based on the performance of the units at optimum medium fan speed, while fan static shall be rated at high fan speed;

(g) In selecting the fan coil unit, allowance shall be made for the actual resistance imposed on the air flow of the units due to ducts and grilles. The added resistance is to be applied to all fan coil units whether shown to have ducts connected or not, and the total fan static external to the unit at high fan speed shall be taken as not less than 30 Pa external to the unit; and

(h) For the connection between cooling coils of fan coil unit and chilled water pipe, suitable fitting/device or methodology approved by the Supervising Officer to prevent galvanic corrosion effect of different pipe materials jointing together shall be provided.

6.2.3.7.2 Casing

Casing shall be of G.I. sheet metal with thickness not less than 1.0 mm suitably stiffened to minimise drumming and vibration and shall be protected against corrosion and, for those exposed to view, finished i outside with stove primer. All corners shall be rounded off without sharp edges. Casing shall be lined with material to act as both thermal and acoustic insulation which shall comply with the relevant requirements in this General Specification. Casing shall include space for pipework connections and valves, and there shall be ready access to the fan and motor, filter, damper, drain pan, pipework connections and valves, for maintenance purposes.

The motor and fan shall be mounted on a detachable mounting chassis that can be removed from the fan coil enclosure as one assembly (with extended cables) to facilitate fan and motor cleaning. It shall then also be possible to remove the fan impeller scroll casing in order to properly clean the fan blades.

6.2.3.7.3 Coil

(a) Cooling coil shall be minimum two-row and shall include an air vent cock and drain valve.

(b) The chilled water cooling coil shall be rated in accordance with ANSI/AHRI Standard 410:2001 or GB/T 14296-2008 and constructed from seamless copper tubes mechanically bonded to aluminium fins.

(c) Each coil shall be provided with motorised 2-way solenoid or modulating control valve and isolation valves. Flexible pipe connectors completed with union joints to facilitate removal of the entire unit shall be provided. The connector shall be copper or stainless steel braided polymer tubing limited to 300 mm long and suitable for the system pressure.

(d) Working pressure of coil shall be 16 bars or suit specific requirements.

6.2.3.7.4 Components

(a) All units shall include an easily removable filter capable of treating the total air volume. Filters shall, unless otherwise specified, be washable. It shall be supported in a stiff aluminium/stainless steel detachable frame.

(b) Drain pans shall be constructed from not less than 0.6mm with ocated cold roll steel with watertight brazed joints and insulated with a minimum of 10 mm thick flexible closed cell elastomeric insulation. Drain pans shall be large and deep enough to collect all condensate from the coil, return bends and pipework connections. The pan shall be removable and have a slight fall to

the drain connection. For units whose loads include a high proportion of latent cooling the fall to the drain point and the size of the drain connection shall be adequate to deal with the condensed moisture.

6.2.3.7.5 Controls, Dampers and Grilles

Fan coil units shall have a combined room temperature sensor completed with 3-speed controller with heating/cooling mode selector as required for standalone control, or connected to CCMS as specified. For LCD type thermostat, it shall be able to realise fast cooling or heating at beginning, and precise temperature control (within +/- 0.5 degree C) at stable condition. The network type thermostat can equip with RS485 port supporting standard BACnet or Modbus communication protocol, not limit can network with group controller to realise zone central control, but also can network with CCMS to realise remote monitor and control. For stepless control motor, the control logic shall include the modulation of fan speed and control valve to provide feedback control in response to the difference between the room temperature and the set point.

Where indicated they shall have connections for both fresh and recirculated air and shall include a damper which shall be adjustable to give up to 25% of the fan capacity drawing from the fresh air source. Outlet grilles shall be capable of adjusting the direction of airflow without adversely affecting pressure drop. On floor mounted units, supply grilles shall be on the top of the unit.

6.2.3.7.6 Noise level

The noise data provided shall include an octave band analysis of the sound power level of each unit when operating at its full or the stated design speed.

6.2.3.7.7 Electric Heaters for Fan Coil Unit

Electric heaters shall be of maximum 2 kW capacity of the black heat sheathed element type, plain or finned, and shall be provided with a safety cut-out thermostat set to operate at 50°C.

Sail switch is to be fitted for each heater battery and is to be connected in series with the safety cut-out thermostat to switch off the heater in the event of reduced air flow.

The mounting, arrangement and terminals, etc. for Electric Duct Heaters shall be in accordance with Drawings or other installation standard approved by the Supervising Officer.

6.2.3.8 CASSETTE TYPE FAN COIL UNIT

6.2.3.8.1 The cassette fan coil units shall comply with requirements of fan-coil unit.

6.2.3.8.2 The fan coil unit shall be of integrated cassette type which combines the supply air slot, return air grille, fan, casing, cooling coil, heating coil or electric heater (if required) into a single unit. No connection of ductwork is allowed except for fresh air.

6.2.3.8.3 Fan coil units shall be selected at design duty and specified noise level with fan running at medium speed.

6.2.3.8.4 Remote control unit shall be provided as specified.

6.2.3.8.5 Cooling coil shall be constructed with copper tubes and shall be arranged horizontally. Tubes shall have brazed copper return bends. Fins shall have smooth drawn collars of length equal to fin spacing and mechanically bonded to tubes. Fins shall be of the plate type, corrugated to ensure maximum air contact. All coils shall have an air release valve and a drain valve. Working pressure of coil shall be of a minimum of 1200 kPa and to suit system pressure design.

6.2.3.8.6 Each fan coil unit shall be provided with a drain pan made of high grade AISI 316 stainless steel or any corrosion resistant material complying with relevant fire safety requirements situated beneath the cooling coil and arranged so that all moisture will collect in and drain from the pan. Drain pans shall be insulated externally with a minimum of 10mm approved type foamed plastic. Each drain pan shall be fitted with a drain pipe which shall be connected via suitable runs (correctly laid to fall) to the drainage system. Drain pans shall have copper male connectors for connection to the condensate drain. The connector shall be positioned to ensure rapid discharge of moisture from the pan.

6.2.3.8.7 Built-in condensate pump shall be provided for the removal of condensate. Condensate pump shall run automatically according to water level. The power source for the condensate pump shall be maintained even the fan coil unit is switched off.

6.2.3.8.8 The filter media shall be of the washable type and shall be enclosed in a one-piece formed frame made of stainless steel or any corrosion resistant material with covers flush mitred and reinforced by a die-formed inverse bead.

6.2.3.8.9 Fan shall be of the quiet running direct driven centrifugal type with blades made of aluminium or any corrosion resistant material mounted to a solid steel shaft. The motor shall be resiliently mounted to the fan tray or scrolls. The motor/fan tray assembly itself shall also be resiliently mounted to the casing structure.

6.2.3.8.10 Adjustable louvres for directional airflow shall be provided for supply air slot in each fan coil unit. Options shall be given to choose from 2-way, 3-way or 4-way supply air discharge.

6.2.3.9 MIXED FLOW FAN

Mixed flow fan casing shall be rigidly constructed of mild steel, or aluminium alloy stiffened and braced where necessary to obviate drumming and vibration. Mounting feet shall be provided where necessary for bolting to a base or supports. Inlet and outlet shall terminate in flanges to facilitate removal. Stator vanes shall be of mild steel or aluminium alloy. The unit shall facilitate access to the impeller. Where motors are mounted external to casings, drives and guards shall be. An access panel with purpose-made air seal shall be provided in the fan casing. The access panel shall be sized and so positioned as to facilitate maintenance.

6.2.3.10 MECHANICAL ROOF EXTRACT UNIT

The fans used in roof extract units shall meet with the appropriate requirements of the preceding content relating to fans generally and in particular to the types of fans involved. The materials of cowls and bases shall be resistant to weather, solar radiation and appropriate to the location of the unit and type of fan installed. Casings shall be formed to facilitate a weatherproof fixture to the building structure. Adequate access to electrical supply terminals and lubrication points shall be provided by means of hinged cowls or otherwise as appropriate. Back-draught dampers and/or fire release dampers shall be provided where indicated. Bird entry preventive guards of not greater than 25 mm mesh shall be provided as an integral part of the unit.

6.2.3.11 PROPELLER FAN

Impeller shall be of steel or aluminium. The blades shall be fastened to the hub or the blades and hub shall be formed in one piece. The bearings may be ball, roller, or sleeve type. Propeller fans may be ring mounted, diaphragm mounted or diaphragm mounted in a casing, as indicated.

The tip speed of propeller fans shall, unless otherwise indicated, not exceed 25 m/s. All ring mounted propeller fans which are exposed, i.e. not installed within a ductwork or other enclosure, shall be adequately protected by safety guards.

6.2.3.12 PROTECTIVELY COATED FAN AND FAN FOR CORROSIVE OR HAZARDOUS APPLICATIONS

Where fan is required to handle toxic, corrosive, flammable, explosive or high temperature gases, the materials and form of construction shall be selected and suit the particular application. Protectively coated fans shall meet with the appropriate requirements of the previous content relating to fan generally and to particular types of fans; the form of protection shall be as indicated. Where a protective coatings is required for use with corrosive gases, the coating shall cover all parts of the complete fan, motor and casing assembly which will be in contact with the corrosive gases. No fan shall be installed if the protective coating has been damaged in any way. Impellers shall be of coated steel, stainless steel, aluminium or fire-proof plastic as indicated.

Where fan is installed in a potentially explosive atmosphere, the EU ATEX 100a directive shall be complied.

6.2.3.13 ROTARY FAN (WALL OR CEILING MOUNTED)

6.2.3.13.1 Capacity

The unit shall be capable of an air delivery of not less than 1.1 m^3/s.

6.2.3.13.2 Dimension

The blade sweep diameter of the unit shall be 400 mm.

6.2.3.13.3 Duty

(a) The unit shall be suitable in all respects for operation in ambient air conditions of 35°C and 95% RH.

(b) The unit shall be suitable for operation on 220 V, 50 Hz, single phase AC supply.

(c) The fan shall not require periodic lubrication.

6.2.3.13.4 Construction

(a) These units shall be of deluxe and pleasing appearance with smooth safe edges and of "easy-to-disassemble" for cleaning. Units not considered of suitable appearance may be rejected by the Supervising Officer.

(b) The fan shall have high quality aluminium or plastic blades.

(c) The fan shall be fully balanced after assembly.

(d) The blades shall be enclosed by a high quality chromium plated metal wire-mesh metal guard. The gap in between the guard wires shall not be greater than 15 mm at any point.

(e) The fan shall be provided with rotary mechanism for a rotational sweep of 360° when mounted on the ceiling for rotary ceiling fan or for a swing of 150o when mounted on a wall or column for rotary wall fan.

(f) The whole unit shall be finished to manufacturer’s standard light colour or as otherwise approved by the Supervising Officer.

6.2.3.13.5 Electrical

(a) All exposed metal parts of the unit shall be suitably earthed via the 3 core flexible cable.

(b) The fan shall be provided with speed regulator and be capable of being switched on and off by a remote 5A DP switch.

(c) The fan shall be provided with an adequate length of 0.75 mm^2 3 cores PVC insulated and sheathed flexible cable and connected to the associated socket outlet. Where provided but not fixed, the cable provided shall be 2 m in length.

6.2.3.14 IN-LINE CENTRIFUGAL FAN

Fans shall be rigidly constructed and fabricated from heavy gauge galvanised sheet. Fan housings shall have flange on the suction and discharge side for connection of flexible joints and ducting. Impellers shall be made of galvanised steel or aluminium, single inlet backward inclined or forward curved centrifugal type. Removable access panels with purpose made air seal shall be provided with sufficient size to permit easy access to all internal components. Motors shall be completed with permanently lubricated ball bearings and being removed from the fan assembly for maintenance.

6.2.3.15 EC PLUG FAN

6.2.3.15.1 Fans shall be direct driven single inlet centrifugal impellers. Fans impellers shall be backward bladed type unless alternative requirement is specified in the particular specification and/or equipment schedule. Fan impeller maximum total efficiency shall not less than 70%.

6.2.3.15.2 Fans shall be tested for air performance and sound ratings in accordance with ANSI/AMCA Standards 210-07 and 300-14, ISO 5801:2017 or equivalent recognised standards as approved by the Supervising Officer.

6.2.3.15.3 Fan casings shall be constructed to permit withdrawal of the fan impeller after fan installation. Fans other than those in factory constructed air handling units (AHUs) shall be provided with flanged outlet connections and spigoted inlet connections suitable for flexible joint connections except those for use with negative pressures greater than 500 Pa in which case inlet connections shall be flanged.

6.2.3.15.4 Except for factory constructed AHUs, all fan casings of 900 mm diameter or greater shall be provided with removable access panels which shall incorporate purpose-made air seals. The sizes of access panels shall be such as to facilitate cleaning and maintenance of the impeller and shall not be less than 300 mm x 300 mm.

6.2.3.15.5 Impellers shall be made of aluminium, air foil type with rotation diffuser mounted on electronically commutated external-rotor motors with variable speed drives.

6.2.3.15.6 Motor efficiency for the fans shall be of minimum IE4 under International Efficiency (IE) classes according to IEC 60034-30-1.

6.2.3.16 JET FAN

Fan shall be direct driven and manufactured in unidirectional as standard with option of fully reversible operation, providing almost same duty in either direction where specified. Fan shall be constructed of either single nozzle or multi nozzle type with each impeller mounted on an independent motor. Fan casing shall be integrated with sound attenuator. Casing materials shall not be less than 0.8 mm galvanised steel, coated with powder to protect from atmospheric corrosion. Fan shall be rigidly constructed and correctly proportioned to allow optimum fan performance. Fan motor assembly shall be for easy maintenance and shall be capable of being slide out without dismounting the complete attenuator. Impellers shall be of galvanised steel or aluminium with high efficiency pitch adjustable at unidirectional flow.

6.2.3.17 CONDUCTING FAN

Fan shall consist of 3 to 10 modules of fans in parallel and operate without duct connection. Each module shall consist of aerodynamically shaped aluminium alloy housing with built-in guide vanes and rotor unit. Fan casings shall be made of aluminium alloy and coated with powder. Fan inlet shall be completed with mild steel wire or rod powdered coated protective screen. Mounting brackets and legs shall be of powdered coated rigid steel sheet and shall be installed by means of suspension bolts from ceilings or walls. Mounting legs shall have at least 8 adjustment angles from horizontal to vertical positions. Impeller shall be made of aluminium sheet, axial type and dynamically balanced. Fan shall be compatible for connection with remote controller or field made control panel for remote on/off and high/low speed operation.

6.2.3.18 TERMINAL AIR CONTROL DEVICES

6.2.3.18.1 General

(a) Terminal units shall be factory fabricated and tested in accordance with British Standard BS 4954-1:1973, BS 4954-2:1978, BS 4857-1:1972, BS 4857-2:1978 where appropriate.

(b) Casing of the unit shall be manufactured from galvanised steel sheet of thickness comply with DW/144:2016.

(c) Noise including in-duct sound power level, which emitted through the unit casing shall not exceed the value as indicated and/or as stated in Sections 6.1.8 and 6.2.8 of this General Specification.

(d) The entire unit shall be internally lined with thermal and acoustic insulation in compliance with the relevant content in Sections 6.1.11 and 6.2.11, and 6.1.8 and 6.2.8 enclosed in a galvanised perforated metal liner. The lining shall be securely fixed and shall be proof against erosion by the air flow. The acoustic and thermal insulation shall comply with NFPA-90A:2018, UL 181:2013 and BS 476-4:1970, BS 476-12:1991, BS 476-6:1989+A1:2009 & BS 476-7:1997 standards (or the related content of ISO 1182:2010and the requirements of the FSD.

6.2.3.18.2 Induction Units

(a) Filters, cooling coils, heating coils and thermal and acoustic insulation shall comply with the relevant Sub-sections of this General Specification.

(b) Casings shall include space for pipework connections and ductwork as necessary, and there shall be ready access to the filter, the primary air nozzles and any valves and controls.

(c) Primary air plenums shall be treated with thermal and acoustic insulation. Units shall be completed with a suitable device to regulate primary air pressure and air volume flow rate. Primary air nozzles shall be arranged to induce an even secondary circulation across the cooling and/or heating coils. The unit air outlet shall incorporate means of directional control of air supply where indicated.

(d) Cooling/heating coils shall include an air cock and shall be effectively sealed to prevent air by-pass around the coil. Drain pans of cooling coils shall be of a material which is resistant to corrosion or is protected against corrosion and shall have a slight fall to a drain connection.

6.2.3.18.3 Single Duct Constant Air Volume (CAV) Terminal Units

Units shall incorporate a self-acting constant flow rate device. The pressure drop across the unit at design air volume flow rate shall not exceed 250 Pa.

6.2.3.18.4 Single Duct Variable Air Volume (VAV) Terminal Units

(a) Unit shall be rated in accordance with ANSI/ASHARE Standard 70-2006 and Air Diffusion Council Test Code 1062R4. The performance data shall be certified by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved. The casing of the VAV terminal unit, re-heater box and multi-outlet box shall be manufactured from galvanised steel sheet of thickness comply with DW/144:2016.

(b) Unit shall be of the pressure independent type throughout the entire range and shall be capable of resetting the air flow to ±5% of the nominal air flow regardless of the change in the system pressure.

(c) The unit shall be capable of being reset to any airflow between zero and the rated air volume automatically to compensate for duct pressure fluctuation.

(d) The air velocity sensor shall measure the true velocity across the inlet of the unit and be unaffected by changes in duct air

temperature and humidity. The sensor shall be field replaceable without opening the associated ductwork.

(e) The entire package shall be calibrated and factory-set for the maximum and minimum flow rates as specified but shall be capable of easy re-adjustment in the field. Each terminal box shall be provided with factory-calibrated, direct reading air flow indicator. Separate gauge taps shall be provided for field re-calibration and commissioning.

(f) The velocity controller and the damper actuator shall be of an integral unit directly mounted onto the damper shaft. The actuator shall be capable of operating in the stalled position without overheating or mechanical damage. Mechanical limit switch will not be accepted. The damper shall remain in a fixed position when electrical power source is interrupted. The control equipment shall be easily accessible through an access door provided with quick-release fasteners.

(g) The damper shall be made of heavy gauge galvanised steel with peripheral gasket, pivoted in self-lubricating bearing. In the fully closed position air leakage past the closed damper shall not exceed 2% of the nominal rating at 250 Pa inlets static pressure.

(h) VAV terminal unit shall be pneumatic, electronic or DDC controlled as specified. One thermostat shall be provided for each VAV terminal unit unless otherwise specified. The thermostat offered shall match the unit and include temperature set point and velocity adjustment point located inside.

(i) The thermostat shall have a calibrated scale showing set point temperature with a constant approximately 1 ^{o}C proportional band regardless of minimum and maximum velocity settings. Air flow set point shall be adjusted by screw and voltmeter tap in the thermostat or by other approved means for both high and low air volume limits. The location of the thermostat shall be determined on Site.

(j) The unit shall not be selected at the top of the catalogue range in order to ensure it meets with the specified room noise level requirement.

(k) Circular connection spigot of insertion dimensions, with self-sealing rubber gasket shall be provided at both the inlet and outlet of the unit. Each multi-outlet section shall be completed with at least one spare outlet, capped for future use.

(l) Unit shall be completed with a mixing attenuator section where specified.

The attenuator shall be factory-fitted to the basic unit and of a length not less than 900 mm. The casing shall be constructed as

the terminal unit, but with acoustic insulation of mineral wool with a minimum density of 70 kg/m^3.

(m) Unit shall be completed with electric heater section where specified. All sections within one metre of the heating elements shall be constructed by double skin casing. The internal insulation shall be lined with minimum 0.7 mm thick galvanised steel sheet. The heater shall be easily withdrawn from the casing for servicing and maintenance. Heating element shall be of the sheathe and black heat type. The heater shall be controlled by contactor and step controller fully interlocked with a sail switch and duct type overheat thermostat with fail safe feature and manual reset. The heating element shall be switched off when the mean temperature inside the air duct exceeds 50°C ±10% and within 90 seconds of reaching this temperature.

(n) VAV terminal unit completed with VAV section (air measuring station, modulation damper with actuator and controller), re-heater section, attenuator section and supply air section shall be supplied by the same manufacturer.

6.2.3.18.5 Dual Duct Terminal Units

Dual duct terminal units shall be constructed as single duct CAV unit and VAV unit and shall incorporate devices for varying the proportions of hot and cold air and for providing thorough mixing of the air.

6.2.3.19 GRILLES AND DIFFUSERS

6.2.3.19.1 General

(a) The grilles and diffusers shall be rated in accordance with ANSI/ASHRAE standard 70-2006 and Air Diffusion Council Test Code 1062R4.

(b) All grilles and diffusers shall have concealed fixing system and shall have quick release frame to facilitate cleaning.

(c) All supply grilles and diffusers shall be mounted on substantial frame and shall be provided with soft rubber or felt joining ring inserted under the frame to prevent air leakage and the formation of condensate on the fitting.

(d) All grilles and diffusers shall not be less than the size indicated; where no size is given they shall be capable of handling the air flows and distribution indicated without producing unacceptable air flow noise. Supply air grilles and diffusers shall be selected to achieve good air distribution and adequate air movement in the conditioned space.

(e) In order for the ceiling grilles and diffusers to match with the false ceiling layout pattern, the actual size of the grilles and diffusers shall be confirmed by the Supervising Officer before ordering.

For all grilles and diffusers which are smaller than the ceiling tile on which they are installed, they shall be located in the centre of the ceiling tile. The exact location of the ceiling grilles and diffusers shall be co-ordinated with other services and shall be submitted for approval by the Supervising Officer.

(f) The finishing colour of the grilles and diffusers shall be approved by the Supervising Officer as different colour may be specified in different areas.

6.2.3.19.2 Grilles

(a) Grilles shall be of steel, aluminium, PVC or as otherwise indicated. Steel grilles shall be protected against rusting and supplied in fully finished stove-enamelled or otherwise specified condition.

(b) Each supply air grille shall have 2 sets of separately adjustable louvres, 1 set horizontal and 1 set vertical, and shall be completed with an opposed blade multi-leaf damper. Alternatively, in lieu of the opposed blade multi-leaf damper a rhomboidal air controller may be provided; this air controller shall control both the volume of air passing and the distribution of air across the grille face. The louvre and the damper or air controller shall be adjustable from the front of the grille. For up to 10 grilles, 1 set of tools required for adjusting the louvre and dampers or air controllers shall be provided. From eleven to 24 grilles, 2 sets and above 25 grilles, 3 sets of tools shall be provided.

(c) Return air grilles shall have either a single set of louvre or bars (either vertical or horizontal) or a lattice, egg crate or expanded metal front.

Each return air grille shall be completed with an opposed blade multi-leaf damper or a rhomboidal air controller operable from the front.

Where return air grilles are fitted for fan coil units, they shall be arranged such that the central core of the grille is hinged and demountable for access to the filter for cleaning. Mounting frames for these grilles shall include provision for fixing the filter in position.

6.2.3.19.3 Diffusers

(a) Diffusers shall be of steel or aluminium. Steel diffusers shall be protected against rusting and shall be stove enamelled for finished colour approved by the Supervising Officer. Diffusers shall

incorporate an edge seal; diffusers mounted on ceilings shall have anti-smudge rings. Pan type diffusers shall be provided except where cone type diffusers are indicated.

Diffusers shall be provided with volume control dampers of the iris, flap or sleeve type which shall be adjustable from the front of the diffuser. Where the length of a vertical duct to a diffuser is less than twice the diameter of the diffuser an equalising deflector shall be fitted.

The supply air diffuser shall be capable to induce adequate air movement and provide the throw to cover the entire air-conditioning space without causing air turbulence and cold draft.

(b) Linear diffusers shall be constructed of extruded aluminium section and include a control damper at the rear of the vanes giving volume control down to complete shutoff and operated from the face of the diffuser. Linear diffusers for supply air shall have adjustable blades to give directional control of air flow. The linear diffuser shall be capable of maintaining a horizontal discharge pattern at a turn down ratio down to 20% of the maximum specified air volume without air dumping.

The linear diffuser shall be completed with factory fabricated plenum with suitable inlet connection for flexible ductwork. The plenum and diffuser neck shall be constructed of galvanised steel sheets internally lined with 25 mm 48 kg/m^3 glass cloth faced fibreglass insulation enclosed in galvanised perforated metal liner.

The insulation shall comply with NFPA-90A:2018, UL 181:2013 and BS 476-4:1970, BS 476-12:1991, BS 476-6:1989+A1:2009 & BS 476-7:1997 standards (or related content of ISO 1182:2010).

Where linear diffusers are mounted in a continuous line there shall be means of ensuring alignment between consecutive diffusers and of equalising pressure behind the vanes. The dummy portion of the diffuser shall be internally covered by a demountable galvanised metal enclosure to block the view into the ceiling void from below.

(c) The square face diffuser for VAV system shall be constructed of aluminium and with large turn down ratio.

Each ceiling mounted square face diffuser shall have a factory assembled diffuser and an air plenum. The air plenum shall be provided with dividing plates such that the diffuser back is divided into an annulus area and a square central area. In the entry to the diffuser plenum, the flow cross section shall also be divided into two parts, one part serving as a bypass and the other equipped with a self contained, weight balance damper. The damper shall be balanced with a weight in such a way that the horizontal outlet jet velocity remains nearly constant over a flow rate range of 100 to

20% of maximum in order to prevent stagnant area, wide temperature gradient and drop of air jet in the conditioned area.

(d) The linear slot diffuser shall be constructed of extruded anodised aluminium, with multiple slots for the required air flow rate.

Each diffuser shall be completed with a factory fabricated plenum of the same construction as the linear diffuser.

6.2.3.20 ENERGY EFFICIENCY AND PERFORMANCE

The efficiency of motor shall be of minimum IE4 under International Efficiency (IE) classes according to IEC 60034-30-1:2014 and the Code of Practice for Energy Efficiency of Building Services Installation.

6.2.3.21 DESICCANT DEHUMIDIFIER

6.2.3.21.1 Wheel Type Desiccant Dehumidifier

(a) The dehumidifier shall be of the absorption or adsorption type and completed with rotor, electric or gas type reactivation heater, process air fan, reactivation fan, process air prefilter, reactivation air prefilter, control panel and all other accessories for a complete unit. The heater shall be fitted in a factory built unit casing.

(b) Rotor shall be impregnated with desiccant such as lithium chloride, silica gel, aluminium oxide or other specified type. The desiccant shall be incombustible, resistant to chemicals and non-dusting. The rotor shall have a service life of minimum 8 years with non-stop operation.

(c) The casing of the dehumidifier shall be constructed of sheet steel with oven-curved enamel coating to minimise corrosion. Casing shall comply with leakage standard to Eurovent Document 2/2 1996, Class B and the leakage volume shall be of maximum 0.81 l/s per cu. metre at 1000 Pa.

(d) A control panel shall be provided for the control of the dehumidifier. The control panel shall include control mode switch for switching between manual and humidistat operation. Indicators for power on, unit running, alarm (for high temperature cut-out, fan motor overload unit, trip and high humidity, etc.), reactivation fan running, reactive heater on, rotor drive motor running, process fan running, humidity normal, and any other control indication requirements as specified. There shall also be digital displays for fan speeds, humidity level, and reactivation temperature readings, etc.

(e) The heater control shall be of multi-step. The dehumidifier shall be capable of operating with the services conditions as specified under Part 1 of this General Specification.

(f) The unit shall be capable of local or remote control, and be completed with interlock control for operation with the connecting air handling unit. The unit itself shall be completed with built-in direct digital controller (DDC) for all control and monitoring functions.

(g) The following safety devices shall be provided as a minimum requirement: -

- Electric safety interlock to prevent the dehumidifier from running with the electric control panel open or the mechanical access panels removed;

- Automatic shutdown in case the control system detected a fault; and

- Two independent thermostats for the heater shall be provided to trigger automatic shutdown in accordance with IEC regulation.

6.2.3.21.2 Liquid Type Desiccant Dehumidifier

(a) The unit shall employ an approved liquid type desiccant as the dehumidification media.

(b) The unit shall comprise three separate operation sections (i.e. collection, heat pumping and regeneration).

(c) In the collection operation, liquid desiccant shall be continually added to the top of a honey comb cellulose material which shall form a flowing liquid film. The untreated air (i.e. process air) shall be cooled and dehumidified when flowing through the liquid desiccant.

(d) The heat pump section shall transfer the heat of the liquid desiccant absorbed during collection operation to the regeneration operation.

(e) The liquid desiccant shall be heated in the regeneration section. The moisture previously collected shall be removed by the regeneration air stream following the same operation principles in collection section.

(f) The equipment shall be a single compact unit of weatherproof type.

6.2.3.22 DOMESTIC EXHAUST FAN

The exhaust fan shall be completed with a safety front grille at suction side and shall be suitable for installation on wall or window opening. Cord control is not acceptable.

Electrical operated shutter blades, covered by internal grilles, shall be overlapped and interlocked for maximum back-draught protection.

Each fan shall be fitted with quiet motor. The shutter mechanism shall be of quiet and vibration free operation.

6.2.3.23 HEAT PIPE

Heat pipe coils shall be provided for humidity control process of the AHU as specified and indicated in the drawings. The heat pipe coils shall be installed into the AHU and tested in the factory.

The heat pipe coil act as a humidity control coil forms a "wrap-around" configuration which wrap around the chilled water cooling coil inside the AHU, with one section of the heat pipe coil upstream and one section downstream. The heat pipe system is being driven entirely by the temperature difference between the two air steams. There are no moving parts and no external power required.

The heat pipe coils shall be at least 2 rows and are partially filled with a suitable working fluid such as R134a or R407C, and hermetically sealed.

6.2.3.24 HIGH PLUME CENTRIFUGAL JET FAN

(a) Fan shall be direct driven or belt driven of single inlet centrifugal type or mixed flow type. Fan impellers shall be backward blade, mixed flow blade or radial-tipped blade unless alternative requirement is specified in the particular specification or approved by the Supervising officer.

(b) Fan shall conform to air performance, induced flow and sound ratings in accordance with ANSI/AMCA Standards 210-07, 260-13 and 300-14 or BS ISO 5801:2017 and BS ISO13347-2-2004 or equivalent standards as approved by the Supervising Officer.

(c) Fan casing shall be constructed of polypropylene (PP) or Glass-Reinforced Fibreglass (FRP), of UV resistant or with UV stabilised gel coat of the outer fan casing, adequately stiffened and braced to provide vibration free operations. Fans with an inlet diameter exceeding 450mm shall have a chemical resistant access door/panel on the fan casing scroll for access and maintenance purposes. Drain outlet plug at the lowest point of the fan casing to facilitate the drain of condensation build-up or rainwater when installed at outdoor. Casing shall be constructed to ensure that there are no metallic parts in contact with the fume gases nor air along the airstream. Casing/shaft shall be correctly sealed to avoid air leakage.

(d) Impeller shall be made of polypropylene (PP) or Glass-Reinforced Fibreglass (FRP) and of radial tip bladed incorporating a steel reinforced hub, backward inclined or mixed flow to guarantee high reliability at high peripheral speeds. The impeller shall be constructed to ensure that there are no metallic parts in contact between the fume gases / air handled. The impeller hub should be well protected with chemical resistant cover and sealed.

(e) Nozzle shall be of polypropylene (PP) or Glass-Reinforced Fibreglass (FRP), of UV resistant or with UV stabilised gel coated, and designed to induce the ambient air by venturi effect and entrain air to ensure the minimum dilution ratio of 2:1 or not less than the ratio specified in the particular specification.

SUB-SECTION 6.2.4

AUTOMATIC CONTROL

6.2.4.1 AUTOMATIC CONTROL SYSTEM (ACS)

An Automatic Control System (ACS) can be a part of Central Control & Monitoring System (CCMS), or as simple as an electronic controller with built-in real time clock for scheduling controls. The requirements of essential content for the completion of an ACS including but not limited to sensors, dampers & actuators shall refer to relevant clauses in Sub-sections 6.1.4 and 6.1.5 as appropriate.

6.2.4.2 AIR COOLING CONTROL

Unless otherwise specified, the output of chilled water cooling capacity shall be controlled by modulating two or three-way valves having a valve authority as indicated in the Particular Specification or Drawings.

All valves shall be sized in accordance with the recommendations of the manufacturer to assure fully modulating operation.

Valves shall be sized on fully open pressure drop equal to the pressure drop of coil under 120% of design flow.

Valve opting pointer shall be provided at each valve actuator for direct indication of valve opening.

Valve actuators shall be mounted directly on the control valve without the need for separate linkage and the need for any adjustment of the actuator stroke. Actuators shall have a manual operation capability.

All valve actuators with valve size shall maintain its last position for or fail-safe operation.

6.2.4.3 AIR HEATING CONTROL

6.2.4.3.1 2 -Way or 3-Way Modulating Valves

(a) Unless otherwise specified, the output of hot water heating capacity shall be controlled by modulating valves having an authority as indicated in the Particular Specification or Drawings.

(b) All valves shall be sized in accordance with the recommendations of the manufacturer to assure fully modulating operation.

(c) Control valves smaller than 20mm diameter shall be normally closed, electrically operated, cage-guided, stainless steel trim, flanged cast-steel body.

(d) Valves shall be sized on fully open pressure drop equal to the pressure drop of coil under 120% of design flow.

(e) Valve opting pointer shall be provided at each valve actuator for direct indication of valve opening.

(f) A manual override device together with auto/manual switch and automatic change-over relay shall be provided as the manual setting facility for the control valve opening and back-up in case of local controller outage.

(g) Valve actuators shall be mounted directly on the control valve without the need for separate linkage and the need for any adjustment of the actuator stroke. Actuators shall have a manual operation capability.

(h) All valve actuators with valve size over 20 mm diameter shall maintain its last position.

6.2.4.3.2 Electric Ductwork Heaters

Specifications for the electric ductwork heaters shall be referred to Clause 6.2.3.2.14. They shall also comply with the requirements of the FSD.

6.2.4.3.3 Differential Pressure Switches

Differential pressure switches shall be able to de-energise the heaters when the air flow stops.

Differential pressure switches are for use only as operating controls. Necessary devices (safety, limit controls) or systems (alarm, supervisory systems) shall be added to protect against control failure.

The operating temperature range of the pressure switches shall be from 40°C to 75°C.

The diaphragm housing shall be made of cold rolled steel with zinc plating.

Sensors shall comply with relevant standards of UL or BS/EN/BSEN or other international standards.

6.2.4.4 ELECTRICAL/ELECTRONIC (LOCALISED) CONTROL SYSTEM

The systems shall be operated at single phase mains voltage or at extra low voltage such as 12 V or 24 V as indicated in the Particular Specification.

Where a particular manufacturer's system is offered and accepted, the Installations shall be installed to comply with that manufacturer's recommended technical details and methods of installation.

6.2.4.4.1 Standalone Direct Digital Controllers/Outstation (DDC/O)

Unless otherwise specified, the direct digital controllers shall have sufficient memory to support its own operating system and databases.

(a) Each controller shall have sufficient memory to support its own operating system and database including: -

- Control Processes;
- Energy Management Applications;
- Alarm Management;
- Historical / Trend Data for all points;
- Maintenance Support Applications;
- Operator I/O; and
- Manual Override Monitoring.

The memory board shall be expandable to a larger size as needs grow.

(b) Communication Ports

Each controller shall be equipped with at least two communication ports for simultaneous operation of multiple operator I/O devices such as modems, printers, personal computers, and portable operator's terminals.

The controller shall have provisions to allow temporary use of portable devices without interrupting the normal operation of the permanently connected modems, printers or network terminals.

(c) Network Communication

The automation network shall be based on PC industry standard of Ethernet TCP/IP. The network shall be capable of operating at a communication speed of 100 Mbps.

Switches shall be provided for manual override on digital and analogue outputs, to allow the user to manually control the position of the end device.

(d) Expandability

Each outstation shall be factory pre-wired comprising a factory fabricated metal enclosure, hinged door with master lock and name plate holder. The outstation shall be of modular type with standard function modules or similar to accept plug in printed circuit cards.

Each outstation shall contain interface hardware modules to accept a plug in portable operator terminal (POT) with visual display and analogue facility to enable commissioning and fault finding to be achieved.

(e) The direct digital controller shall provide local LED status indication for each digital input and output. Status indication shall be visible without opening the panel door.

(f) Real Time Clock (RTC)

The real time clock shall be able to display in the forms of year, month of the year, day of the month, hour of the day, and minutes.

(g) Automatic Start After Power Failure

The control station shall be provided with a power fail safe and restart feature.

An orderly restart controlled from the data processing controller shall occur on resumption after a power failure without manual intervention.

There shall be no loss of system memory on power failure.

(h) Battery Backup

Battery shall be able to support the real time clock, programme, and all volatile memory for a minimum of 72 hours.

When the battery replacement is necessary, the open processor shall illuminate a "battery low" status LED and shall send an alarm message to the selected printer or terminals.

(i) Time Scheduling

The following commands shall be able to be time scheduled for issue at a later day and time:-

- Start and stop a point;
- Change alarm limits, warning limits or set-point;
- Lock/unlock point reporting or point control;
- Demand limit target setting; and
- Alarm summary.

Separate schedules shall be stored for:-

- Regular weeks;
- Special weeks; and
- Holidays.

After recovery from a power failure, the system shall determine any time-scheduled commands which shall have been issued during the period that the power was off. These commands shall automatically be issued.

The system shall allow holidays to be scheduled with a minimum of one year in advance.

(j) Alarm Management

Each analogue point shall have the following defined:-

- High Alarm Limit;
- High Warning Limit;
- Low Warning Limit;
- Low Alarm Limit; and
- Differential.

When an analogue point goes outside the High Warning or Low Warning Limit for more than one minute, a user defined warning message shall be sent to the appropriate alarm printers.

When a binary point goes into alarm, a user defined alarm message shall be sent to the appropriate alarm printers.

When a point returns to normal, the event shall be recorded in the printer output.

When the point module is placed in override, an alarm shall be sent to the output of the printers.

6.2.4.4.2 ACMV Sub-System Controllers

Temperature/humidity/pressure controllers shall have separate zero and proportional band adjustments. Local display and keypad shall be provided for viewing and controlling each output. Analogue output of controllers shall be available with either 0 to 10V or 0/4 to 20 mA DC proportional output, two positions, or any combination. Controller shall have internal switches for each output to change the output signal to either direct or reverse. Controller shall be available with integral electronic circuit for absolute high or low limit control.

Air contamination controllers shall be available in one or two stages. Controller shall close its contacts to initiate ventilation system when the air contamination exceeds its set point.

Chilled water reset controller shall have integral reset action to eliminate sustained system offset and be capable of receiving signals from chilled water and outdoor air sensors to control chilled water supply temperature according to an adjustable reset schedule. The controller shall have an adjustable set point for absolute high limit. Controller shall have an indicating lamp that will vary in intensity with the controller output. Controller shall be available with either proportional or 3-point floating output.

Rate/reset controller shall be of the proportional type with adjustable integral and derivative actions. The controller shall be field adjustable for

either direct or reverse action and shall be supplied with a switch to eliminate the integral and derivative functions for calibration purposes. The output of the controller shall be 0-20V or 0/4 to 20 mA DC. An indicating lamp shall be provided which will vary in intensity as the output varies.

Constant temperature controller shall be of the proportional type with integral reset action to eliminate sustained system offset. The controller shall have capability to adjust the integral reset times.

6.2.4.4.3 Control Panel

The Control Panel shall be installed in the A/C Control Room of the building at location as shown in the Drawings with a sub-panel, if required, for monitoring and data logging in location as specified.

The panel shall be constructed with 1.5 mm thick hairline finished stainless steel sheets c/w all flush galvanised iron (G.I.) supports and accessories. All the lettering shall be in English and Chinese characters and to be engraved on the panel. All lettering and characters shall be approved by the Supervising Officer before fabrication. The front cover shall be of 2 mm thick hairline finished stainless steel with sectional recessed hinged cover for easy inspection and maintenance.

The panel shall include the following: -

(a) Indicating lights, ammeters, gauges, control switches, push buttons, control wiring and other necessary equipment to enable remote operation and monitoring of all A/C equipment;

(b) The running and alarm indicating lights for a particular equipment shall be fitted onto the panel as standard module blocks; and

(c) An alarm chime shall be provided to sound an alarm condition when any of the alarm indicating lights is energised. An alarm mute button shall also be provided to acknowledge the alarm by the operator. Alarm indicating lights shall remain on until the conditions causing the alarms are returned to normal state.

6.2.4.5 CHEMICAL DOSING CONTROL FOR WATER QUALITY IN COOLING TOWER

6.2.4.5.1 Controllers

The controller shall be suitable for operation of the respective sensors application. It shall be BACnet compatible with output high level signal in BACnet protocol directly.

6.2.4.5.2 Sensors

(a) Residual Chlorine Sensor

The sensor shall, without use of reagents, continuously and directly measure either free or total residual chlorine.

The sensor shall have the measuring range of 0-20mg/L with resolution 0.01 mg/L and the accuracy shall be within + 2% or better.

The sensor shall include flow cell or flow assembly which enable steady sample flow rate recommended by manufacturer to achieve accuracy. Accessories to adjust working condition (i.e. working pressure and flow rate) shall be included.

The sensor shall include electrodes in electrolyte fill solution to measure current to flow which is proportional to the concentration of free chlorine in the medium. The electrodes shall be of gold cathode and silver anode unless otherwise of approved material suitable for the liquid to be measured.

The sensor shall connected to the remote controller by means of suitable cables, and sensors shall not require compensation for cable length.

(b) Conductivity Sensor

The sensor shall have the measuring range of 0-3,000 μS/cm with resolution 0.1 μS/cm and the accuracy shall be within + 1% or better.

(c) pH Sensor

The sensor shall have the measuring range of 0-14 with resolution 0.01 pH and the accuracy shall be within + 2% or better.

(d) Oxidation Reduction Potential (ORP) Probe

The probe shall have the measuring range of -2000 to 2000 mV with sensitivity of 0.1 mV.

(e) Turbidity Sensor

The sensor shall be ranged from 0 -100 NTU. Measurement resolution shall be 0.01 NTU (for measurement at or below 10 NTU) and 0.1 NTU (for measurement above 10 NTU). Measurement accuracy shall be ± 5% of reading.

SUB-SECTION 6.2.5

CENTRAL CONTROL AND MONITORING SYSTEM (CCMS)

6.2.5.1 GENERAL

6.2.5.1.1 Manufacturing Standards

The system shall be built from standard packages. The estimated amount of customisations to suit the requirements of the Particular Specification shall be specified in the tender submission.

All materials and equipment used shall be standard manufacturer's products. All systems and components shall have been thoroughly tested and proven in actual field use for at least 6 months and with at least 3 relevant job references locally either private sector or with government. The manufacturer shall have a local agent to provide full technical support with adequate spare parts holding and technical expertise in testing, commissioning and trouble-shooting.

The CCMS shall be a fully integrated system of computer-based building automation. The system shall be modular, permitting expansion by adding hardware and software without changes in communication or processing equipment. The CCMS, while "on-line" shall be capable of adding, modifying, deleting points and inter-lock sequences without changes to "hardware" and field wiring or control devices. These changes shall be input through various input/output devices incorporated into the CCMS.

All CCMS server and associated devices shall be able to operate properly under environmental conditions as specified in this General Specification. The CCMS Server and peripheral devices shall not be installed until the operating area is air conditioned and reasonably free of dust and other contaminants which could impair their operation.

All controllers' cubicles shall be supplied factory pre-wired and terminated for connection to the field devices.

Controllers' electronics shall be solid state, utilising distributed processing techniques, and of the plug-in circuit board type. Separate fusing shall be provided for all control voltages.

Construction standards for panels, racks, cabinets and other equipment provided shall meet with the following minimum standards: -

(a) Racks and panels shall comply with ANSI/EIA-310-D:1992 or equivalent standard;

(b) Panels shall be made of steel, suitably reinforced and braced so as to provide flat-surfaced, rigid construction;

(c) Material surfaces shall be free of scale, welding slag and dirt;

(d) Panel surfaces shall be flat and free from waviness;

(e) Stiffness and bracing shall be provided as required;

(f) Handling during installation shall be such that the panels will not suffer distortion or buckling; and

(g) Cut outs shall be square with consoles to ensure that the controls shall be installed level and square. Finished cut outs and holes shall be free of burrs and sharp edges and fitted with rubber grommets to prevent cable insulation damage.

6.2.5.1.2 License and Ownership

Engineering software and licenses for equipment including but not limited to Central Control and Monitoring System (CCMS) servers, Operator Workstations, Network Controller Units (NCUs) and Direct Digital Controllers (DDCs), shall be provided. The ownership of the software and licenses shall be transferred to the HKSAR Government. Licensing restriction of such engineering tools for the equipment shall not be placed.

All licenses for equipment including software in the CCMS Installation shall be one-off life-time subscription.

6.2.5.1.3 Spare Parts

All spare parts supplied during the Maintenance Period, shall be genuine standard parts having equivalent or better specifications than those produced or recommended by the manufacturer of the equipment.

Written statements from the manufacturers committing the availability of spare parts in the local market for at least seven (7) years after completion of the Maintenance Period shall be submitted.

From time to time, software may need to be upgraded for reasons, such as those due to debugging of the software itself, and/or due to upgrades in the Operating System (OS). Written statement from manufacturers to ensure the necessary software tools and/or software patches for implementing such upgrades are freely available to the Employer for at least five (5) years after completion of the Maintenance Period shall be submitted.

The DDC database, programming, graphic software key and engineering tools are the property of the Employer perpetually. All licenses for equipment including software in the CCMS Installation shall be one-off life-time subscription.

6.2.5.1.4 Relevant Standards

Where applicable standards exist, the products provided shall comply with the standards of the relevant authorities as stated in Section A2 of this General Specification or equivalent standard, and the list below: -

(a) ASHRAE Standard 135-2016 - A Data Communication Protocol for Building Automation and Control Networks (BACnet);

(b) International Organization for Standardization ISO/IEC 9075-9:2016/COR 1:2019 - Information Technology - Database Languages SQL – Part 9 : Management of External Data (SQL/MED);

(c) TIA/EIA-232-F-1997 Interface Between Data Terminal Equipment and Data Circuit Terminating Equipment Employing Serial Binary Data Exchange;

(d) TIA/EIA-485-A-1998 - Electrical Characteristics of Generators and Receivers for use in Balanced Digital Multipoint Systems;

(e) ANSI/TIA-568.1-D-2015 - Commercial Building telecommunications Cabling Standard;

(f) Transmission Control Protocol/Internet Protocol of Defence Advanced Research Project Agency (TCP/IP);

(g) International Organization for Standardization ISO/IEC 1989:2014- Information Technology – Programming Languages - COBOL; and

(h) International Organization for Standardization ISO/IEC/IEEE 8802-3:2017/AMD 4:2017 – Standard for Ethernet.

6.2.5.2 DATA COMMUNICATION NETWORK

6.2.5.2.1 General

CCMS shall interface in form of BACnet or equivalent with digital relays and remote I/O devices for status monitoring installed in various engineering systems. The data communication network shall allow all signals to be relayed to, displayed and analysed by the CCMS. A comprehensive monitoring of the entire building engineering equipment infrastructure by combining the functions of digital network analysers and digital relays shall be performed by the CCMS.

System architectural shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices. The system shall maintain all settings and overrides through a system reboot.

The network shall maintain an operating speed of 100Mbps and serve all functions related to the building management monitoring and controls, data switches and data exchange among all CCMS equipment items. Each device on the transmission network shall have equal status and shall communicate with other devices in turn. Systems employing master/slave or ring topology is not acceptable. The communication protocol shall incorporate checks to detect transmission errors. Parity bit error checking is not acceptable.

The network architecture shall consist of two levels, an Ethernet based backbone network for all operator workstations, servers and supervisory controllers/high level DDC controllers, and the field level networks (FLN) of DDC controllers / input/output (I/O) modules, field devices, actuators and sensors.

Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the CCMS network shall be totally transparent to the users when accessing data or developing control programs.

The network shall reserve future connection and expansion among the new CCMS and the third party's BACnet software like integrated building management system at other building sites to allow the integrated building management system server to centrally control and monitor E&M plant equipment through BACnet/IP or other open protocols as approved by the Supervising Officer.

The interfacing units/gateway shall communicate with the CPUs using a dual differential parity line asynchronous communications standard.

Means for DDC panels coupled to the bus shall be provided to assure that any failure will not cause loss of communications with other bus connected devices. The data transmission system shall be of the continuously active type providing positive supervision of data transmission.

In the event of failure of communications between the DDC controllers and the operator terminal, alarms, reports and logs shall be stored at the DDC controller and transmitted to the terminal upon restoration of communications.

The communication network shall support true peer-to-peer protocol and allow inter-panal event programs, global application programs and bus-to-bus communications without the presence of a host computer. Each panel shall have equal rights for data transfer and shall report in its predetermined time slot. No single device shall be designated as the communication master but each device on the bus shall be capable of taking over the function of bus monitors to assure that loss of any single device will not cause bus failure.

All messages transmitted shall be positively acknowledged as received or negatively acknowledged as not received. Negative acknowledgements shall immediately force a re-transmission of the message automatically before failure conditions are reported to the operator. The minimum number of retries shall be 5.

Detection scheme shall be included to detect and annunciate analogue sensor errors. Receipt of erroneous data shall cause a display on the remote operator workstations and a print-out on the respective alarm printers.

Full communication shall be sustained as long as there are at least two (2) operational devices on any segment of the bus. Global data (all station messages) shall be available for use by any devices on the bus as inputs or outputs to its resident control programs.

On failure of the transmission system, an alarm signal characterised by highlight or any other visible means shall be indicated immediately by display and printout with the time and address of the area failing to respond at the respective system and printers.

(a) Panel-to-Panel and Panel-to-Terminal Communication

All supervisory controllers shall directly reside on the BACnet/IP Ethernet network such that communications may be executed directly between supervisory controllers/high level DDC controllers, and between server/operator's terminals and supervisory controllers/high level DDC controllers on a peer-to-peer basis.

Systems that operate via polled response or other types of protocols that rely on a central processor, file server, or similar device to manage panel-to-panel or device-to-device communications shall not be acceptable.

All operator interfaces shall have the ability to access all point status and application report data or execute control functions for any and all other devices. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.

BACnet/IP over Ethernet shall be used for the network. All devices shall be: -

- Auto-sense 10/100 Mbps networks.

- Receive an IP Address from a Dynamic Host Configuration Protocol (DHCP) Server or be configured with a Fixed IP Address.

- Resolve Name to IP Addresses for devices using a Domain Name Service (DNS) Server on the Ethernet network.

- Allow MMI access to an individual network controller using industry standard Telnet software to view and edit entire network.

The network shall meet the following performance requirements as minimum: -

- Provide high-speed data transfer rates for alarm reporting, report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any DDC controllers is displayed at any PC workstations, all DDC controllers, and other alarm printers within 15 seconds.

- Message and alarm buffering to prevent information from being lost.

- Error detection, correction, and re-transmission to guarantee data integrity.

- Synchronisation of real-time clocks between DDC controllers, including automatic daylight savings time corrections.

- The backbone network shall allow the DDC controllers to access any data from, or send control commands and alarm reports directly to, any other DDC controllers or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC controllers shall send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The network shall also allow any DDC controllers to access, edit, modify, add, delete, back up, restore all system point database and all programs.

- The network controllers shall back-up and restore their own current database including programs, and points without the requirement for connection to a mass storage device.

- The network controllers shall provide system-wide wild card point search, command, and access direct from any DDC controller on the network.

- The backbone network shall allow the controllers to access on-demand display and reports regarding system-

wide information including point names, point status, present value, command priority array, trend information, field panel configuration information.

- The backbone network shall allow the controllers to be configured system-wide by software-based tools, and by direct access from any DDC controllers on the network. Proprietary vendor specific software shall not be required for system configuration.

- The backbone network shall allow the controllers to assign password access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorised for. All other points shall not be displayed at the PC workstation or portable operator terminal. (e.g. all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

- Devices containing custom programming may reside on the backbone Network.

(b) Field Level Network (FLN) – Application Specific Controller Communication

The FLN shall be able to communicate with DDC controllers / I/O modules.

For further expansion, the FLN shall also be able to communicate with BACnet MS/TP protocol or other BACnet protocols.

This level communication shall support a family of application specific controllers for terminal equipment.

The supervisory controllers shall communicate bi-directionally with the backbone network through DDC controllers for transmission of global data.

A maximum of 96 terminal equipment controllers may be configured on individual FLN trunks to insure adequate global data and alarm response times.

(c) Communication with third party's BACnet Integrated Building Management System

All necessary networking equipment including cabling, IP routers, gateways, firewall, VPN servers, etc. to facilitate the connection

to the designation remote site for interface the required CCMS data and BACnet data from other sub systems e.g. Building Energy Management System (BEMS) through high level interfacing with BACnet Open Communication Protocol shall be designed, supplied, installed and configured under this Works.

Remote connection shall be completed by implementing Virtual Private Network (VPN) technology to establish a secure connection with the designation remote site. The VPN infrastructure and all necessary accessories shall be supplied and installed. The VPN tunnel shall provide a way to send encrypted CCMS data through the VPN service. The data encryption shall take place at the edge & end devices which shall not computationally burdened with the task of encrypting or decrypting traffic and are free to perform other BACnet functions.

All works carried out shall strictly follow the latest version of the IT Security Policy and IT Security Guidelines issued by the Office of the Government Chief Information Officer (OGCIO).

Provision of cable containment and cabinet for installation of modem and other equipment for the purpose of wiring and connection of broadband internet services shall be provided.

6.2.5.2.2 Wiring for Data Communication

System servers, central control workstation and supervisory controllers shall be attached to, as a minimum, a 100Mbps wired Local Area Network of CAT5e Ethernet cables or optical fibres, and the communication among these system components shall conform to the open protocol BACnet/IP. At field controller level, the supervisor controllers (if any) shall communicate with DDC controllers / I/O modules using BACnet MS/TP protocol. Inclusion of supervisor controllers is however, not mandatory.

Unless otherwise permitted by the Supervising Officer, all communication networks deployed for the system shall be wired, rather than wireless. Any faults of the supervisory controllers / DDC controllers / I/O modules shall not cause the failure of the entire system.

All data transmission between workstation/operator's terminal and the remote Supervisory controllers/gateways shall be transmitted in digital form, using at minimum CAT 5e Ethernet cable and be supervised so that any break in transmission shall be automatically identified and reported in an advisory message.

The UTP cabling shall be of category 6 UTP cable specification. 2 nos. of wall data outlets shall be available in each plant room in addition to the connection of CCMS equipment for future IoT expansion. All data outlets shall meet or exceed category 6 transmission requirements for connecting hardware and relevant standards. The outlets cabling shall terminate on

patch panels at their associated equipment rack to connect to the CCMS network.

Wirings among field equipment and I/O modules / DDC controllers / interfacing units shall be Class 2 twisted pairs with screening. These wires shall be at least 0.68mm diameter without taking the thickness of insulation into account. For any binary points such as on/off controllers, the wiring shall be via voltage free contacts installed at each controller. Any open or short circuits in wiring shall cause an alarm at CCMS workstation.

Wirings shall be installed in either GI conduits or metal trunking. All conduits and trunking shall have at least 55% spare space capacity for future wiring requirements. Necessary conduits or trunking from field point equipment to the outstation or interfacing units shall be included in the Contract.

Necessary provisions and measures to protect the equipment against interference caused by the operation of any other electrical and electro-mechanical equipment shall be provided. If such interference occurred and is found to be caused by poor materials, poor workmanship or faulty wiring, the equipment shall be re-wired /re-installed to the satisfaction of the Supervising Officer.

Wiring and cables between devices and/or equipment shall be free of joints. All signal transmission through the wires and cables shall be clear without any spurious information. Maximum transmission loss within cables shall be less than 6dB.

All insulated wire to be copper conductors, UL labeled for 90°C minimum service.

Wiring shall comply with minimum wire size and insulation based on services listed below:

Service	Minimum Gage/Type	Insulation Class
AC 24V Power	12 Ga Solid	600 Volt
DC 24V Power	10 Ga Solid	600 Volt
Class 1	14 Ga Stranded	600 Volt
Class 2	18 Ga Stranded	300 Volt
Class 3	18 Ga Stranded	300 Volt

Class 2 twisted pair insulated cables shall be used for digital input/output wiring.

Class 2 twisted shielded pair, insulated and jacketed with grounded shield cables shall be used for analogue input wiring.

CAT 5e ethernet cable or above shall be used for backbone network.

RS-485/24 gage, TSP, low capacitance cable shall be used for FLN.

6.2.5.2.3 Server Configuration

System servers shall be arranged in duty-hot-standby dual redundant configuration, and with associated peripherals, to provide high-availability architecture. In addition, hot-redundant software shall be provided.

The duty server and standby server shall have the same configuration in terms of function and performance. Each server shall have its own set of mass storage devices. The system shall maintain consistent and matched sets of updated databases and operating parameters at all times.

During normal operation, all changes to the primary server's database shall be automatically transferred to the standby server's database, ensuring that the databases mirror each other at all times. Both servers shall be synchronised to a common reference time for the correct interpretation of time-based data (e.g. history, events, etc.)

Alarm on redundancy problem shall be generated when synchronisation is lost.

In case of malfunction of the duty server, an automatic changeover to the standby server shall be initiated, and the fully functioning standby server shall assume the duty server's role within 30 seconds.

The failed server shall be able to re-boot automatically after non-fatal errors and shall resume acting as the standby server automatically.

The system shall include a firewall (software implemented) for connection to the internet. The firewall shall act to filter malicious messages from the internet according to pre-defined configuration of the firewall.

It shall be possible for the operator to access the system servers for the followings: -

- monitoring the status of the servers;
- configuring parameters of the servers; and
- manually changeover to standby server.

6.2.5.2.4 Network Security

Adequate measures shall be incorporated in the software system to combat the threat of software sabotage. The software is required to be protected against unauthorised access at all time. The risk of software system breakdown shall be addressed and protection facilities are to be incorporated in the design of the system.

All works carried out shall strictly follow the latest version of the IT Security Policy and IT Security Guidelines issued by the Office of the Government Chief Information Officer (OGCIO).

Anti-virus software with a 3-year license shall be installed to the servers.

6.2.5.3 UNINTERRUPTED POWER SUPPLY

The Uninterrupted Power Supply Unit (UPS) shall consist of a battery power source, charger, AC output inverter system, and automatic load transfer circuits for fully automatic operation. It shall protect the CCMS from voltage surge and spike.

The UPS shall be an on-line type UPS. When normal AC power returns, the UPS shall transfer the load to the rectifier output. At this time the charger shall turn on to its "high" charge position until the batteries are recharged to 80% of their rated capacity, then automatically switches to its maintenance "sensing" position to keep the batteries in their best full-charge condition. The total recharge time shall be less than 24 hours for a fully discharged battery set.

Two pilot lights shall be located in the front operating panel. One pilot light indicates that incoming AC power is available, the other pilot light indicates that the UPS is in the ready or standby mode.

The battery system shall be of totally enclosed type, separate from and independent of other battery systems, capable of operating the entire Central Control and Monitoring System under 100% full load condition for a period of 0.5 hours. The CCMS shall back up the workstation memories, alarms, instructions and operation requirements in the event of mains or standby generator supply failure. Any battery with gas leakage shall not be accepted.

Should the emergency outage of line power exceed the maximum operation time of the UPS, there shall be no resultant damage. When the UPS's maximum duty cycle is exceeded, automatic shutdown shall occur.

6.2.5.4 CENTRAL WORKSTATION

The communication protocol of CCMS Server and Workstations shall comply with BACnet Standard. The CCMS Server and Workstation shall conform to BACnet Operator Workstation (B-OWS) or Advanced Operator Workstation (B-AOWS), or other BACnet device profiles where appropriate.

The operator workstation shall be an operator's terminal and comprise the followings: -

(a) Computer capable to meet the requirements of the CCMS software and expandability;

(b) Mouse and keyboard;

(c) Minimum 21" monitor;

(d) Alarm printer capable of handling papers;

(e) A3 laser printer;

(f) UPS capable of backup for more than 1 hour of operation for the PC, monitor, printer as well as other UPS connected equipment; and

(g) A 16-bit/full duplex audio system c/w speakers.

All equipment, where applicable, shall have obtained a Recognition Type Energy Label under the Energy Efficiency Labelling Scheme of EMSD.

6.2.5.5 BUILDING CONTROLLER

The communication protocol of Building Controllers shall comply with BACnet Standard. The Building Controllers shall conform to BACnet Building Controller (B-BC) or BACnet Router (B-RTR), or other BACnet device profiles where appropriate.

The building controller shall be a fully user-programmable, digital controller that communicates via BACnet IP protocol for high-level communication and/or BACnet MS/TP protocol for field device communication. It shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controller that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.

The building controller shall comply with the requirements as stated in this specification and fulfil the requirements for BACnet devices in Section L.4 “Controller Profiles” of ASHRAE 135-2016 and the relevant sections within the standard. The building controllers shall also be BACnet Testing Laboratories (BTL) certified.

Building controllers shall include supervisory controllers, DDC controllers and routers, etc.

The building controller shall have a standalone capability such that a failure of the communication network shall still permit the plant and controls associated with the controllers, to continue to operate normally continuing to communicate with one another.

In the event of transmission failure in the controller network, the controllers shall continue to operate with all sequence interlocks and control strategies operating normally except those which require global information. Either operator adjustable values or the last sensed value (operator selectable) shall then be assumed for these global parameters.

The BACKnet Router shall support direct ethernet or a communication card, and perform BACnet Broadcast Management Device (BBMD) function and BACnet routing with Network Address Translation (NAT) function to across multiple IP subnets with dynamic device binding without human configuration.

Source codes of the whole system shall be provided which is communication-ready and adaptable to communicate different third-party systems with BACnet protocol without further decoding. All related compilation tools, software tools (word processing, spreadsheet and presentation) operating systems and anti-virus software shall also be provided.

Selection of data to be recorded and transmitted for communication shall be carried out easily at the CCMS without the need for any kind of programming or assistance from the original manufacturer.

The building controller hardware shall be manufactured to withstand the operating conditions at 55°C and 95% R.H. without condensation.

The building controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients.

6.2.5.5.1 Supervisory Controllers / Network Control Unit

It is possible that in some CCMS architecture, supervisory controllers are not required. Hence, the provision of supervisory controllers is only required where its deployment is critical to the functionality stipulated in this specification.

Where it is deployed, it shall be able to monitor all connected DDC controllers / I/O modules; and facilitate the system navigation, configuration, and operation by performing communication between system servers / operator's terminals and attached DDC controllers / I/O modules.

The actual numbers of supervisory controllers shall be determined base on verified point schedule.

The RAM and the real time clock shall be provided with battery-backup. The real time clock shall be automatically synchronised upon system recovery.

The supervisory controller shall be automatically reinitialised upon restart or power restoration.

The supervisory controller shall communicate with system servers / operator's terminals, and other peer supervisory controllers using BACnet/IP protocol, and communicate with the attached DDC controllers / I/O modules using BACnet MS/TP protocol or other BACnet protocols.

6.2.5.5.2 DDC Controllers / Routers

(a) General

Failure of any DDC controllers / routers shall not render the CCMS inoperable, but shall only result in loss or degraded performance of that panel.

The DDC controller / router shall have LED indicator lights for identification of malfunction for speedy replacement without changing or undoing wiring.

The DDC controller /router shall be capable of complete stand-alone operation.

The firmware of the DDC controller /router shall be upgradable through uploading of software.

The RAM and the real time clock of the DDC controller / router shall be provided with battery-backup. The real time clock shall be automatically synchronised upon system recovery. The DDC controller /router shall be automatically reinitialised upon restart or power restoration.

The DDC controller / router shall provide standard inputs such as 0-10 V DC, 4-20 mA, resistance-type, dry contact closure, pulse accumulator inputs, as necessary so as to comply with the functional requirement of the Specification for the system. The analogue to digital conversion shall have a minimum resolution of 12 bits. The pulse accumulator input shall accept pulses up to 15 Hz. The DDC controller / router shall provide standard analogue outputs (0-10V DC or 4-20 mA), standard 24 VAC digital outputs as necessary so as to comply with the functional requirement of the Specification for the system.

(b) Accommodation

The DDC controllers / routers shall be housed in DDC panels. The construction of the DDC panels shall have a corrosion-resistant metal enclosure with hinged door, key lock and name plate holder. All inputs and outputs shall be connected to separately numbered terminals, located in the DDC controllers / routers.

(c) System Requirements

(i) 32-bit microprocessor.

(ii) Minimum 1GB of RAM with the application programme stored in flash EPROM.

(iii) Circuit boards shall be socketed into terminals of the panel. Microprocessor and memory chips shall also be of socketed type for easy replacement.

(iv) A real time clock to provide time, day, month and year. A minimum of fifth year calendar with public holidays of Hong Kong shall be integrated in the memory of the clock.

(v) Each DDC controller /router shall have memory capacity allocated for alarm report and event logging storage.

(vi) Power supply shall be provided as follows:

- 72-hour battery complete with battery charges, battery low voltage and failure alarm back up for the RAM.

- Power supply shall be provided from the DDC for the A/D and D/A converters, memory and motherboard.

- Automatic re-initialisation upon full system recovery after power restoration from an outage shall be provided.

(d) Input and Output Capacity shall be as follows:

- The I/O modules shall be capable of handling the required design input/output points as per the point schedule with at least 25 % spare capacity.

- The DDC inputs and outputs including transmission trunk shall be isolated via optical couplers or other approved means to provide protection against voltage surges, incorrect voltages and other such disturbances.

(e) Input characteristics shall be as follows:

- DDC inputs shall be provided to handle the design current, voltage, resistance or opened and closed contacts in any mix as required. The DDC unit shall be facilitated to be programmed of the characteristic curves of the sensors. Individual calibrations of each input point via calibration instrument shall be provided.

- Programmable intermediate ranges and linearisation shall be provided for sensors.

- For all RTD type sensors of 1000 ohms or less, each input point shall be calibrated via precision decade boxes to compensate for lead length errors.

- Adjustable pulse inputs shall have minimum 10 pulses per second.

- Digital input types to be supported shall include volt-free normally open/close contacts.

- Each analogue input shall be calibrated to compensate for non-linear characteristics of input devices, line resistance and similar items. Calibration data shall be retained in the DDC controller memory and shall not require adjustment once programmed. It shall be possible to assign high and low alarms to each analogue input.

Alarms shall be locked out when the associated equipment is not operating.

(f) Output characteristics shall be as follows:

(i) The DDC controller / router shall accommodate both digital and true analogue outputs of voltage (0-12V) and current (4-20mA). All analogue outputs shall have a minimum incremental resolution of 0.5% of the full operating range of the device to be controlled. Zero and maximum voltage or current values shall be provided for shut-down or close off of control devices. Values of all analogue/digital outputs shall be available in the database for troubleshooting, calibration and analysis through the Portable Operating Terminal.

(ii) Digital outputs shall be of momentary & latched type and in the form of voltage free contacts. The relay shall stay in the last position commanded.

(iii) Each digital output shall be complete with switch or equivalent devices as approved by the Supervising Officer to disable or enable the controller output selectively. On/Off/Auto override switches shall be integrated and provided for each output.

(g) Each DDC controller / router shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, and dial-up communications.

(h) Each DDC controller / router shall continuously perform self diagnostics, communication diagnosis, and diagnosis of all panel components. The controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.

(i) In the event of the loss of power, there shall be an orderly shutdown of all DDC units to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 100 hours.

6.2.5.6 GATEWAY/INTERFACING HARDWARE

The communication protocol of Building Controllers shall comply with BACnet Standard. The Gateway/Interfacing Hardware shall conform to BACnet Gateway (B-GW) or other BACnet device profiles where appropriate.

The Gateway/Interfacing unit shall basically resemble the hardware of the DDC controller without the necessary controller's functional components. The processor speed shall be at least 16.7 MHz with a minimum of 20 MBytes RAM. The gateway, which also acts as a controller, shall have the same analogue/digital input and output points.

The exact number of the unit shall be determined in accordance with the capacity / capability of equipment offered and the number of DDC controllers to be linked, together with minimum of 25% spare capacity for future expansion.

The unit shall be factory available product. No custom-made software or programming shall be required for connecting DDC controllers to communication network. Once configured, there shall be no need to modify / reconfigure the unit when additional DDC controllers and/or control and monitoring points are required.

6.2.5.7 UNITARY CONTROLLERS

The communication protocol of Building Controllers shall comply with BACnet Standard. The unitary controllers shall conform to BACnet Advanced Application Controller (B-AAC) or Application Specific Controller (B-ASC) or other BACnet device profiles where appropriate.

The processor speed of unitary controllers shall be at least 10 MHz with a minimum of 512 Kbytes RAM.

Temperature/humidity/pressure controllers shall be of the plug-in proportional type with integrated circuits. The controller shall be capable of having up to 3 separate outputs. Each shall have separate zero and proportional band adjustments. Indicating lamps shall be provided for each output which will vary in intensity to indicate the amount of output. The controller shall be available with either 0 to 20V DC proportional output, two-position output, or any combination. The controller shall have internal switches for each output to change the output signal to either direct or reverse. The controller shall be available with integral electronic circuit for absolute high or low limit control.

Air contamination controllers shall be available in one or two stages. The controller shall close its contacts to initiate ventilation system when the air contamination exceeds its set point.

Chilled water reset controllers shall have integral reset action to eliminate sustained system offset and be capable of receiving signals from chilled water and outdoor air sensors to control chilled water supply temperature according to an adjustable reset schedule. The controller shall have an adjustable set point for absolute high limit. The controller shall have an indicating lamp that will vary in intensity with the controller output. The controller shall be available with either proportional or 3-point floating output.

Rate/reset controllers shall be of the proportional type with adjustable integral and derivative actions. The controller shall be field-adjustable for either direct or reverse action and shall be supplied with a switch to eliminate the integral and derivative functions for calibration purposes. The output of the controller shall be 0-10V DC. An indicating lamp shall be provided which will vary in intensity as the output varies.

Constant temperature controllers shall be of the proportional type with integral reset action to eliminate sustained system offset. The controller shall have a switch for selecting long or short integral reset times. The controller shall have an indicating lamp that will vary in intensity with controller output.

6.2.5.8 FIELD DEVICES

6.2.5.8.1 Sensors

All sensors specified in this Clause shall meet with the requirements in the Guidance Notes for Management of IAQ in Offices and Public Places and the Guide for Participation in the IAQ Certification Scheme published by HKSAR Government.

(a) Temperature Sensors

Temperature sensors shall be either of the thermister (NTC) type with a high linear resistance change versus temperature change or Platinum (PT100 or PT1000) to ensure good resolution and accuracy.

Sensors shall be factory calibrated and shall be connected to remote controller by means of suitable cables.

Sensors shall not require compensation for cable length etc.

For immersion temperature sensors, sensors shall be mounted complete with stainless steel immersion pocket. The sensing range shall be selected according to its application. The accuracy at calibration point shall be within ±0.3°C. For all temperature sensors served for cooling / heating energy measurement purpose, the accuracy at calibration point shall be within ±0.05°C.

For room / wall mounted temperature sensors, sensors shall have a connection plate to permit easy removal of the sensor during decorations etc. The sensing range shall be of 0°C to 40°C. The accuracy at calibration point shall be within ±0.5°C. There shall be option for temperature display at 0.5K interval in the sensors.

For ductwork type temperature sensors, sensors shall have a separate mounting flange with snap-on connection to permit sensor adjustment.

For outdoor temperature sensors, the sensing range shall be of -40°C to 40°C. The accuracy shall be within ±0.5%.

All sensors shall comply with relevant standards of UL or BS/EN/BSEN or other international standards.

(b) Humidity Sensors

Humidity sensors shall be of the capacitance type with operating range of 5% to 95% and the accuracy shall be within ±3% R.H. between 23°C and 25°C. Sensors shall be suitable for use on the duty expected.

The sensors shall vary the output voltage with a change in relative humidity.

Humidity sensors shall be available for room or ductwork mounting.

Sensors shall be connected to remote controller by means of suitable cables. Sensors shall not require compensation for cable length etc.

All sensors shall comply with relevant standards of UL or BS/EN/BSEN or other international standards.

(c) Absolute Humidity (Dew Point) Sensors

Absolute humidity (dew point) sensors shall utilise an active element to sense the actual quantity of water vapour per volume of dry air when the relative humidity is from 12% to 100%.

Sensors shall be highly repeatable and change resistance with a change of moisture content in the air.

Sensors shall be connected to remote controller by means of suitable cables. Sensors shall not require compensation for cable length etc.

Accuracy of the sensors shall be within ±3% relative humidity between 23°C and 25°C.

All sensors shall comply with relevant standards of UL or BS/EN/BSEN or other international standards.

(d) Combined Type Humidity and Temperature Sensors

Sensors shall have elements mounted in a common enclosure and be able to be connected to remote controller by means of suitable cables.

Sensors shall not require compensation for cable length etc.

Accuracy of the sensors shall be within ±0.5°C and ±3% relative humidity between 23°C and 25°C for temperature and humidity control respectively.

All sensors shall comply with relevant standards of UL or BS/EN/BSEN or other international standards.

(e) Differential Pressure Sensors

Differential pressure sensors shall vary the output voltage with a change in differential pressure.

Sensors shall be connected to the remote controller by means of suitable cables, and sensors shall not require compensation for cable length etc.

Accuracy of the sensors shall be within ±1.0% for full scale measurement.

All sensors shall comply with relevant standards of UL or BS/EN/BSEN or other international standards.

(f) Carbon Dioxide Sensors

Non-dispersive Infrared (NDIR) technology with sensing range of 0 to 2000 ppm shall be used for carbon dioxide sensors.

The accuracy shall be within 5% of reading or ±50 ppm maximum over operating range between 0°C and 45°C air temperature and up to 100% relative humidity.

Carbon dioxide sensors shall be available for room or ductwork mounting.

All sensors shall comply with relevant standards of UL or BS/EN/BSEN or other international standards.

(g) Carbon Monoxide Sensors

Carbon monoxide sensors shall be factory assembled units to continuously monitor and indicate the level of carbon monoxide in parts per million on its meter with 4 mA to 20 mA or 0V to 10V DC output and to activate the alarm circuit, alarm horn and warning light when the carbon monoxide concentration reaches the alarm point and deactivate the alarms when the carbon monoxide concentration drops below the alarm point.

The alarm point shall be factory set at 200 ppm and shall be internally or through CCMS adjustable from 10 to 300 ppm. Sensor response shall be 90% of maximum reading within 20 seconds with 200 ppm carbon monoxide concentration.

The sensor coverage shall be based on the requirements of the appropriate regulations but not be less than 500 m^2 per one sensor.

Unit shall be manufactured for operation with either 24 V DC, or 220 V AC, single phase supply and shall have solid-state circuitry, terminal strip with contacts for recorder, alarm and fault outputs, replaceable factory-matched pair of catalytic, semi-conductor sensors, meter calibrated 0 to 300 ppm, illuminated ON, PURGE, ALARM ON, FAULT/TEST switches, momentary ALARM RESET switch and an alarm horn, all mounted on the unit's cover or through CCMS to display.

Unit shall have environment-proof, fibreglass polyester case with hinged, latched and lockable cover. Alarm light shall be mounted on the top of the case and conduit connector or opening and a test gas connector at the bottom of the case.

Sensors shall have at least a life time of three years. Replacement shall consist of replacing the detector head and filter.

Sensors shall comply with relevant standards of UL or BS/EN/BSEN or other international regulations / standards for gas monitoring.

(h) Nitrogen Dioxide Sensors

Nitrogen dioxide sensors shall be factory assembled units to continuously monitor and indicate the level of nitrogen dioxide in parts per million on its meter with 4 mA to 20 mA or 0V to 10V DC output.

Electrochemical type sensor with resolution of 0.1 ppm shall be used for the nitrogen dioxide sensors. The sensing range of 0 to 10 ppm shall be used.

Unit shall have environment-proof, fibreglass polyester case with hinged, latched and lockable cover. Alarm light shall be mounted on the top of the case or display through CCMS and conduit connector or opening and a test gas connector at the bottom of the case.

Sensors shall have at least a life time of three years. Replacement shall consist of replacing the detector head and filter.

Sensors shall comply with relevant standards of UL or BS/EN/BSEN or other international regulations / standards for gas monitoring.

(i) Air Velocity Sensors

Air velocity sensors shall be capable of linear indication of the velocity of air in a ductwork from 0 to 15 m/s, and shall vary its output voltage with a change in air velocity.

Sensors shall have range selection for low velocities.

Accuracy of the air velocity sensors shall be within ±1% of the range.

Sensors shall be connected to the remote controller by means of suitable cables, and sensors shall not require compensation for cable length etc.

All sensors shall comply with relevant standards of UL or BS/EN/BSEN or other international standards.

(j) Contamination Sensors

Contamination sensors shall vary the conductivity as the degree of gas or smoke concentration changes.

The sensor shall be connected to the remote controller by means of suitable cables, and sensors shall not require compensation for cable length etc.

(k) Flow Meters

Flow meters shall be of the electromagnetic in line type. Insertion type or ultrasonic flow meters may be accepted subject to the approval of the Supervising Officer.

Sensors shall be capable of measuring range suitable for the application.

Electrodes shall be of stainless steel or other approved material suitable for the liquid to be measured.

Energy saving function for external battery power supply shall be provided as required.

Complete self diagnostic function of the measurement system (sensor and converter) shall be provided.

Accuracy of the flow sensors shall be within ±0.5% of the range.

All sensors shall comply with BS EN 1434, BS EN 61000 or other international standards.

(l) Flow Switches

Flow switches shall be electric and two-position with snap action.

Operating pressure of the switches shall conform to the requirement of the Installations and shall not be less than 1000 kPa.

Switches shall be adjustable for sensitivity to flow and the adjustment range shall include flow valves applicable to the equipment protected by the flow switches.

6.2.5.8.2 Dampers

Automatic operated dampers for application in conjunction with a CCMS shall have frames of a minimum of 3.5 mm galvanised steel not less than 50 mm in width and aerodynamically formed blades of not less than 1.5 mm galvanised steel sheet. Dampers shall be adequately braced to form a rigid assembly. No damper shall have blades more than 200 mm wide. Length of blades shall be not more than 1220 mm.

Blades shall be secured to 13 mm diameter zinc plated axles by zinc plated bolts and nuts. All blade bearings shall be nylon or bronze. Teflon coated thrust bearings shall be provided at each end of every blade to minimise torque requirements and insure smooth operation. All blade linkage hardware shall be constructed of corrosion resistant, zinc plated steel and brass.

For all dampers incorporated as part of a CCMS controlled systems, the control damper manufacturer shall submit leakage and flow characteristics plus a size schedule for all controlled dampers.

Supply and exhaust dampers for building systems incorporating a CCMS shall be of the low leakage types and shall be generally as described below.

(a) Standard Applications

Dampers shall be of the parallel or opposed blade (as selected by the manufacturer's application techniques) with replaceable butyl, spring stainless steel or closed cell neoprene edging.

(b) Low Leakage Applications (Intake, Exhaust & Recirculation Dampers)

Dampers shall be of the parallel or opposed blade type. Frames and blades shall be of 3 mm extruded aluminium. Blades shall be of the single unit "Pin- Lock", 150 mm wide, with the "Pin-Lock" an integral section within the blade centre axis. Frames shall be of 100 mm extruded aluminium channel and angle, with reinforcing bosses and groove inserts for vinyl seals. Minimum size dampers shall have 50 mm by 15 mm aluminium frames. Pivot rods shall be of 13 mm diameter extruded aluminium, "Pin-Lock" interlocking into blade section. Bearings shall be of the "Double-Sealed" type with Colcon inner bearing on rod riding in Marlon Polycarbonate outer bearing inserted in frame so that outer bearing cannot rotate (no metal-to-metal or metal-to-bearing riding surfaces). Blade linkage hardware shall be installed out of air stream. All hardware shall be of non-corrosive reinforced material or cadmium plated. Interconnecting linkage shall have

separate Colcon bearing to eliminate friction in linkage. Dampers shall be of the overlap type with extruded vinyl seals in both frames and blades for minimum air leakage. All dampers in excess of 1 m² free area shall have reinforced corners. Curves shall be based on a velocity of 10 m/s. Opposed blade dampers shall have less than 1/2 of 1% leakage at 0.5 kPa static pressure. Parallel blade dampers shall have less than 1% leakage at 0.5 kPa static pressure. Parallel blade dampers shall have less than 1% leakage at 0.5 kPa static pressure.

(c) Two-Position Control Dampers

Dampers shall be sized for minimum pressure drop at the indicated ductwork size.

(d) Modulating and Proportioning Dampers

Dampers shall be sized for an effective linear air flow control characteristic within the angle of rotation and maximum pressure drops specified.

(e) Dampers at Louvres

Dampers located immediately adjacent to intake and exhaust louvres shall be furnished in sizes as indicated because of reduced free area at louvres.

(f) Isolation Dampers

Dampers shall provide tight shut-off with negligible leakage, and shall withstand the applied pressure, velocities and turbulence in the open position.

(g) Fire and Smoke Dampers

Dampers shall be of all metal, low leakage construction, with metal-to-metal seals at blades and frame, and capable to operate automatically as specified in Sub-section 6.2.2.

6.2.5.8.3 Actuators

(a) Valve Actuator

Valves used in conjunction with a CCMS for control of chilled water shall be of the modulating type with a turn down ratio of at least 50 to 1. Valve bodies shall be cast gunmetal, brass cast iron or as otherwise indicated. Seat and inner valve material shall be brass, stainless steel or as otherwise indicated. Valve sizes 50 mm and smaller shall be screwed and supplied with union fittings. Valve sizes 65 mm and larger shall be flanged. Valves shall be of the straight-through type as required by the sequence or shown on the drawings. Valves actuator shall be equipped with manual opener to allow manual positioning of valve in the absence of control power. Valves shall have authority of at least 0.5 (50%) and

shall have suitable actuator to close against full pump head. Valve body shall be rated for differential pressure stroke < 20 mm.

For valves used for fan coil unit, valve body and seat body shall be bronze. The inner valve and stem material shall be stainless steel. The valve shall be of the 2-way type have authority of 0.5 (50%), with body rated for differential pressure, actuator closed against full pump head, and stroke < 5 mm.

Valves schedules for all valves modulations/on-off shall be submitted detailing the maximum allowed and actual pressure drops, authority, turndown ratio, max. pressure the actuator will close against and other valve data.

Actuators for modulating valves shall be opened or closed by motorised mechanism. The valves shall be synchronous motor driven spring return operation type. The valve actuator shall be mounted directly on the control valve. Subject to fail-safe operation, each of the valves hall be in "Open" position normally, and closed in case of failure of motorised control. The motorised mechanism shall be actuated by associated control.

Actuators for butterfly valves shall have resilient seats which are (in-the-field) replaceable with moulded-in O-rings to serve as a flange gasket. For sizes of 50 mm dia. to 150 mm dia. inclusive, a notched plate handle shall be provided for the control of the valve and indication of disk position. For sizes of 200 mm dia. and above, gear actuator shall be used. All butterfly valves shall be capable of bubble tight shut off.

(b) Damper Actuator

Actuators shall be of the linear or rotary type for either modulating or two-positioning control. Actuators shall have a manual opener for power failure. Control voltage shall be either 24 V DC or 220 V AC as required by the application, product of clutch, micro-switch shall not be accepted.

6.2.5.9 OTHER CCMS SUB-SYSTEM

Where specified in the Particular Specification, the CCMS shall also be designed to include the control and monitoring of the systems of the following system and equipment:-

(a) Electrical: LV Switchboards, power analysers, emergency generators, UPS etc.

(b) Fire Service: Fire alarm system, pumps, sprinker valves, etc.

(c) Plumbing and Drainage: Fresh and Flush water pumps, etc.

(d) Lift and Escalator and Others

6.2.5.10 SCHEDULE OF FUNCTION FOR ACMV SYSTEM

Schedule of Functions monitored and / or controlled by CCMS shall be in accordance with Code of Practice for Energy Efficiency of Building Services Installation and as follows: -

6.2.5.10.1 Chiller/Heating Water Circuit

(a) Chilled/Heating water supply temperature;
(b) Chilled/Heating water return temperature;
(c) Chilled/Heating water flow rate in each main circuit (normal hour, 24 hrs,);
(d) Chiller/Heating water circuit supply/return pressure;
(e) Building cooling demand (chilled water flow rate, supply temperature, return temperature);
(f) Energy demand of each floor (chilled water flow rate, supply temperature, return temperature);
(g) On/off control/status of all motorised on/off valves;
(h) Valve opening control/status of modulating valves;
(i) External enthalpy/dry bulb/RH; and
(j) Plant efficiency (total electrical power/total cooling load)

6.2.5.10.2 Chiller

(a) On/off status;
(b) On/off control;
(c) Trip/fault status;
(d) Open/close status of on/off control valve;
(e) Operating current
(f) Compressor frequency;
(g) Power input;
(h) Water failure alarm;
(i) Evaporator refrigerant pressure/temperature;
(j) Condenser refrigerant pressure/temperature;
(k) Chilled water inlet/outlet temperature;
(l) Heating water inlet/outlet temperature;
(m) Condenser water flow rate;
(n) Chiller water flow rate;
(o) Chilled water set point;
(p) On/off status of each condenser fan;
(q) Trip/fault alarm of each condenser fan;
(r) Local/CCMS selector status;
(s) Cooling capacity (chilled water flow rate, supply temperature, return temperature);
(t) Heating capacity for heat recovery chillers (heating water flow rate, supply temperature, return temperature);
(u) Chiller efficiency (cooling capacity/power input);
(v) Refrigeration leakage alarms (2 stage); and
(w) All safety alarms.

6.2.5.10.3 Cooling Tower

(a) On/off status;
(b) On/off control;
(c) Trip/fault status;
(d) Open/close status of on/off control valve;
(e) Open/close control of on/off control valve;
(f) Condensing water inlet/outlet temperature;
(g) For fan with frequency inverter:
- Running status;
- Trip/fault status;

6.2.5.10.4 Primary/Secondary Chilled Water Pump, Sea Water Pump, Heating Water Pump

(a) On/off status;
(b) On/off control;
(c) Trip/fault status;
(d) Supply/return pressure;
(e) flow rate;
(f) Supply/return temperature;
(g) 3-phase operating currents;
(h) Power input (kWh);
(i) Water failure alarm;
(j) Local/CCMS selector status; and
(k) For pump with frequency inverter: -
- Running status;
- Trip/fault status;
- Inverter speed control/status; and
- Local/CCMS status.

6.2.5.10.5 Motor Control Centre (MCC)

(a) 3-phase voltage, 3-phase + N current, p.f., THD and kWh of each incoming cable;
(b) 3-phase voltage, 3-phase + N current and kWh of each outgoing cable to each chiller, chilled water pumps, heating water pumps, control circuit;
(c) ON/OFF and trip status of each incoming or outgoing or interlocking ACB; and
(d) Battery charger failure alarm.

6.2.5.10.6 AHU, PAU

(a) Supply/return air fan on/off status;
(b) Supply/return air fan on/off control;
(c) Trip/fault status;
(d) Local/CCMS status;
(e) Filter clog alarm;
(f) Supply air temperature;
(g) Return air temperature;

(h) Ductwork static pressure for control of fan speed;
(i) Fresh air flow rate;
(j) Outdoor temperature/Enthalpy;
(k) Chilled water valve control;
(l) Chilled water valve position;
(m) Heating water valve control;
(n) Heating water valve position;
(o) Return air damper control;
(p) Return air damper position;
(q) Fresh air damper control;
(r) Fresh air damper position;
(s) Loss of air flow alarm;
(t) Fire trip alarm;
(u) Power input;
(v) CO2 concentration for demand control; and
(w) For AHU/PAU with frequency inverter: -
- Running status;
- Trip/fault status;
- Inverter speed control/status; and
- Local/CCMS status.

6.2.5.10.7 Ventilation fan

(a) Fan On/off status;
(b) Fan Trip/fault status;
(c) Local/CCMS status;
(d) Damper control;
(e) Damper position;
(f) Filter clog (if any);
(g) CO level (for carpark exhaust);
(h) Loss of air flow alarm;
(i) Fire trip alarm;
(j) Power input; and
(k) For fan with frequency inverter: -
- Running status;
- Trip/fault status;
- Inverter speed control/status; and
- Local/CCMS status.

6.2.5.10.8 VAV/CAV boxes

(a) Room temperature;
(b) Room temperature set point;
(c) PIR sensor (if any);
(d) Air flow rate;
(e) Heating water valve (if any) modulating control;
(f) Damper position control/monitoring; and
(g) Time schedule by real-time clock w/battery (if any).

6.2.5.10.9 FCU

(a) On/off control of each FCU;

(b) Room temperature;
(c) Room temperature set point;
(d) Chilled water valve on/off or modulating control;
(e) Heating water valve (if any) on/off or modulating control;
(f) Ductwork heater (if any) stage control;
(g) 3-position fan speed;
(h) filter clog alarm; and
(i) Power input of group of FCU (department basis).

6.2.5.10.10 Computer Room Air Conditioner

(a) On/off control and status;
(b) Trip/fault status;
(c) Local/CCMS status;
(d) Room temperature;
(e) Room humidity;
(f) Room temperature set point;
(g) Room humidity set point;
(h) Chilled water valve modulating control/status;
(i) Heating water valve (if any) modulating control/status;
(j) Ductwork heater (if any) stage control;
(k) Humidifier (if any) on/off control/status;
(l) filter clog alarm;
(m) Loss of air flow alarm;
(n) Fire trip alarm; and
(o) Power input.

6.2.5.10.11 Gas Tight Damper, Fire Damper, Smoke/Fire Damper

(a) Closure alarm.

6.2.5.10.12 Chilled Water/Heating Water F&E (closed type)

(a) High and low level alarm; and
(b) Pump fault/trip status.

6.2.5.10.13 Water Treatment for Cooling Towers

(a) On/off status;
(b) Trip/fault status;
(c) Auto/local control status;
(d) Auto/timer control status;
(e) Conductivity sensor reading/set point;
(f) Bleed off valve position/control; and
(g) Bleed off flowrate.
(h) Dosing pump on/off status;
(i) Dosing pump on/off control;
(j) Dosing pump trip/fault status;
(k) Dosing pump total run time;
(l) Dosing pump last run time;
(m) Dosing tank low level alarm;
(n) Residual chlorine content; and

(o) pH value.

6.2.5.10.14 Room Condition Monitoring for Critical Rooms, such as Computer Room, Network Room, PBX Room, etc.

(a) High temperature alarm;
(b) High humidity alarm;
(c) Room temperature; and
(d) Room humidity.

6.2.5.10.15 Cooling Energy Monitoring

(a) Energy meters reading. The energy meters shall be located at the main tee-off at each floor for both normal and 24-hours CHW system.

SUB-SECTION 6.2.6

CENTRAL REFRIGERATION MACHINE, DIRECT EXPANSION EVAPORATOR AND HEAT REJECTION PLANT

6.2.6.1 GENERAL

In this section, refrigeration machine may refer to chiller or heat pump.

The refrigeration plant for air conditioning purposes shall generally be of the mechanical, vapour compression type.

The refrigeration machine shall be factory assembled and tested complete "packaged" units which may have reciprocating, centrifugal, screw or scroll type compressors and as specified in the Particular Specification. The testing of the cooling/heating capacity of the refrigeration machine shall be carried out in accordance with AHRI Standard 550/590(I-P/2020), BS EN 14511-1:2018 to BS EN 14511-4:2018 or other international recognised standards.

The plant shall include any accessories necessary to ensure continuous and reliable automatic operation and remote monitoring and control. Power supply voltage-dip ride-through devices shall be provided to delay the protective shut down of refrigeration machine. Fast restart to allow the refrigerant machine to restart and going to a postlude operational mode shall be required for minimising downtime.

Each unit shall be capable of running continuously at the lowest step of cooling or heating capacity provided without any adverse effect.

Compressor and motor speeds shall not exceed 50 revolutions per second for reciprocating type and not exceed 100 revolutions per second for screw type. For non-oil-free centrifugal type, the motor speed shall not exceed 60 revolutions per second and the compressor speed shall not exceed 250 revolutions per second. For oil-free centrifugal type, both motor and compressor speed shall not exceed 800 revolutions per second. Energy efficient motor to optimise the system coefficient of performance shall be required. The airborne noise emission of the refrigeration machine shall comply with the requirements as specified in the Particular Specification, the Government's Green Specifications and the relevant environmental protection ordinances whichever is more stringent. If acoustic silencer is required in order to achieve the required noise level, it shall be factory-built and shall not de-rate the machine efficiency and capacity as specified in the Particular Specification. The maximum annual system leakage rate of the refrigerant should be equal to or less than 1% of full refrigerant charge according to the Government's Green Specifications.

For non-oil-free chiller, each compressor shall form a separate oil circuit with its own oil separator, oil filter and positive lubrication oil safety control circuit equipped to ensure proper functioning of each compressor and accessories.

All units shall comply, where applicable, with the following codes: ISO 5149:2014, ASHRAE Standard 90.1: 2019, ASHRAE Standard 189.1-2017, ANSI/ASHRAE 15-2019 and ANSI/ASHRAE 34-2019; AHRI Standard 550/590(I-P/2020) Testing and Ratings; BS EN 14511-1:2018 to BS EN 14511-4:2018 Testing and Ratings and Code

of Practice for Electricity (Wiring) Regulations and Code of Practice for Energy Efficiency of Building Services Installation.

Refrigerants shall comply with flammability safety classification in accordance with Sub-section 6.1.6 of this General Specification.

Characteristic curves shall show the energy consumption in kilowatts, pressure drop through the evaporator, chilled or hot water flow rates and temperatures, condenser fan speeds, etc., for each unit at 25%, 50%, 75% and 100% of full capacity.

Performance characteristics, Integrated Part Load Value (IPLV) and Non-standard Part Load Value (NPLV), to shown the performance rating of refrigeration system while operating at various capacities shall be measured in accordance with the latest edition of AHRI Standard 550/590(I-P/2020).

Sound pressure level characteristic curves shall be in dB measured in accordance with ANSI/AHRI standard 575:2017 for 25%, 50%, 75% and 100% of full capacity.

The testing of the cooling/heating capacity of the refrigeration machine shall be carried out in accordance with AHRI Standard 560:2000, BS EN 14511-1:2018 to BS EN 14511-4:2018 or other international recognised standards.

6.2.6.2 ABSORPTION UNITS

Absorption refrigeration units if required will be fully specified in the Particular Specification. They are not commonly used for general refrigeration applications in place of conventional reciprocating, centrifugal or screw types in Hong Kong due to its less favourable energy performance.

6.2.6.3 COLD STORAGE REFRIGERATION

Independent refrigeration circuits shall be supplied and installed at the cold storage room and shall comprise an air-cooled refrigeration system with semi-hermetic reciprocating compressor connected to each room unit cooler. The unit cooler shall be of the ceiling type, drawn through direct expansion with distributor, heat exchanger for better efficiency, and electric defrost heaters. Requirements for cold storage facilities will be fully detailed in the Particular Specification for specific application. The cold storage refrigeration shall be factory assembled and tested in accordance with BS 2502:1979, ASHRAE 62.1-2019 and requirements of the International Association for Cold Storage Construction (IACSC) the International Association of Refrigerated Warehouses and Institute of Refrigeration, UK.

6.2.6.4 COMPRESSORS, RECIPROCATING TYPE

6.2.6.4.1 Hermetic compressors will be acceptable where either: -

(a) The entire refrigeration system is completed and charged with refrigerant at the manufacturer’s works; or

(b) The condensing unit incorporating the hermetic compressor has a hold charge of refrigerant or inert gas on arrival at Site.

6.2.6.4.2 Crankshafts or eccentric shafts of all open or semi-hermetic compressors shall be balanced and, if having an input power greater than 2.25 kW, run in replaceable bearings.

6.2.6.4.3 Pistons greater than 50 mm diameter shall be fitted with either: -

(a) Compression and/or oil control rings; or

(b) A combination of compression rings and a piston ring specially shaped to act as an oil scraper.

6.2.6.4.4 All open and semi-hermetic compressors having an input power in excess of 350 kW shall have: -

(a) Removable cylinder liners; and

(b) Side or end covers which will enable servicing or repair of the unit to be carried out "in-situ".

6.2.6.4.5 Open type compressors shall have a rotary mechanical seal fitted to the driving shaft which effectively prevents leakage of refrigerant or oil. Direct coupled type units shall be driven through flexible coupling units. Compressors with an input power greater than 25.0 kW shall be of a type which will enable the shaft seal to be removed without moving compressor or motor.

6.2.6.4.6 Open and semi-hermetic compressors of 6.0 kW input power and above shall have: -

(a) A crankshaft driven oil pump used to force feed lubricant via a strainer to the main and big end bearings and the shaft seal;

(b) An oil pressure relief valve or bleed device provided between the oil pump discharge and the crankcase;

(c) Provision for draining oil from the suction manifold into the crankcase and for venting refrigerant gas (but not oil) in the opposite direction; and

(d) A crankcase heater arranged to operate while the compressor is at rest.

6.2.6.4.7 All types of compressor, with the exception of hermetic units or factory sealed systems, shall have the following fittings provided and connected: -

(a) Stop valves on refrigerant suction and discharge connections;

(b) Refrigerant pressure gauges, not less than 75 mm diameter and fitted with means of isolation, on suction and discharge. Gauges shall have pressure and saturation temperature scales for the refrigerant being used. Alternatively, gauges with pressure scale only may be used in conjunction with a pressure/saturation temperature conversion table fixed nearby;

(c) Refrigerant monitor to display the concentration level of refrigerant;

(d) Oil pressure gauge, not less than 75 mm diameter, with means of isolation (compressors with oil pump only);

(e) Crankcase oil level sight glass;

(f) High and low refrigerant pressure safety cut-outs with adjustable differential pressure set point. Protection settings shall be pre-set in accordance with manufacturer's recommendations;

(g) Low oil pressure safety cut-out with hand reset (compressors with oil pump only);

(h) Suction refrigerant strainer; and

(i) All instruments shall be mounted in a neat instrument panel mounted on the package unit or on a varnished teak frame mounted panel near to the machine being served.

Alternatively, pressure measurements read from the display panel of the chiller is acceptable to the Supervising Officer.

6.2.6.4.8 All compressors having a refrigeration duty in excess of 35 kW shall have capacity control by means of cylinder unloading. Compressors shall be arranged so that they start unloaded.

The hot gas by-pass or injection system of capacity control will not be accepted.

6.2.6.4.9 All compressors shall be mounted on vibration isolators.

6.2.6.5 COMPRESSORS, CENTRIFUGAL TYPE

6.2.6.5.1 For non-oil-free type centrifugal compressor, the following features shall be equipped: -

(a) Open type centrifugal compressors shall have a rotary seal fitted to the driving shaft which effectively prevents leakage of refrigerant or oil. Open compressors shall be driven through a flexible coupling of a type which enables the shaft seal to be removed without moving the compressor or motor.

(b) The lubrication system shall be arranged with an interlock to ensure adequate oil pressure at all bearings before the compressor starts and during the "coast down" period. A replaceable or cleanable filter shall be positioned in the oil delivery pipe. Where an oil cooler is used, it shall be thermostatically controlled. A hand reset pressure or flow switch shall stop the compressor on a lubrication system failure. The oil sump shall have a thermostatically controlled electric heater which operates while the compressor is at rest.

The hot gas by-pass or injection system of capacity control will not be accepted.

(c) The compressor shall have automatic capacity regulation which will control at any point from 25 to 100% of full duty by inlet guide vane (for constant motor speed) or inlet guide vane and variable speed control (for variable motor speed) without inducing a surge condition. The compressor shall always start in the unloaded condition.

(d) The motor of a semi-hermetic compressor which is refrigerant gas cooled shall have in-built protection against inadequate cooling.

(e) The compressor shall have lubrication oil management system which will ensure appropriate and sufficient lubrication to the bearings during the compressor operation and to minimise refrigerant dilution in the oil. The lubrication oil management system shall comprise differential oil switch and oil temperature sensors to perform safety checks and manage the operation of oil pump and oil heater.

(f) The following fittings shall be provided and connected: -

(i) Refrigerant pressure gauges;

(ii) Oil pressure gauge;

(iii) Oil sump or reserve level sight glass;

(iv) Pressure safety cut-outs;

(v) Low oil pressure or flow switch with manual reset;

(vi) High oil temperature cut-out with reset;

(vii) Instrument mounting; and

(viii) Stop valve on refrigerant discharge and suction.

Alternatively, pressure measurements read from the display panel of the chiller is acceptable.

6.2.6.5.2 For oil-free type centrifugal compressor, the following features shall be equipped.

(a) The compressor shall be of semi-hermetic type and directly driven and powered by pulse width modulating voltage supply. The motor shall be compatible with high-speed variable frequency operation that affords high speed efficiency, compactness and soft start capability. The motor shall have a thermistor integrated into the windings providing real time feedback of core motor temperature allowing accurate control of liquid motor cooling. The motor cooling shall be provided by an integrated liquid refrigerant injection system with individual refrigerant stop valves at suction and discharge line.

(b) The rotor shaft of the compressor shall be supported by oil-free magnetic bearings. The rotor shaft and the impellers of the compressor shall levitate during rotation and float on a magnetic cushion. The rotor shaft of the compressor shall be self-corrected and maintained at centred rotation during operation constantly. Bearing sensors shall be provided to ensure real-time feedback on the orbit of the shaft and to control the magnetic bearings. When the compressor is not under operation (not rotating), the rotor shall be supported by touchdown bearings made from durable materials.

(c) Adequate radial and axial magnetic bearings shall be provided to withstand the radial and axial force so created during compression.

(d) Each compressor shall have a bank of capacitors or UPS system used for energy storage and filtering DC voltage fluctuations. In case of power failure, the capacitors shall continue to provide power to the bearings to keep them levitated, allowing the motor to turn into a generator and to power itself down to a stop.

(e) The compressor motor shall be a permanent magnet synchronous motor, with its completely integrated variable speed drive, which shall provide efficiency not less than 96% at full load.

The compressor motor speed shall be regulated by a variable frequency drive according to the load condition. The variable speed drive shall have suitable rating to operate the unit at any loading by proportionately increasing or decreasing the motor speed without surging.

(f) The motor shall be suitable for nominal 380V, 3 phase, 50 Hz and 24 hours continuous operation. Otherwise, transformer shall be provided for rated voltage and frequency by the compressor manufacturer and factory assembled. The isolation transformer shall comply with IEC 60076-1:2011 with copper primary and secondary wings. The transformer shall be manufactured to operate at 50Hz and capacities at least 20% higher than the required power rating of the chiller and its components. Efficiency shall be over 98% at full load and isolation class shall be minimum

Class H. Each transformer shall be housed in a metal enclosure with minimum IP55 rating. Protective devices for overcurrent and earth fault shall be provided. Properly rated fast-acting fuses shall be installed in the line before each compressor's AC input terminals. UL-approved EMI/EMC filter device shall be provided on the input power line. Each compressor shall equip with built-in current limiting device to restrict the start-up current.

(g) Each compressor shall provide with surge suppression device parallel to power input line for protect against electrical surge by the manufacturer. The surge protection device for chiller shall be cabled to performance under a standard test wave of 20 kV 1.5/50 μs voltage impulse and 10kA 8/20μs current impulse.

Built-in voltage dip protection device shall provide for whole system, sensing instrument and devices of the chiller unit and shall be factory assembled in compliance with IEC61000-4-11:2004/A1:2017 and IEC61000-4-34:2007+A1:2009.

Each compressor circuit shall equip with a line reactor to protect against incoming power surges and reduce harmonic distortion. The line reactor shall comply with the following requirements:

- Sustain up to at least 600V 3 Phase 50 Hz,
- UL Standard 58 with dielectric strength tests at 2.2kVAC for 1 minute,
- CSA certified and CE marked or equivalent, and
- National Electrical Manufacturers Associated Insulation Class H or better.

(h) Cabinet shall be made of galvanised steel sheet and painted to provide a high resistance to corrosion. Any pipes/hoses carrying liquid (e.g. water, coolant etc.) shall not be allowed to run within the cabinet. However, if it is not practical due to physical constraints or other justified reasons, the equipment shall be installed in a separate compartment segregated from the rest of the electrical parts. Sufficient access shall be allowed for inspection and replacement of drive and associated components.

(i) The compressor motor speed shall be regulated by a variable frequency drive according to the load condition. The variable speed drive shall have suitable rating to operate the unit at any loading by proportionately increasing or decreasing the motor speed without surging. The capacity of the compressor shall be controlled by the variable speed drive and the inlet guide vanes at any point from 25% capacity to full capacity. The compressor shall start unload and current inrush less than 5 amps.

(j) The compressor speed shall reduce as condensing temperature and/or heat load reduces optimising energy performance through the entire range from 100% to 25% below of full load capacity of teach compressor given AHRI unloading condition.

(k) Inlet guide vanes shall be built-in to further trim the compressor capacity in conjunction with the variable speed control to optimise compressor performance at low load.

(l) The compressor shall include a microprocessor controller capable of controlling magnetic bearings, inlet guide vanes, and speed control. The controller shall be capable for providing commissioning assistance, energy outputs, operation trends, and fault codes via a high level interface.

The compressors shall be controlled by staged one-by-one by staging the compressors depending on the system load and demand. The lead compressor shall start and load up close to its full capacity before the next compressor is brought on line. Prior to energising any lap compressor, the lead compressor shall run in a stable condition for a few minutes and demand shall be checked to see if there is still enough load to justify staging an additional compressor. The load shall be high enough to ensure that the compressor(s) online plus the compressor being added shall not over shoot and/or surge. During the staging operation, the compressors shall in full vane away from surge and choke lines as far as possible. If additional compressors need to be brought online after going through the above process, the operating compressor(s) shall be unloaded (slowed down) to decrease the discharge pressure and increase the suction pressure. Continue to reduce the pressure ratio to less than 2.4, then start the next compressor. Operate all energised compressors in parallel and load them equally. A staging valve shall be provided to minimise the influence of the check valve and facilitate the smooth staging process.

The service valves shall be equipped at the inlet and outlet of each compressor and condenser. Service valves shall be accessible whilst the chiller is in operation.

Compressor(s) shall be mounted directly on the base frame of the chiller. Each compressor shall be able to field isolated and removed from both refrigerant and electrical circuits for maintenance without interrupting the chiller operation. The removal of compressor shall not require any soldering, welding or cutting woks on the chiller.

(m) Each compressor shall have one refrigerant circuit including:

- 1 or 2 compressors
- Electronic expansion valve
- Evaporator

- 1 or 2 (1 for each compressor) safety valve(s) on suction side

- Manometers on evaporator and condenser

- Condenser

- Safety valve on evaporator and condenser

- Water pressure differential switch on evaporator and condenser

- Refrigerant pressure gauges (not less than 75mm diameter and fitted with means of isolation, on suction and discharge. Gauges shall have pressure and saturation temperature scales for the refrigerant being used. Alternatively, gauge with pressure scale only may be used in conjunction with a pressure/saturation temperature conversion table fixed nearby)

- Pressure safety cut-outs (high and low refrigerant pressure safety cut-outs with adjustable differential set point. Settings of the protection shall be pre-set at the manufacturer ' s recommended settings by the manufacturer at factory)

- Instrument mounting (all instruments shall be mounted in a neat instrument panel mounted on the package unit or on a varnished teak frame mounted panel near to the machine being served

- Soft-start controller board

- EMI filter for compressor

- Silicon controlled rectifier module

- DC-link Capacitor Board

- DC/C converter

- IGBT Inverter

- Bearing Motor Compressor Controller

- Driver module

- Compressor I/O Board

- Fast acting fuse

(n) Automatic correction action to reduce unnecessary cycling shall be provided through pre-emptive control of low evaporator or high discharge pressure conditions to keep the chiller operating through abnormal transient conditions. The chiller shall allow +25% and -50% of chiller water flow rate.

(o) The oil free centrifugal chiller unit shall be factory assembled and tested in the manner completed whole unit. The testing of cooling capacity, coefficient of performance (COP) and Integrated Part Load Valve (IPLV) of the chiller unit shall be carried out in accordance with BS EN 14511-1:2018 to BS EN14511-4:2018, AHRI 550/590(I-P/2018), or other international recognised standards as considered acceptable to the Supervising Officer. The characteristic curves shall show the energy consumption in kilowatts, pressure drop through the evaporator, chilled or hot water flow rates and temperatures, condenser fan speeds, etc., for each unit at 25%, 50%, 75% and 100% of full capacity.

(p) Built-in or standalone active harmonic filter shall be assembled and tested in the factory for the whole unit.

(q) Control panel

Microprocessor-based control panel shall be provided consist of touch-screen operator interface and a unit controller. Power and control shall locate in two sections of the main panel to ensure protection against all weather conditions. The control panel shall be IP54 and internally protected with panel against possible accidental contract with electrical component IP20. The main panel shall be fitted with a main switch interlocked door.

(r) The control system shall be touched screen panel to provide clear, real time and adaptive type, and concise information on the chiller status, alarms, trends, and set point adjustment. The compressor controllers shall continue uninterrupted operation of the chiller whilst the touch screen become inoperable. The touch-screen shall display the chiller operating parameters, set point changes with multi-level password protected, and can be capable of resetting faults and alarms. The control system shall be capable to quick re-start the chiller automatically after power failure within 30 seconds. The following parameters, but not limited, shall be displayed on the home screen and trend curves on the trend screen.

- Entering and leaving chilled water temperatures, chilled water supply temperature reset point, ambient air temperature, time, date, operating hours, system demand, chiller status, alarm, fault, etc.

- Compressor information including compressor maximum speed, actual speed, percent of full speed per compressor, compressor demand, alarm, fault, suction pressure, discharge pressure, pressure ration, power

demand, actual power input, 3-phase current, voltage, surge RPM, choke RPM, liquid line temperature etc.

- Entering and leaving condenser water temperatures, Condenser saturated refrigerant pressure, condenser water in and out temperatures, refrigerant pressure and temperature, etc.

- Evaporator water in and out temperatures, refrigerant pressure and temperature, liquid line temperature, etc.

- Trending log data Including entering and leaving chilled water temperatures, ambient air temperature, actual power input, number of compressor operating, etc. all data shall have time stamp for analysis

(s) Each chiller shall have control panel, interface port, and interface cable. The control panel shall contain USB port(s) for downloading the unit's history, major parameter trends, alarms, fault history, and unit operating manual that is stored in the microprocessor. The fault history shall be displayed with date and time stamped. The alarm and fault history shall be downloadable from the chiller's USB port(s).

(t) The control panel shall connect to the Central Control and Monitoring System. The chiller manufacturer shall provide all required hand-held tools with licensed software for the interfacing to chiller and chiller control system. Access code at client level shall be provided for the proprietary monitoring software.

(u) The following fittings shall be provided and connected: -

- Refrigerant pressure gauges;

- Pressure safety cut-outs;

- Instrument mounting; and

- Stop valve on refrigerant discharge and suction.

Alternatively, pressure measurements read from the display panel of the chiller is acceptable.

6.2.6.6 COMPRESSORS, SCREW TYPE

6.2.6.6.1 Screw compressors shall have quiet operation with oil injection lubrication system. Open compressors shall have a rotary seal fitted to the driving shaft which effectively prevents leakage of refrigerant or oil. Open compressors shall be driven through a flexible coupling of a type which enables the shaft seal to be removed without moving compressor or motor.

6.2.6.6.2 A device shall be fitted to prevent the pressure differential across the compressor causing backward rotation at a normal or emergency stop.

6.2.6.6.3 The lubrication system shall be arranged with an interlock to ensure adequate oil pressure at all bearings before the compressor starts. A hand reset pressure or flow switch for stopping the compressor shall be fitted at an appropriate location from the oil pump delivery pipe to the oil sump. A replaceable or thermostatically controlled oil cooler shall be used to remove the heat gained by the oil in the rotor chamber or the chiller manufacturer shall select and confirm that the lubrication oil used can be operated at a temperature higher than the rotor chamber. The oil sump shall have a thermostatically controlled electric heater which operates while the compressor is at rest.

6.2.6.6.4 The compressor shall have automatic capacity control equipment which will control at any point between 25% and 100% of full duty via control of the compressor speed by variable speed drive or slide valve. For compressor with stepped capacity loader control, each chiller shall have capacity control steps as specified in Particular Specification and the minimum step capacity shall be maximum 25% of full load. The compressor shall be fitted with a device which ensures that it cannot start unless in the fully unloaded condition.

The hot gas by-pass or injection system of capacity control will not be accepted.

The motor of a semi-hermetic compressor which is refrigerant gas cooled shall have in-built protection against inadequate cooling.

The following fittings shall be provided and connected: -

(a) Stop valves on refrigerant discharge and suction;

(b) Refrigerant pressure gauges;

(c) Oil pressure gauge;

(d) Oil sum or reservoir level sight glass;

(e) Pressure safety cut-outs;

(f) Low oil pressure or flow switch with manual reset;

(g) High oil temperature cut-out with manual reset; and

(h) Instrument mounting.

Alternatively, pressure measurements read form the display of the chiller is acceptable.

6.2.6.7 COMPRESSORS, SCROLL TYPE

6.2.6.7.1 Scroll compressor shall be fully hermetic, directly driven by suction gas-cooled electric motor of speed not exceeding 50 revolutions per second. Each compressor shall be complete with internal motor protection against overloads, positive lubrication, mufflers, crankcase heater and vibration isolation.

6.2.6.7.2 The following fittings shall be provided and connected: -

(a) Stop valves on refrigerant discharge and suction;

(b) Refrigerant pressure gauges;

(c) High and low pressure safety cut-outs;

(d) Filter dryer; and

(e) Instrument mounting.

Alternatively, pressure measurements read from the display panel of the chiller is acceptable.

6.2.6.8 CONDENSERS, SHELL AND TUBE (FRESH COOLING WATER APPLICATION)

6.2.6.8.1 Condensers shall be of the manually cleanable type capable of being re-tubed "in-situ".

6.2.6.8.2 For fresh water condenser cooling applications, the condenser shall be of steel and the water boxes/end covers shall be of steel or cast iron.

6.2.6.8.3 The tubes shall be of copper, aluminium brass, cupro-nickel, AISI 316 stainless steel or as otherwise indicated in the Particular Specification. The tube plates may be of the same alloys of the tubes or alternatively made in mild steel.

6.2.6.8.4 Internal baffles and other fittings in either water or refrigerant circuits shall be made of material such that they will not corrode or set up corrosion or permit electro-chemical action with the liquids and/or other materials used in the condensers.

6.2.6.8.5 End water boxes shall provide adequate space for water movement such that there is no erosion of the tube ends. The water boxes shall be epoxy resin coated internally to prevent corrosion.

6.2.6.8.6 End box covers shall be removable, and allow easy access for cleaning the tubes. Means shall be provided for venting and draining of the water side of the unit.

6.2.6.8.7 The design fouling factor on the water side of the tubes shall be 0.000044 $m^2°C/W$ for cooling tower fresh water.

6.2.6.9 CONDENSERS, SHELL AND TUBE (SEA OR BRACKISH COOLING WATER APPLICATION)

6.2.6.9.1 Condensers shall be of the manually cleanable type capable of being re-tubed "in-situ".

6.2.6.9.2 For sea water or brackish water condenser cooling applications, the condenser shell shall be of steel and the water box/end covers shall be of steel or cast iron.

6.2.6.9.3 The tubes shall be of titanium and the tube plate shall be of titanium clad steel.

6.2.6.9.4 Internal baffles and other fittings in either water or refrigerant circuits shall be made of material such that they will not corrode or set up corrosion or permit electro-chemical action with the liquids and/or other materials used in the condensers.

6.2.6.9.5 End water boxes shall provide adequate space for water movement such that there is no erosion of the tube ends. The water boxes shall be epoxy resin coated internally to prevent corrosion. The water boxes shall be provided internally with a sacrificial zinc anode at both ends.

6.2.6.9.6 End box covers shall be removable, and allow easy access for cleaning the tubes. Means shall be provided for venting and draining of the water side of the unit.

6.2.6.9.7 The design fouling factor on the water side of the tubes shall be 0.000088 $m^2°C/W$ for cooling tower fresh water.

6.2.6.10 CONDENSERS, SHELL AND TUBE-GENERAL REQUIREMENT

6.2.6.10.1 The positioning of the condenser shall be such that removal or maintenance of the tubes is not obstructed by walls, pipework, valves, etc.

6.2.6.10.2 Means shall be provided for the controlled venting of non-condensable from the refrigerant side of the condenser. For machine using R-134a, this may be manually controlled.

6.2.6.10.3 Automatic control of the condensing pressure shall be incorporated.

6.2.6.10.4 The refrigerant and water systems shall be pressure tested at the manufacturer’s factory.

6.2.6.11 CONDENSERS, AIR-COOLED

6.2.6.11.1 Air cooled condensers shall have tube-and-fin or micro-channel configuration as approved by the Supervising Officer.

For tube-and-fin type, the condenser shall have copper tubes with: -

- Aluminium fin coated with epoxy resin or other approved corrosion protection coating;

- Electro-tinned copper fins;

- Copper fin; or

- Type of fin as otherwise indicated in the Particular Specification.

Corrosion protection coating of the condenser fins shall be applied in factory by the chiller manufacturer. Fins with minor damage shall be combed straight. Units with extensive damage to fins will not be accepted. Provision shall be made for the purging of non-condensable from the condenser.

For micro-channel type, the condenser shall have overall aluminium structure in construction with epoxy resin or other approved corrosion protection coating which shall be applied in factory by the chiller manufacturer.

6.2.6.11.2 Air cooled condensers mounted outside buildings shall have weather-proof fan motors. The units shall discharge air vertically upwards.

6.2.6.11.3 Automatic control of the condensing pressure shall be incorporated. Modulation of air flow shall be by staging of condenser fans or by variable speed devices and the fan motor shall be selected for this application and de-energised when necessary.

6.2.6.11.4 Fans shall comply with limitations on permitted noise levels where indicated in the Particular Specification. Fans shall have sufficient static pressure to cater for the additional acoustic treatment such as silencer, if any, in order to meet the noise requirements, set out in Sub-section 6.2.8 and the Particular Specification.

6.2.6.11.5 The complete condenser coil shall be pressure tested at the manufacturer's factory.

6.2.6.12 CONDENSERS, EVAPORATIVE

Should such equipment be required, it shall be fully detailed in the Particular Specification.

6.2.6.13 COOLING TOWER

6.2.6.13.1 General

(a) Cooling towers shall be of the type with induced or forced draught fans as indicated. The entering and leaving water temperatures and the water flow rate shall be suitable for peak heat rejection rate at the maximum ambient wet bulb temperature indicated in the Particular Specification. The performance of the cooling towers shall be certified by the Cooling Tower Institute (CTI) in accordance with CTI STD-201 RS:2017.

(b) Casings shall be of glass reinforced plastics (GRP), or as indicated. The casing shall have a treatment to minimise corrosion or decay and suitable for the casing material used. The casing and structure shall withstand extreme typhoon gale force winds from any direction. All hardware with the exception of the supporting grillage shall be fabricated of AISI 316 stainless steel. This shall include the mechanical equipment support structure, fan guards and all bolts, nuts and fasteners used in the construction of the tower.

(c) The water distribution system shall be easily cleanable to minimise collection of deposits and growth of algae which might encourage the growth of "legionella pneumophila" bacteria, and also be protected by a strainer. Open distribution pans or troughs shall be fitted with coarse mesh grids to exclude debris.

(d) Fill shall be of the film-type and vacu-formed PVC, with louvres and drift eliminators formed as part of the fill sheets. The PVC fill shall be self-extinguishing for fire resistance with a flame spread of less than 25 per ASTM E84-18b. Fill sheets shall be individually suspended from stainless steel structural tubing, or by other suitable methods, supported by the tower columns and intermediate stainless steel panels, and shall be elevated above the floor of the cold water basin to facilitate cleaning. Air inlet faces of the tower shall be free of water splash-out, and guaranteed drift losses shall not exceed 0.001% of the design water flow. All packing shall be resistant to corrosive attack by algae, fungal growth, the type of condenser water used or the chemicals used to treat the condenser water.

(e) Where the tower is to circulate sea water, treated wastewater effluents or brackish well water, all components shall be capable of withstanding the corrosive effects of these liquids. All metal parts shall be of zinc free bronze or suitable grades of stainless steel coated. Measures shall also be taken against insect and fungus attack. The packing material shall not distort in any manner which would obstruct the air or water flow.

(f) The cooling tower "basin" shall be provided in reinforced concrete to a specified standard by the Building Contract. Alternatively, if

specified to be provided in the Specialist Services Contract, it shall be of AISI 316 stainless steel, GRP or as otherwise indicated. Sheet mild steel basins if specified (for fresh water applications only) shall be hot dipped galvanised after manufacture and have two coats of an approved anti-corrosion paint applied.

(g) The AISI 316 stainless steel or GRP as specified hot water distribution basin shall be equipped with metering orifice-type nozzles to deliver incoming water by gravity to the fill. Nozzles shall be easily removable and replaceable.

(h) The GRP cold water basin shall be sealed watertight, and shall include a float-operated mechanical make-up valve, a 100 mm diameter overflow connection and a depressed GRP sump completed with a debris screen made of stainless steel or other suitable corrosion resistant material.

(i) The capacity of the basin shall be sufficient to prevent overflow when the tower is at rest. There shall be adequate and easy access for cleaning out the basin.

6.2.6.13.2 Cooling Tower Fan

(a) Fans shall be of the axial type mounted to provide a vertical upwards air discharge. In circumstances where centrifugal units are required, these will be fully specified in the Particular Specification.

(b) Particular attention shall be given to the limitations on permitted noise levels, where indicated. However, where not indicated, noise levels shall be restricted and shall be stated with the plant offered. Plant likely to generate unacceptable noise will not be accepted.

(c) Fan casings and impellers shall either be made of corrosion resistant material or proofed against corrosion after manufacture. Fan motors shall be totally enclosed and weatherproofed, TEFC or TEAO, 1.15 service factor, mounted outside the humid interior of tower. Fan motors on induced draught units shall have suitable protective treatment as they will be mounted in the moist air stream.

(d) Belt or gear drives shall be readily accessible but fully protected against the weather and personnel. Anti-vibration "cut-out" devices shall be provided to protect the fans drive, etc. Warning of a "cut-out" shall be wired back to the plant room in order to draw attention to any such problem.

(e) The energy efficiency performance of cooling tower fan shall comply with Code of Practice for Energy Efficiency of Building Services Installation.

6.2.6.13.3 Water Treatment and Monitoring

(a) A bleed-off pipe with stop valve and flow regulating device shall be provided on each cooling tower. The bleed-off water shall be re-used after treatment free from bacteria for buildings flushing water connection.

(b) Chemical treatment equipment for maintenance of cooling water quality shall be provided.

(c) Physical treatment equipment including side-stream filtration system, ultra-violet light, and/or electromagnetic device for minimising scale formation and biofouling shall be provided, as specified in the Particular Specifications.

(d) Real time monitoring of specific parameters of the cooling water system shall be provided in accordance with Section 6.1.4.5 for efficient control of water quality. The real time monitoring system shall determine the control action to be taken (e.g. the amount of chemicals to be dosed in the water system) through the comparison between the measuring results and the set points of the parameters.

6.2.6.14 EVAPORATORS, SHELL AND TUBE WATER CHILLING

6.2.6.14.1 Evaporators shall be of the shell and tube type, capable of being re-tubed "in-situ". Where an evaporator which cannot be re-tubed "in-situ" is required, it shall have the refrigerant and water connections flanged and be mounted on the packaged unit in a manner which permits easy removal. The design fouling factor on the closed circulation water side of the tubes shall be 0.000018 $m^2°C/W$.

6.2.6.14.2 For flooded type evaporator, the evaporator shell and tube plates shall be of steel and the water boxes/end covers shall be of steel or cast iron. The tubes shall be of copper, aluminium brass, cupro-nickel, AISI 316 stainless steel or as otherwise indicated in the Particular Specification. The water box/end covers shall be removable and the plant components arranged such that the space for tube removal is not obstructed.

6.2.6.14.3 The flow of refrigerant to a multiple circuit dry expansion evaporator shall be controlled by an externally equalised thermostatic or electronic expansion valve which shall not "hunt" at any step of compressor unloading. The refrigerant passages in direct expansion type evaporators shall be such that any oil present is always carried back to the compressor at the lowest stage of capacity reduction.

6.2.6.14.4 Where a fixed orifice expansion system is used with a semi-flooded evaporator, a durable nameplate shall be permanently fixed adjacent to the sight glass, in the refrigerant liquid pipe feeding the orifice, with wording as follows: -

"Bubbles" do not always indicate refrigerant undercharge. Special charging instructions by the manufacturer shall be followed.

6.2.6.14.5 Provision shall be made on flooded and semi-flooded evaporators for returning oil from the evaporator to the compressor. If the system uses and passes oil-rich refrigerant into the compressor suction pipe it shall not damage the compressor or cause foaming of the oil in the sump.

6.2.6.14.6 The refrigerant and water systems shall be pressure tested at the manufacturer's factory.

6.2.6.15 EVAPORATORS, AIR COOLING

6.2.6.15.1 Air coolers using direct expansion of primary refrigerant shall be provided with refrigerant distributors. Connections to the tubes shall ensure equal flow of refrigerant to each tube.

6.2.6.15.2 The flow of refrigerant to a multiple circuit with dry expansion evaporator shall be controlled by an externally equalised thermostatic or electronic expansion valve which shall not "hunt" at any step of compressor unloading.

6.2.6.15.3 The refrigerant passages in direct expansion type evaporation shall ensure that the return (or suction) connections are arranged such that any oil present is always carried back to the compressor even at the lowest stage of capacity reduction.

6.2.6.16 HEAT EXCHANGER

The material and equipment specification shall refer to Clause 3.1.3.8.

6.2.6.17 LIQUID RECEIVERS (REFRIGERANT RECOVERY UNIT)

A separate refrigerant recovery unit (RRU) shall be provided for chiller units. Combination of condenser / receiver is not acceptable. At least one RRU shall be provided for the largest size of chiller unit for each chiller plant room. The RRU shall be complete with a compressor, condenser, liquid/gas transfer valve, pressure relief valve and all other necessary fittings and accessories.

The RRU shall have a capacity of not less than 1.2 times the refrigerant charge of the largest chiller unit. A factory test certificate for the pressure vessel safety operation issued by the manufacturer shall be provided.

6.2.6.18 PRESSURE TESTING

The units shall have full pressure test for refrigeration and water circuits according to manufacturer's recommendation.

6.2.6.19 PUMP DOWN OF SYSTEM

6.2.6.19.1 The control system for reciprocating compressors in direct expansion systems shall be so arranged that, on the compressor stop circuit being actuated, the compressor will automatically pump down the system before it stops running. The following features shall therefore be incorporated: -

(a) A discharge line check valve; and

(b) The low pressure cut-out shall be set at the pressure corresponding to the following temperatures for air conditioning applications: -

Table 6.2.6.19.1 Cut In/Out Temperature

	Cut out	Cut in
R134a	-15°C	-3.9°C
R407c	-2°C	0.2°C
Ammonia	-2.2°C	0.2°C

6.2.6.19.2 Pump down will not be required: -

(a) Where the compressor is stopped by a safety cut-out when its driving power will be immediately terminated; or

(b) On fully manually operated systems.

6.2.6.20 REFRIGERANT PIPEWORK

6.2.6.20.1 Pipework for refrigerant systems shall be of copper or steel, which shall be internally degreased and cleaned.

6.2.6.20.2 For all chloro-fluoro-methane or ethane compounds: -

(a) All pipes from up to 108 mm OD shall be of copper complying with BS EN 12735-1:2016 or BS EN 12735-2:2016 or another international recognised standard.

(b) All pipes over 108 mm OD shall be of black extra heavy seamless steel pipe to BS EN 10216-1:2013 grade 1.0255 or another international recognised standard.

(c) On fully packaged refrigeration machine, pipework other than copper, i.e. steel fitted and tested in the factory as standard production for the units, will be acceptable subject to notification and written approval by the Supervising Officer.

6.2.6.20.3 Size of Refrigerant Piping: -

Refrigerant piping shall be sized to avoid excessive pressure drop of the fluids or gases they carry. The recommendations of the CIBSE and/or ASHRAE /or other reputable/factory standards approved by the Supervising Officer on the sizing of refrigerant piping shall be complied with.

6.2.6.21 REFRIGERATION PLANT ACCESSORIES AND CONTROLS

Refrigeration plant shall have built-in devices to monitor and control the machine for safe and reliable operation. The following accessories and controls shall be provided: -

(a) Every refrigeration system shall be protected by a pressure relief device unless it is so constructed that pressure due to fire conditions would be safely relieved. The equipment provided shall comply with ANSI/ASHRAE 15-2019 and ANSI/ASHRAE 34-2019 or BS EN 378-2:2016 as appropriate and the outlet piped to discharge outside the building.

(b) Systems using a thermostatic expansion valve shall have the following items preceding it in the refrigerant liquid pipe: -

- A solenoid valve;
- A sight glass;
- A refrigerant drier (replaceable);
- A refrigerant strainer; and
- A capped refrigerant charging valve.

(c) An evaporator pressure regulating valve where fitted shall be protected by a strainer, and an evaporator pressure gauge shall be provided, up-stream of the valve, fitted with means of isolation.

(d) Units having a direct expansion evaporator at a higher level than the compressor shall operate on a pump down cycle. On water chilling installation, the chilled water pump shall be kept running during this process.

(e) Refrigerant stop valves which incorporate a spindle gland shall be of the back seat type. The spindle gland shall be serviceable with the valve "in-situ".

(f) A flow switch shall be provided in the chilled water pipeline to each shell and tube evaporator to prevent the compressor starting or continuing to run if the water flow is below the minimum stipulated by the evaporator manufacturer.

(g) A low temperature thermostat with alarm and manual reset shall be provided for each shell and tube evaporator to stop the compressor(s) if the chilled water flow temperature falls below +3°C. For other settings as recommended by the manufacturer shall be submitted for approval.

(h) Full flow driers with strainers shall be supplied for all refrigerant liquid lines and shall be completed with isolating valves and bypass arrangements. Driers shall be of the renewable cartridge type.

(i) A suitable sight glass shall be provided, either built-in to the drier, or as a separate component installed adjacent to the drier to show through a suitable glass eye whether the moisture content of the refrigerant is within permissible limits.

(j) Strainers shall be provided before all expansion valves, float valves, solenoid valves, etc. Except where the expansion valve is fitted just downstream of a solenoid valve, only one strainer needs to be fitted.

(k) Full flow strainers of the cleanable and renewable type shall be fitted at the suction of all compressors.

(l) All strainers and driers shall be easily and readily accessible for cleaning or replacement of cartridges.

(m) Full flow oil filters shall be incorporated in all force-feed lubricating system.

(n) Where oil separation equipment is to be provided, it shall be completed with traps, strainers, floats, receivers and gauges.

(o) The oil separator shall be a fabricated steel shell with dished steel endplates and ample and accessible cleaning handholes. The oil return control floats shall not be fitted inside the shell. No pipes shall be fitted inside the shell. No pipes shall be connected through the lids of cleaning or access holes. Adequate provision shall be made for purifying and flushing the system.

6.2.6.22 ROOF MOUNTED PACKAGED WATER CHILLER / HEAT PUMP PLANTS

The Units shall include the number and type of compressors indicated in the Particular Specification, with air cooled condenser coils, condenser fans and motors, shell and tube direct expansion evaporator water chiller/heat pump.

Expansion valves controls and safety devices shall all be housed in a substantial weatherproofed casing.

The units shall have full noise suppression treatment with outlet silencers.

Unitary package chiller/ heat pump units shall conform to and shall have rated and tested capacity to the requirements of AHRI 210/240:2017 or other equal Internationally Recognised Standard accepted by the Supervising Officer.

6.2.6.23 HEAT RECOVERY CHILLER

6.2.6.23.1 Heat recovery chiller unit shall be completed with a heat recovery condenser and condensing unit. The exact configuration of these devices shall follow the details recommended by the chiller manufacturer. The heat which is normally rejected to the air-cooled or water-cooled condenser shall be reclaimed and made available through the heat recovery condenser and other provisions as specified, for a variety of uses aiming to optimise the building energy performance.

6.2.6.23.2 Waste heat shall be reclaimed by adding a heat recovery condenser, refrigerant control valve, liquid line receiver and controls to the standard air-cooled or water-cooled chiller, making it as a heat recovery chiller. The heat recovery chiller shall have only one refrigerant control valve which makes its operation reliable, simple to control and easy to maintain.

6.2.6.23.3 During operation in the cooling mode, the hot refrigerant gas shall be condensed only in the normal air-cooled or water-cooled condenser, the system cooling load heat and the heat of compression shall be rejected to the atmosphere via this condenser. The system shall sub-cool the liquid refrigerant which shall increase the capacity of the machine by up to 12 percent without increasing power consumption. The condenser fans shall operate in a cycle according to the outside temperature. Suitable air dampers/head pressure control devices shall be equipped to maximise the machine heating or cooling output efficiency.

6.2.6.23.4 Under heat recovery mode, the refrigerant gas shall condense in the shell-and-tube or plate type heat recovery condenser. The high pressure and temperature refrigerant gas shall flow into the heat recovery condenser and the heat released from the cooling load and heat of compression shall be rejected to the heating water circuit.

6.2.6.23.5 The flow modulation device shall control refrigerant flow or condensing water flow through the heat recovery unit and normal air-cooled or water-cooled condensers. It shall be controlled by the system heating requirements. The unit shall operate with 0 to 100 percent heat recovery, so that part of the heat shall be rejected and part recovered for system water heating or room relative humidity (RH) control application.

6.2.6.23.6 The heat reclaim condenser shell shall be of carbon steel. For shell and tube type, water boxes at a minimum of 1050 kPa or to suit system application shall be provided which shall have steel pipe stub connections grooved for couplings.

6.2.6.23.7 The heat exchanger tubes shall be of seamless copper tubing rolled into tube header sheets. Other energy efficient heat exchange equipment/devices may be accepted subject to the approval of the Supervising Officer.

6.2.6.24 HEAT PUMP

6.2.6.24.1 Heat pump shall be of the air-to-water or water-to-water type as specified in the Particular Specification.

6.2.6.24.2 Air-to-water heat pump shall be operating in reverse refrigeration cycle whilst water-to-water heat pump makes use of the building cooling load as a heat source for water heating. Each heat pump shall include compressor, compressor motor, evaporator, condenser, lubrication system, capacity control, solid state control centre and indication accessories.

6.2.6.24.3 The refrigerant circuit shall be leak tested at factory, evacuated and pumped up with a holding charge of refrigerant under positive pressure prior to the delivery of the unit. If this holding charge is lost on arrival, the system will not be accepted.

6.2.6.24.4 The unit shall be factory assembled, charged, wired, insulated and tested.

6.2.6.24.5 The capacity control of the heat pump shall be based on the leaving hot water temperature sensing in order to maintain constant leaving water temperature.

6.2.6.24.6 A water flow switch shall be installed in the water piping line to prevent the unit from starting when water is not circulating through the evaporator.

6.2.6.25 ENERGY EFFICIENCY PERFORMANCE

To strive to achieve carbon neutrality, more energy efficient equipment are required. The equipment shall comply with the minimum coefficient of performance requirements stipulated in Code of Practice for Energy Efficiency of Building Services Installation and shall be accepted with a minimum coefficient of performance as specified the particular specification.

Details of energy efficiency assessments shall be submitted before the equipment is accepted. Factory test and field test reports shall be provided to substantiate the equipment performance.

Ample time approved by the Supervising Officer shall be allowed for the submission in order to meet with the installation programme.

6.2.6.26 TOTAL ENERGY HEAT PUMP

6.2.6.26.1 The total energy heat pump unit shall serve as a normal chiller unit and hot water plant, and capable to produce chilled water and hot water to meet both the cooling and heating demand simultaneously. The unit shall be either a proprietary product, or specially developed and manufactured by a manufacturer which have sound experiences in developing such system /equipment in the past. All relevant information, including but not

limited to, the schematic design, components sizing, components selections, technical calculations, materials uses, operation features, system performances under full load and part load conditions, etc. shall be submitted to the Supervising Officer for approval prior to ordering.

6.2.6.26.2 Each unit shall be factory built, assembled, piped, wired, refrigerant charged and fully tested before shipment as complete sets supplied from a single manufacturer. The only field connections required on site shall comprise only external control circuitry, system water piping and electrical power supply. Facilities for connection and working under the control of the CCMS system shall be provided.

6.2.6.26.3 The total energy heat pump shall be manufactured to cater for using ambient air as media for residual cooling /heating energy dissipation and suitable for operating with ambient temperature from 4°C to 40°C.

6.2.6.26.4 The total energy heat pump shall be capable to cool chilled water from 12.5°C to 7°C and to heat hot water from minimum 40°C to 45°C simultaneously with dual setting for both chilled and hot water temperature available in order to suit the varying cooling and heating demand. The minimum chilled water-out temperature shall be 5°C at cooling mode and the maximum hot water-out temperature shall be 60°C at heating mode.

6.2.6.26.5 The total energy heat pump unit shall consist of compressors, air-cooled heat exchanger (condenser coil), two nos. of water-side heat exchangers for chilled water and hot water respectively, necessary numbers of electronic expansion valves and 3-way electronic refrigerant flow control valves and all necessary accessories.

6.2.6.26.6 Depending on the demand and priority on cooling and heating loads, the total energy heat pump shall be switched among the following five operating modes freely during system operation by varying the refrigerant flow path: -

(a) Heating Mode

The refrigeration circuit shall operate as an air-cooled heat pump when there is no cooling requirement. The air-cooled heat exchanger (acting as evaporator) shall absorb heat energy from the ambient air. The system heat energy shall be recovered by the heat exchanger at hot-water side so as to provide hot water source for the connected hot water system. In this mode, the heat exchanger at chilled-water side is isolated from the refrigerant circuit.

(b) Heat Recovery Mode

The refrigerant circuit shall be arranged to provide chilled water as well as uncontrolled hot water simultaneously. The heat exchanger at chilled water side (acting as evaporator) absorbs building heat energy (to provide cooling to the building) and the system heat energy shall be recovered by the heat exchanger at

hot-water side (act as heat recovery condenser) so as to provide uncontrolled hot water for heating purposes. In this mode, the air-cooled heat exchanger is isolated from the refrigerant circuit.

(c) Cooling Mode

The refrigerant circuit shall be arranged to operate as a normal air-cooled package chiller when there is no heating requirement. The refrigeration circuit shall be arranged to absorb the building's heat energy (i.e. to provide cooling to the building) by the heat exchanger at chilled-water side (acting as evaporator) and to reject the heat energy by the air-cooled heat exchanger (act as condenser) to the atmosphere through the refrigeration process.

(d) High Cooling and Small Heating Mode

The refrigeration circuit shall be arranged to operate such that the heat exchanger at chilled-water side (acting as evaporator) absorbs the building's heat energy (i.e. to provide cooling to building). The system heat energy shall be partially recovered by the heat exchanger at hot-water side to provide hot water source for the connected hot water system. The surplus heat energy shall be rejected to the atmosphere via the air-cooled heat exchanger (acting as condenser) at the same time.

(e) Small Cooling and High Heating Mode

The refrigeration circuit shall be arranged to operate such that the heat exchanger at chilled-water side (acting as evaporator) absorbs the building's heat energy (i.e. provide cooling to the building) and, at the same time, the air-cooled heat exchanger absorbs the heat energy from the ambient air in order to meet the total heat load. The system heat energy shall be recovered by the heat exchanger at hot-water side to provide the required heating load.

The operation of the 3-way electronic valves and other refrigerant flow control valves shall be arranged to achieve the above five operating modes.

6.2.6.27 AUTOMATIC CONDENSER TUBE CLEANING SYSTEM

6.2.6.27.1 Automatic condenser tube cleaning system shall be provided for each water-cooled condenser of the refrigeration machine as specified and indicated on the drawings and particular specification. The system shall comprise of rubber sponge balls, ball injector, ball strainer/collector, programmable control panel, inspection chamber, control valves, associated pipework and all necessary accessories to form a complete fully automatic condenser tube cleaning system.

6.2.6.27.2 The sponge balls shall be injected to into the condenser inlet pipe by the ball injector. The balls shall then flow through the condenser tubes in a

random distribution manner within the stream to wipe away any fouling deposits that are present so as to maintain at or near the peak design heat transfer coefficient of the condenser. After passing through the condenser tubes, the sponge balls will be collected at the ball collector and ready to be injected to the condenser in the next cleaning cycle. The cleaning cycle shall be programmable from 30 to 120 minutes. The system shall be operated on-line and shall not disrupt the normal operation of the refrigeration machine.

6.2.6.27.3 The sponge balls shall have a certain oversize compared to the inner condenser tube diameter. The density of the sponge balls shall be equivalent to the density of the condenser water and the material, size and quantity of the balls shall be selected as per manufacturer's recommendation and shall be approved by the Supervising Officer.

6.2.6.27.4 The control system shall be connected to the CCMS via appropriate interface to monitor the operation of the system and to make adjustment to the parameters.

SUB-SECTION 6.2.7

ELECTRIC MOTORS AND ELECTRICAL EQUIPMENT

6.2.7.1 LOW VOLTAGE - GENERAL

Unless otherwise indicated, all electrical equipment shall be tropicalised and suitable for use in service conditions as specified in this General Specification. Equipment shall be protected against atmospheric corrosion, including that caused by salt-laden air. Materials used shall not be susceptible to mould growth or attack by vermin.

Cables for power circuits shall not be less than 2.5 mm^2 copper conductors and cables for control circuit shall not be less than 1.5 mm^2 copper conductors.

6.2.7.2 LOW VOLTAGE - WIRING FOR REFRIGERATED SITUATIONS

All electric wiring to be installed into refrigerated situations where the temperature is to be maintained at or below 0°C shall be either MICS or elastomeric cables that are applicable for the operating environment.

6.2.7.3 LOW VOLTAGE - ELECTRIC EQUIPMENT

The low voltage electric equipment shall comply with the relevant sections in Part 7 of this General Specification.

6.2.7.4 HIGH VOLTAGE - ELECTRIC EQUIPMENT

The high voltage electric equipment shall comply with the relevant sections in Part 7 of this General Specification.

SUB-SECTION 6.2.8

NOISE AND VIBRATION CONTROL

6.2.8.1 GENERAL

The Corrected Noise Level at potential Noise Sensitive Receiver in the adjacent or nearby building, if so identified in the Particular Specification and/or Drawings, shall not exceed the Acceptable Noise Level stipulated in the Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites issued by the Environmental Protection Department when the plant/equipment installed are put into operation.

Noise assessment shall be carried out for air-cooled chillers / condensing units / condensers and/or water-cooled chillers / cooling towers and chilled water / condensing water pumps or external ventilating fan intakes/outlets to ensure compliance with the statutory requirements of the Environmental Protection Department.

6.2.8.2 OFF SITE PRE-FABRICATION

6.2.8.2.1 General

Floor mounted equipment shall be installed on 100 mm high concrete housekeeping pads provided by the Building Contractor covering the whole floor area requirements of the equipment bases plus a minimum of 150 mm further on each side or on inverted beams at the roof. Vibration isolators shall be mounted on this concrete pad or inverted beams.

6.2.8.2.2 Welded Structural Steel Bases

Bases shall be constructed of adequate "I" or channel hot dipped galvanised steel members reinforced as required to prevent the bases from flexing at start-up and from misalignment of drive and driven units.

All perimeter members shall be of steel sections with a minimum depth equal to 1/10th of the longest dimension of the base but need not exceed 350 mm provided that the deflection and misalignment are kept within acceptable limits as determined by the equipment manufacturer.

Height saving brackets shall be employed in all mounting locations to provide a base clearance of 50 mm.

6.2.8.2.3 Concrete Inertia Bases

Concrete inertia bases shall be formed within a structural steel beam or channel frame reinforced as required to prevent flexing, misalignment of the drive and driven units or transferral of stresses into equipment. The base shall be completed with height saving brackets, concrete reinforcement and equipment bolting down provisions.

In general, the thickness of concrete inertia bases shall be of a minimum of 1/12th of the longest dimension of the base but never be less than 150 mm. The base depth needs not exceed 300 mm unless specifically required.

As an indication of the standards required, minimum thickness of the inertia base shall generally comply with the following table or be 1/12th of the longest dimension of the base, whichever is the larger: -

Table 6.2.8.2.3 Minimum Thickness of Inertia Base

Motor Size (kW)	Minimum Thickness
3.7 - 11	150 mm
15 - 37	200 mm
45 - 55	250 mm
75 - 185	300 mm

Base forms shall include minimum concrete reinforcement consisting of 13 mm bars or angles welded in place on 150 mm centres running both ways in a layer of 40 mm above the bottom, or additional steel as is required by the structural conditions.

Unless otherwise specified, concrete inertia bases shall weigh from 2 to 3 times the combined weight of the equipment/plant to be installed thereon.

Base forms shall be furnished with drilled steel members and with anchor-bolt sleeves welded below the holes where the anchor bolts fall in concrete locations.

Height saving brackets shall be provided in all mounting locations to maintain a base clearance of 50 mm.

6.2.8.3 VIBRATION ISOLATORS

The following types of vibration isolation mountings or suspensions are not exhaustive but serve to cover the main types that shall be applied as appropriate unless otherwise stated in the Particular Specifications.

6.2.8.3.1 Type "A" - Free Standing Spring Mounts

These shall be free standing and laterally stable without any housing and completed with a minimum of 6.0 mm neoprene acoustical friction pads between the base plate and the support.

All mountings shall have levelling bolts that shall be rigidly bolted to the equipment.

Spring diameters shall be no less than 80% of the compressed height of the spring at rated load with a horizontal spring stiffness 1.1 times the rated vertical spring stiffness.

Springs shall have a minimum additional travel to "solid" (fully compressed) equal to 50% of the rated deflection.

Ends of the springs remain parallel.

The springs selected for any given application shall be non-resonant with the equipment's or support structure's natural frequencies. This shall apply to all springs hereafter described.

6.2.8.3.2 Type "B" - Restrained Spring Mounts

Equipment with operating weight different from the installed weight such as chillers, boilers, etc. and equipment exposed to the wind such as cooling towers and other roof mounted plants shall be mounted on spring mountings as Type 'A' but a housing shall be used that includes vertical limit stops to prevent spring extension when some of the weight is removed, i.e. when the system is drained or lifted by abnormal wind pressure.

6.2.8.3.3 Type "C" - Double Deflection Neoprene Mounts

These mountings shall have a minimum static deflection of 8.5 mm. All metal surfaces shall be neoprene covered to avoid corrosion and shall have friction pads on both the top and the bottom so that they need not be bolted to the floor. Bolt holes shall be provided for applications where bolting down is required.

6.2.8.3.4 Type "D" - Neoprene Pads

These mountings shall consist of "waffle" form neoprene pads of 8.0 mm thickness. Where required these shall be adhesive cemented to 3 mm steel plate of similar area so as to form a sandwich.

The area of pad to be used and the number of layers shall be determined for each application in accordance with the manufacturer's recommendations.

6.2.8.3.5 Type "E" - Spring Hangers

These shall contain a steel spring located in a neoprene cup manufactured with a grommet to prevent short circuiting of the hanger rod.

The cup shall contain a steel washer to properly distribute the load on the neoprene and prevent its extrusion.

Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° to 35° arc before contacting the edge of the hole and short circuiting the spring.

Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.

6.2.8.3.6 Type "F" - Spring and Double Deflection Neoprene Hangers

These shall be as Type "E" but incorporate an 8 mm deflection neoprene element at the top of the hanger box.

The neoprene element shall be moulded with a rod isolation bushing that passes through the upper part of the hanger box.

6.2.8.3.7 Type "G" - Pre-Compressed Spring Hangers

These shall be as Type "F" but shall be pre-compressed to the rated deflection so as to keep the piping or equipment at a fixed elevation during installation.

The hangers shall with a release mechanism to free the spring after the installation is completed and the hanger is subjected to its full load.

Deflection shall be clearly indicated by means of a scale.

6.2.8.3.8 Type "H" - All Directional Anchor Units

These units shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 13 mm thickness of heavy duty neoprene isolation material for horizontal restraints.

Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction.

6.2.8.3.9 Type "I" - Pipe Anchors and Guides

Resilient pipe anchor shall be formed by welding a steel pipe clamp to the pipe and the clamp in turn supported at its two ends by a pair of Type "H" all directional anchor units. In this way, both the radial and axial motion of the pipe are controlled.

Resilient pipe guide shall be formed by welding localised longitudinal guide ribs around the pipe at location over which slides fit the oversized pipe clamp which is in turn supported at its two ends by a pair of Type 'H' all directional anchor units. In this way, radial motion of pipe is controlled while axial motion of pipe is guided.

6.2.8.3.10 Type "J" - Split Wall/Floor Seals

These shall consist of two bolted pipe halves with 19 mm or thicker neoprene sponge bonded to the inner faces.

Seals shall project a minimum of 25 mm past either face of the walls.

Where temperatures exceed 115ºC, fibreglass shall be used in lieu of the sponge.

6.2.8.3.11 Type "K" - Horizontal Thrust Restrains

Air handling equipment shall be protected where necessary against excessive displacement, which might result from high air thrusts in relation to the equipment weight.

The horizontal thrust restraint shall consist of a spring element located in a neoprene cup manufactured with a grommet to prevent short circuiting of the threaded rod. The thrust assembly shall be so construced that the spring element can be pre-set for thrust at the factory and adjusted at the site to allow for a maximum of 6 mm movement at start and stop.

The assembly shall be furnished with one threaded rod and two angle brackets for attachment to both the equipment and ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centre line of thrust and symmetrically on either side of the unit.

6.2.8.3.12 Type "L" - Built in Inertia Block Plant Support

Where specified in the contract document, the Building Contractor shall provide plant foundations and housekeeping pads in the form of large concrete blocks recessed into the main floor slab.

Unless otherwise indicated, the sides and bottom of the embedded portion of the concrete block shall be lined with a minimum of 50 mm thick "load bearing" cork pad to the following specification.

Table 6.2.8.3.12 Density of Vibration Isolators

Density Designation	Density (kg/m^3)	Loading (kg/m^2)
Light	3.0 – 4.5	250 – 2500
Medium	5.5 – 6.0	2500 - 20000
Heavy	7.0 – 7.5	15000 - 30000

6.2.8.4 PLANT/EQUIPMENT VIBRATION ISOLATION

6.2.8.4.1 General

All vibration isolators shall have their known undeflected heights or calibration markings so that, after adjustment when carrying their loads, the deflection under load can be verified, thus determining that the load is within the proper range of the device and that correct degree of vibration isolation is being achieved.

The static deflection of the isolator at each support point shall not differ from the design objective for the equipment as a whole by more than ±10%.

The ratio of lateral to vertical stiffness for spring shall be not less than 0.9 nor greater than 1.5.

All neoprene mountings shall have hardness of 40 to 65 durometers, after minimum aging of 20 days or corresponding over-aging.

In order to resist corrosion, all vibration isolation mountings and hangers shall be treated as follows: -

(a) Springs to be neoprene coated or hot dip galvanised or polyester powder coated with a 1000-hour salt spray rating as per ASTM B-117;

(b) Wearing hardware to be hot dip galvanised or steel A36 or ductile iron or stainless steel of an appropriate grade; and

(c) All other metal parts to be hot dip galvanised or powder coated finish rated with a 1000-hour salt spray per ASTM B-117.

All vibration isolators and associated equipment bases shall whenever possible be of the product of a single manufacturer. Acceptable manufacturer's systems shall strictly comply with the requirements of this General Specification and/or the Particular Specification.

6.2.8.4.2 Selection Guide for Equipment Base and Vibration Isolator

Unless otherwise specified, the selection of the type of equipment base and vibration isolator (mounting/hanger) for different plant/equipment and on different floor spans and levels shall follow the requirements as indicated in the Selection Guide for Vibration Isolation (Table 47 in the Chapter 48 for "Sound and Vibration Control" of the ASHRAE Applications Handbook) and the static deflection of the vibration isolator selected shall either provide a minimum isolation efficiency of 90% in ground floor areas and 95% in upper level areas or be not less than the corresponding values shown in Table 47. The selected vibration isolation system shall be suitable for the specific plant/equipment and the specific building structure on which the plant/equipment is mounted.

More efficient isolation than those suggested in Table 47 shall be provided in case if the adjacent occupied space is a noise critical area such as board room and executive office. Advice from vibration isolator manufacturer shall be sought if necessary.

6.2.8.5 PIPEWORK VIBRATION ISOLATION

6.2.8.5.1 Flexible Connectors

Flexible connector shall consist of a single or twin-sphere body manufactured with reinforced rubber, the ends of which are raised and wire reinforced to form the cuffs for sealing purposes. The cuffs shall be backed by floating steel flanges.

The rubber body shall be reinforced by multi-layered nylon tire cord fabric.

Flexible connectors shall have a life in excess of 10 years under the design working conditions.

The rubber membranes shall have an indelible identification system to clearly identify the model and hence suitability for the application and working conditions and have the date of manufacture moulded into the cover to ensure that no units that have exceeded the recommended shelf life are used.

Straight connectors shall be of the twin-sphere construction whilst elbow connectors shall be of the single-sphere construction.

Straight connectors connected to resiliently supported equipment shall be equipped with acoustical control cables to prevent excessive elongation of the connectors if the system operating pressure is in excess of the value recommended by the manufacturer for use without control cables.

Acoustical control cable assembly shall consist of four large triangle anchor plates, two control cables with large swedged-on end fittings and 13 mm thick acoustical washer bushings of sufficiently large load bearing area to isolate the end fittings, axially and laterally.

6.2.8.5.2 Flexible Metallic Hose

Allowable stress levels shall be within PD 5500:2018+A1:2018.

The corrugated seamless hose body shall be of the annular and close pitched type.

For all ferrous applications, the hose body and the braid shall be manufactured from stainless steel material to BS EN 10095:1999 Type X8CrNi25-21. End terminations shall be carbon steel threaded male nipples to ISO 7-1:1994/Cor1:2007 for 65 mm size and below and flanges to BS EN 1092-1:2018 Standard for 75 mm and above.

For copper or non-ferrous pipework systems, the hose body and the braid shall be manufactured in bronze throughout. End terminations shall be copper female ferules suitable for soldering.

The lengths of the flexible metallic hoses shall be in accordance with the manufacturer's recommendation.

6.2.8.6 DUCTWORK VIBRATION ISOLATION

They shall be made of approved materials such as lead vinyl or similar of minimum surface density of 5 kg/m^2 and installed such that airflow is not obstructed. The material used shall be approved or accepted by the FSD.

6.2.8.7 DUCTWORK ACOUSTIC INSULATION

Unless otherwise specified, the acoustic ductwork liner shall conform to the requirements of ASTM C1071-19. It shall be glass fibres type firmly bonded together with a thermosetting resin into a rigid board of 50 mm thickness and 48 kg/m^3 density. The air stream surface shall be overlaid with a fire-resistant black woven glass fabric which adds strength to the product during fabrication, installation and system operation. The manufacturer's product identification shall appear on the air stream surface.

All components of the acoustic insulation including coverings shall have a fire hazard classification with a flame spread rating of not over 25, and a smoke developed rating of not over 50. Ratings shall be as established by the tests conducted in accordance with UL 723:2018, ASTM E84-21A or NFPA 255:2006 or BS 476-6 and BS 476-7 to the BS 5422 of Class "0" (National Class) fire performance and satisfy the FSD circular letter 4/96. All related certificates shall be submitted before any insulation is installed to prove that the products to be used in meeting the above standard..

The acoustic linings shall have the following minimum sound absorption coefficients when tested in accordance with ASTM C423-17.

Table 6.2.8.7 Minimum Sound Absorption Coefficient

Octave Band Centre Freq. (Hz)	125	250	500	1k	2k	4k
Sound Absorption Coefficient	0.12	0.67	0.99	0.97	0.91	0.87

6.2.8.8 ACOUSTIC DUCTLAG

Unless otherwise specified, the acoustic duct lag shall consist of 50 mm thick glass fibre/lead sheet or barium loaded vinyl sheet/glass fibre with a factory applied aluminium vapour-barrier jacket which shall also be used for thermal insulation of ductwork.

The fibreglass shall have a density of 24 kg/m^3 and thermal conductivity of 0.032 W/m^{o}C or lower. The lead sheet shall have a surface weight of 5 kg/m^2.

Duct lag shall have the following minimum sound transmission loss when tested in accordance with ASTM E90-09.

Table 6.2.8.8 Minimum Sound Transmission Loss

Octave Band Centre Freq. (Hz)	125	250	500	1k	2k	4k
Sound Transmission Loss (dB)	15	17	19	24	30	33

6.2.8.9 DUCTWORK SILENCERS

Outer casing of rectangular ductwork silencers shall be fabricated from galvanised steel not thinner than 0.8 mm. Seams shall be "lock-formed" and mastic filled. Each silencer shall be provided with flanged inlet and outlet in accordance with ductwork size specified in DW 144. The internal baffles or splitters shall be of galvanised perforated steel not thinner than 0.5 mm and having open area less than 33%.

All internal components shall be spot welded in place with welds on centres not exceeding 100 mm. All spot welds shall be treated after with anti-corrosive epoxy resin or other approved coating. Mani folded silencers shall be provided with continuous metallic nosing crimped in place. The filler material shall be of inorganic mineral or glass fibre of a density sufficient to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin and moisture proof.

Combustion rating for the silencer acoustic in-fill shall not exceed the following when tested in accordance with ASTM E84-18b, NFPA Standard 255:2006 or UL 723:2018 or BS 476-4:1970.

- Flame Spread 25
- Smoke Developed 15
- Fuel Contributed 20

The silencer shall be leak-proof at a differential air pressure of 2 kPa.

Unless otherwise specified, ductwork silencers shall have the following minimum Dynamic Insertion Loss under forward and reverse flow conditions of 10 m/s: -

Table 6.2.8.9 (1) Insertion Loss (dB) - for Lowest Pressure Drop Silencer

Silencer Length (mm)	Octave Band Centre Freq. (Hz)					
	125	250	500	1k	2k	4k
900	5	9	14	23	24	14
1500	7	13	21	29	39	20
2100	13	18	28	40	47	26

Table 6.2.8.9 (2) Insertion Loss (dB) - for Low Pressure Drop Silencer

Silencer Length (mm)	Octave Band Centre Freq. (Hz)					
	125	250	500	1k	2k	4k
900	5	10	17	17	13	10
1500	8	15	28	30	21	14
2100	12	20	36	38	28	18

Table 6.2.8.9 (3) Insertion Loss (dB) - for Medium Pressure Drop Silencer

Silencer Length (mm)	Octave Band Centre Freq. (Hz)					
	125	250	500	1k	2k	4k
900	7	12	19	23	23	18
1500	10	18	30	42	34	23
2100	14	24	36	48	44	31

Table 6.2.8.9 (4) Insertion Loss (dB) - for Standard Pressure Drop Silencer

Silencer Length (mm)	Octave Band Centre Freq. (Hz)					
	125	250	500	1k	2k	4k
900	10	15	25	34	35	28
1500	16	22	38	45	46	41
2100	17	34	44	49	49	45

Unless otherwise specified, ductwork silencers shall have the following maximum self-generated sound power level (dB re 10-12 Watt) under the flow conditions of 10 m/s: -

Table 6.2.8.9 (5) Maximum Self-Generated Sound Power Level

Silencer Length (mm)	Octave Band Centre Freq. (Hz)				
	125	250	500	1k	2k
Lowest	51	51	49	47	50
Low	52	46	43	42	45
Medium	54	52	50	47	48
Standard	69	63	64	61	63

Before ordering ductwork silencers, the proposed manufacturer's certified test data (from an approved laboratory) for pressure drop and insertion loss ratings shall be submitted for the Supervising Officer's approval.

6.2.8.10 ACOUSTIC DOORS

Door leaf shall be at least 65 mm thick, fabricated from 1.5 mm steel and filled with sound-absorbing and damping materials. Door frame shall be fabricated from 1.5 mm steel and furnished in two inside and outside mitred and welded pieces.

Doors shall be fully gasket, hinged and secured by approved latch mechanism.

Door hinges shall be of cam-lift type which shall raise or lower as the door is opened or closed respectively.

Side and head of door and frame shall receive two sets of self-aligning compression seals. Acoustic labyrinth shall be created when the door is in the closed position. Bottom of door leaf shall contain continuous compression seal and the gravity action of the cam hinges shall cause the door to compress the bottom seal tightly against the floor every time the door is closed.

Unless otherwise specified, the door shall be 1-hour fire rated and the compression seals shall be fire-resistant to BS 476-20:1987 to BS 476-22:1987.

The acoustic door shall have the following minimum sound transmission loss when tested in accordance with ASTM E90-09.

Table 6.2.8.10 Minimum Sound Transmission Loss (Door)

Octave Band Centre Freq. (Hz)	125	250	500	1k	2k	4k
Sound Transmission Loss (dB)	26	42	43	47	52	56

6.2.8.11 ACOUSTIC LOUVRES

Unless otherwise specified in the Particular Specifications, the acoustic louvres to be installed to the external walls of plant rooms when specified shall be not less than 300 mm thick.

Outer casings shall be made of 1.6 mm thick galvanised sheet steel. The noise absorbing surfaces of the louvre blades shall be made of 0.8 mm thick perforated galvanised sheet steel and all other surfaces of the louvre blades shall be made of 0.8 mm thick galvanised sheet steel.

Louvre blades shall be filled with glass fibre of density 48 kg/m^3.

The acoustic louvres shall have the following minimum Transmission Loss (TL).

Table 6.2.8.11 Minimum Transmission Loss (Louvre)

Octave Band Centre Freq. (Hz)	125	250	500	1k	2k	4k	8k
Sound Transmission Loss (dB)	7	11	12	13	14	12	9

Static pressure drop of louvres shall not exceed 50 Pa at a face velocity of 2.2 m/s.

6.2.8.12 ACOUSTIC ENCLOSURES

6.2.8.12.1 General

Where required for in the Contract, double-wall, insulated, and air-pressure-tight acoustic enclosures for housing noisy plant or machinery shall be constructed as specified below and supplied by a specialist manufacturer of insulated housings and casings, with published standards of construction and performance.

6.2.8.12.2 Panel Construction

The outer surface of the panel shall be made of 1.2 mm thick galvanised solid sheet steel and the inside surface shall be made of 0.8 mm thick perforated galvanised sheet steel. Interior panel perforation shall be of 2.4 mm round holes on 4.8 mm staggered centres.

Panels shall be 100 mm thick or as otherwise indicated and be filled with glass fibre insulation, 40 kg/m^3 minimum density, with following UL Composite Fire Resistance Ratings or to BS 476-20:1987 to BS 476-22:1987: -

- Flame Spread 15
- Smoke Developed 0
- Fuel Contributed 0

Mineral wool to a comparable specification would also be accepted.

The insulation material shall be non-hygroscopic, inert and vermin-proof. It shall not settle, shed or dust.

Panel joints shall be of the joiner and connector type construction such that the adjacent panels are held rigidly in position, effective both on the inside and outside.

Mechanical joints shall be made leak-proof with ductwork sealer, which shall be retained between adjoining flat metal surfaces. Panel construction shall hold the assembly motionless to avoid sealer displacement. Sufficient sealer shall be used to allow extrusion of surplus sealer to give visible evidence of sealer. Assembled structure shall have deflection under load limited to 1/240 of span at 3.0 kPa pressure.

For spans greater than 3000 mm, additional and approved structural reinforcement shall be installed to provide for structural rigidity.

Connection of roof to wall panels shall be by suitably sized angles held by approved screws, and using an approved sealer to provide an airtight seal.

6.2.8.12.3 Access Doors and Louvres

Where required under the Contract, access doors and louvres forming part of the complete acoustic enclosures shall be of the acoustic type.

Access door shall be 600 mm wide x 1500 mm high or 900 mm wide x 1800 mm high as specified in the Drawings or otherwise indicated. Each door shall be factory/workshop installed in its panel opening which shall be reinforced with 3.4 mm thick galvanised sheet steel channel of suitable width to suit the wall thickness of the panel. The doors shall be constructed of 1.2 mm thick galvanised solid sheet steel and they shall be 100 mm thick and of the overlapping seal type. Each door shall be equipped with single continuous air/acoustic seals around the sill, jambs and head and shall have 2 hinges and 2 latches with an inside release handle.

6.2.8.12.4 Openings and Sealing

All openings with dimensions greater than 150 mm shall be factory/workshop cut and framed.

The clearance space between the acoustic enclosure and any ductwork, pipes, or conduits passing through the enclosure shall be tightly packed with glass fibre or rock wool. Both ends of the opening shall then be

covered up by 1.2 mm thick sheet steel and sealed airtight by high pressure ductwork sealer.

6.2.8.12.5 Acoustic Test Data for Panels

The minimum allowable Transmission Loss (TL) of the panel, including all components, when tested in accordance with ASTM E90-09, shall be as stated below: -

Table 6.2.8.12.5 (1) Minimum Transmission Loss (Panel)

Octave Band Centre Freq. (Hz)	125	250	500	1k	2k	4k	8k
Sound Transmission Loss (dB)	23	30	42	51	59	58	58

The composite panel assembly when tested in accordance with ASTM C423-17, shall have minimum sound absorption coefficients as follows: -

Table 6.2.8.12.5 (2) Minimum Sound Absorption Coefficients

Octave Band Centre Freq. (Hz)	125	250	500	1k	2k	4k	8k
Sound Transmission Loss (dB)	0.89	1.20	1.16	1.09	1.01	1.03	0.93

6.2.8.13 PLANT ROOM ACOUSTIC LININGS

Where required under the Contract, the acoustic linings to walls and/or ceilings of the plant rooms are used to reduce the reverberant noise levels of the plant rooms. The material and the sound absorption coefficients of the acoustic wall lining shall comply with Clause 6.2.8.7.

SUB-SECTION 6.2.9

PIPE MATERIAL, VALVES, COCKS AND STRAINERS

6.2.9.1 AUTOMATIC AIR VENTS

Automatic air vents shall be used where indicated. The body shall be made of gunmetal or brass or ductile iron with non-ferrous or stainless steel or polypropylene floats, corrosion resistance valves and seats. Each automatic air vent shall be controlled by a lock-shield valve. Air release pipes shall be run to discharge at the nearest suitable and visible point and agreed by the Supervising Officer.

6.2.9.2 BALL FLOAT VALVES

Ball float valves shall be of the sizes indicated and shall suit the fill and expansion cisterns or tanks specified. Ball float valves for use with feed and expansion cisterns shall be of the long arm type arranged to shut off when the cistern contains 150 mm depth of water. Floats shall be of the vacated plastic, solid polystyrene, copper alloy or stainless steel construction and provided with a non-ferrous threaded in built connector.

6.2.9.3 BUTTERFLY VALVES

6.2.9.3.1 Butterfly valves shall be installed where indicated. These shall have resilient seats which are (in-the-field) replaceable with moulded-in 0-rings to serve as a flange gasket. For sizes of 50 mm dia. to 150 mm dia. inclusive, a notched plate handle shall be provided for the control of the valve and indication of disk position. For sizes of 200 mm dia. and above, gear actuator shall be used. All butterfly valves shall be capable of bubble tight shut off. Butterfly valves shall comply with the recognised international standards (e.g. ISO or BS EN).

6.2.9.3.2 Butterfly valves in connection with wafer, full-lug, flange or grooved ends may also be accepted. The valves shall be in accordance with the following: -

(a) Grooved ends butterfly valves shall be bubble tight complying to ISO 5208:2015 or BS EN 593:2017 standard, enabling quick assembly with mechanical grooved coupling on ISO standard pipes;

(b) The manufacturer shall provide tests for pressure rating by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved. All testing records and data shall be submitted to the Supervising Officer for approval;

(c) Bodies shall be made of cast iron to BS EN 1561:2011 or ductile iron to BE EN 1563:2018, completely coated with epoxy or products having equivalent functions or performance against

corrosion, suitable for the temperature range of 0ºC to 50ºC. The valve shall provide dead end service at maximum rating;

(d) The discs shall be made of ductile iron, stainless steel, aluminium bronze or brass ASTM B124, with protective coating for fresh water application;

(e) The shafts stems shall be made of Type 420 stainless steel;

(f) The control handles and the gear operators shall be suitable for locking in any position. The micro switches shall be built in the actuators and factory adjusted at full open and full closure. Manufacturer shall provide certificate of factory adjustment;

(g) Valve electric operators shall be mounted on valves and tested at factory; and

(h) The valves shall have marking tag in accordance with ISO 5209:2019 standard.

6.2.9.4 CHECK VALVES

The body of the check valve of size 50mm or below shall be made of gunmetal or bronze to BS EN 1982 or brass to BS EN 12163, BS EN 12164 and BS EN 12165 or relevant BS EN standard. For check valve of size 65mm or above, its body shall be made of cast iron to BS EN 1561:2011or ISO 185:2020 or ductile iron to ASTM A536 or BS EN 1563:2018. The flaps/discs shall be made of bronze to ISO 197-4:1983 or ductile cast iron to BS EN 1563:2018 or stainless stain to BS EN 10088. The discs of swing check valves shall be of light construction and pivot on a spindle secured by two stainless steel or bronze hangers. Each valve shall be fitted with a stop to prevent undue movement of the flap and shall be as silent as possible in operation.

The discs of lift check valves shall be provided with means of guiding the discs and preventing components from becoming detached in service.

Recoil check valves with size 100 mm and above shall have removable cover on top of the outlet body casing to facilitate inspection of bearings and movement door.

6.2.9.5 PIPEWORK APPLICATIONS

Except as may otherwise be specified in Particular Specification, the application of pipework types to the various systems shall be as stated in Table 6.2.9.5(1)-(7). All pipes and fittings shall comply with the relevant Standard and shall have suitable markings to indicate the Standard.

Table 6.2.9.5 (1) Chilled Water and Low Pressure Hot Water Circulation (Closed System)

Size	Type	Treatment
Up to 150 mm	Steel to ISO 65:1981 (BS EN 10255: 2004) of medium grade	Black mild steel (painted external before insulation)
Over 150 mm up to and including 600 mm	Steel to ISO 9330-1 to ISO 9330-3 (BS EN 10217-1:2019)	Black mild steel (painted external before insulation)

Note: For pipe sizes of over 600 mm, the requirements, including the pipe wall thickness, will be fully detailed in the Particular Specification.

Table 6.2.9.5 (2) Chilled Water Drain, Vent and Overflow

Size	Type	Treatment
Up to 150 mm	Steel to ISO 65:1981 (BS EN 10255: 2004) of medium grade	Galvanised

Table 6.2.9.5 (3) Chilled Water Condensate Drains

Size	Type	Treatment
Up to 150 mm	Steel to ISO 65:1981 (BS EN 10255: 2004) of medium grade	Galvanised
Over 150 mm up to and including 300 mm	UPVC to BS EN ISO 1452-1 to 1452-5 or BS 3505:1986	Self-finish

Note: For pipe sizes of over 300 mm, the requirements, including the pipe wall thickness, will be fully detailed in the Particular Specification.

Table 6.2.9.5 (4) Condenser Circulation Pipework, Fresh Water Closed System With Air/Water Heat Exchanger

Size	Type	Treatment
Up to 150 mm	Steel to ISO 65:1981 (BS EN 10255: 2004) of medium grade	Black mild steel (painted external before insulation)
Over 150 mm up to and including 300 mm	Steel to ISO 9330-1 to 9330-3 (BS EN 10217-1:2019) with wall thickness not less than 6 mm	Black mild steel (painted external before insulation)

Note: For pipe sizes of over 300 mm, the requirements, including the pipe wall thickness, will be fully detailed in the Particular Specification.

Table 6.2.9.5 (5) Condenser Circulation Pipework, Fresh Water passing through Cooling Tower

Size	Type	Treatment
Up to 150 mm	Steel to ISO 65:1981 (BS EN 10255: 2004) of medium grade	Galvanised
Over 150 mm up to and including 300 mm	UPVC to BS EN ISO 1452-1 to 1452-5 or BS 3505:1986	Self-finish
Over 150 mm up to and including 300 mm	Ductile iron to BS EN 545:2010 of appropriate grade For screw-on flanges connection, thickness grade of Class K12	External Coating: Metallic zinc covered by a finishing layer of bitumen paint Internal Lining: Cement Mortar as in Note 4 below
Over 150 mm up to and including 300 mm	Steel to ISO 65:1981 (BS EN 10255: 2004) of medium grade	Galvanised
Over 300 mm up to and including 600mm	Steel to ASTM A53 or steel to ISO9330-1 to 9330-3 (BS EN 10217-1:2019) with wall thickness not less than 8 mm	Galvanised

Note: For pipe sizes of over 600 mm, the requirements, including the pipe wall thickness, will be fully detailed in the Particular Specification.

Table 6.2.9.5 (6) Condenser Circulation Pipework for Sea Water Treated Effluent Water and Brackish Well Water (Cooling tower or once through systems)

Size	Type	Treatment
Up to 150 mm	UPVC to BS EN ISO 1452-1 to 1452-5 or BS 3505:1986	Self-finish
Over 150 mm up to and including 300 mm	Ductile iron to BS EN 545:2010 of appropriate grade For screw-on flanges connection, thickness grade of Class K12	External Coating: Metallic zinc covered by a finishing layer of bitumen paint Internal Lining: Cement Mortar as in Note 4 below

Note: For pipe sizes of over 300 mm, the requirements, including the pipe wall thickness, will be fully detailed in the Particular Specification.

Table 6.2.9.5 (7) Cold Water Make-up Supply to Air-conditioning Plant Cold Feed

Size	Type	Treatment
Up to 150 mm	UPVC to BS 3505: 1986 or BS EN ISO 1452-1 to 1452-5 of appropriate grade	Self-finish

Where copper pipework is indicated, the tubes shall be of the following types: -

(a) Light gauge copper to BS EN 1057:2006+A1:2010. Refrigeration copper tubes to BS EN 12735-1 :2020 (tubes for piping system) or 12735-2 :2016 (tubes for equipment) for refrigerant distribution purpose;

(b) Where buried underground tubes shall be to BS EN 1057:2006; and

(c) Tubes shall be suitably joined by capillary or compression fittings to ISO 2016:1981 or to BS EN ISO 6708:1996 and ISO 7268: 1983/Amd 1:1984 (BS EN 1254-1:1998 or BS EN 1254-2021). For jointing screwed copper tubes, cast copper alloy fittings to ISO 7-1:1994/Cor1:2007 (BS EN 1254-1:1998 or BS EN 1254-2:2021) shall be used.

Note 1: Expansion and contraction due to condenser water temperature changes shall be adequately accommodated particularly for UPVC pipework.

Note 2: UPVC pipe has several pressure ratings, i.e. appropriate grade for BS EN ISO 1452-1 to 1452-5 or BS 3505:1986. If pressure ratings are not indicated in the Drawing or Particular Specification, pipes with pressure ratings equal to twice the actual working pressure to which the pipes are being subjected shall be provided.

Note 3: Where UPVC pipe is likely to be exposed to sunlight, it shall be protected against the effects of ultra violet light by a suitable paint work coating material or other form of protection to be agreed with the Supervising Officer.

Note 4: All pipes and fittings shall be cement mortar lined in accordance with BS EN 545:2010, BS EN 598:2007+A1:2009, BS EN 969:2009, Type A - Portland pulverised fuel ash cement (PFAC) in accordance with BS EN 197-1:2011 with a minimum pulverised fuel ash content of 25%; or Type B - sulphate resisting cement (SRC).

Note 5: UPVC pipework to BS 3505:1986 or BS EN ISO 1452 shall be in accordance with BS EN ISO 1452-1:2009, BS EN ISO 1452-2:2009, BS EN ISO 1452-3:2010, BS EN ISO1452-4:2009 and BS EN ISO 1452-5:2009.

6.2.9.6 PLUG COCKS

Plugs for gland cocks shall be ground in. A loose key of mild steel forged to shape shall be provided for each gland cock.

Air cocks shall be nickel or chrome plated, of the spoutless pattern and with screwed taper thread. Two loose keys shall be provided for each installation having up to ten air cocks and one loose key shall be provided for every additional ten air cocks.

Three-way cocks shall be of the 'T' ported type, the position of the ports being clearly grooved on the square end of the plug. A loose key shall be provided for each three-way cock.

6.2.9.7 PRESSURE REDUCING VALVES

Where indicated pressure reducing valves shall be installed. Unless otherwise specified they shall be as follows: - Valves of up to 50 mm size shall have bronze or malleable iron bodies and may have taper screwed ends. Valves of 65 mm size and over shall have cast iron bodies with ends flanged. Flanges for bronze and iron valves shall be to ISO 7005-2:1988 & ISO 7005-3:1988 or BE EN 1092-1:2018, each according to the maximum working pressure. Valves shall be of the following types, as indicated: -

(a) Valves for reducing pressure to apparatus not manufactured to withstand the maximum pressure of a high-pressure line shall be of an approved spring-loaded relay operated type. The valve seats and discs shall be of nickel-alloy or stainless steel and shall be renewable. Each valve shall be capable of maintaining a reduced outlet gauge pressure within 3.5 kPa of the set pressure and shall be installed with an excess pressure isolating protection valve on the low pressure side; and

(b) Where the apparatus on the low-pressure side is capable of withstanding the maximum pressure of the high-pressure line, valves shall be of the single-seated spring-loaded diaphragm type. They shall be adjustable within the specified low-pressure range and shall be installed with a safety or relief valve on the low pressure side.

Each reducing valve shall be installed with an isolating valve and strainer on the high-pressure side, excess pressure isolating valve or relief valve on the low pressure side, pressure gauge with mild steel siphon and bronze cock followed by down-stream side isolating valve.

Unions shall be provided on the pressure reducing valve side of both isolation valves in order to facilitate removal of the pressure reducing valve set for servicing or replacement. Where indicated, a bypass valve shall also be installed.

6.2.9.8 STRAINERS

Strainers shall be of the single or the double type as indicated with connections screwed thread for bores of up to and including 50 mm and flanged for bores of 65 mm and over.

Strainers of up to 50 mm shall be of gunmetal, bronze or brass alloy. The bodies of single strainers of 65 mm bore and above and all double strainers shall be of cast iron or ductile iron.

Straining cages and their supporting structure shall be of non-ferrous metal or stainless steel with 1.5 mm diameter for size up to 100mm or perforations or finer if indicated. Cage of the basket type strainer shall be at least five times the cross-sectional area of the pipe or Y-type strainer of appropriate size as approved by the Supervising Officer.

Double strainers shall incorporate a changeover device to enable either strainer to be selected and to isolate the idle strainer from the fluid flow.

6.2.9.9 SPECIALISED CONTROL VALVES

Motorised control valves, and solenoid valves used for automatic control purposes shall be as specified in this General Specification or the Particular Specification. Mixing valves shall comply with BS EN 1287:2017.

6.2.9.10 VALVE APPLICATIONS

For fresh and chilled water, gate valves shall be used except where regulation is required in which case globe valve shall be installed but they shall be positioned so as not to prevent drainage of the piping.

For fresh water service valve both the gate and globe type shall be constructed of cast iron or ductile iron body with bolted cast iron bonnet with cast iron body to BS EN 1561 or ductile iron to BS EN 1563, malleable iron hand wheel, cast iron, ductile iron or brass or bronze disc and bronze or EPDM seat, forged manganese bronze or high tensile bronze spindle, with graphited packing and compressed fibre.

Sea water services valves installed in the sea water pump house and/or inside the air conditioning plant room shall be constructed of cast iron body or ductile iron with zinc free bronze or gunmetal or stainless steel 316 trim, bolted cast iron bonnet, malleable iron hand wheel, zinc free bronze stuffing box, gland, thrust, plate, yoke, wedge, seat and yoke sleeve with nickel alloy faces, stainless steel spindle with outside screw of rising stem or inside screw of non-rising stem (whichever is specified), gunmetal nuts, and graphited packing compressed fibre packing.

6.2.9.11 VALVES AND COCKS

Valves, cocks, taps and other accessories shall be of the type and working pressure suitable for the applied system and shall be supported by valid documents with approval from the appropriate authority. They shall also bear the appropriate ISO Standard with marks.

Bodies of valves and cocks of up to and including 50 mm size shall be of cast gunmetal or bronze or brass, approved valves having hot-pressed bodies may be offered as an alternative.

Unless otherwise specified, bodies of valves of 65 mm size and larger shall be of cast iron or ductile iron. Castings and pressings shall be of good quality, clean and smooth and free from scale or flaws.

All working parts shall be of gunmetal or bronze or brass . Holes in covers or in gates for screwed portions of spindles shall have full threads of a length not less than the diameter of the spindle over the threads. Glands shall be machined to provide a naming fit between the spindle and the stuffing box. Stuffing boxes shall be properly packed, or fitted with 'O' rings which shall be located in plastic bushes.

Gate valves shall have split or solid wedge gates. Disc valves shall have renewable discs free to rotate on the spindle.

Valves and cocks on mild steel pipework of up to and including 50 mm size shall have taper screwed ends, and of 65 mm size and above shall have flanged ends.

Valves and cocks on copper pipework shall have connecting generally as for fittings.

Wheel valves where exposed to view on appliances such as fan coil units and induction units shall have union ends and either: -

(a) Composition hand-wheels shaped to enclose the stem and gland; or

(b) Easy clean polished lock shields and composition hand-wheels.

Valves not normally exposed to view shall be fitted with cast metal hand wheel or lock shields.

Straight pattern valves shall be of the full-way gate type. Angle valves shall be of domed discs type to offer minimum resistance to flow.

Regulating valves on circuits shall have characterised plugs and a lockable spindle with an indicator to show the proportional opening.

Lock-shield valves shall have easy-clean shields or enclosures to match with the inlet valves; a minimum of 2 loose keys shall be provided for each size of valve spindle used on the Contract. Where indicated, the lock-shield valves shall have characterised plugs as for the regulating valves.

Isolating valves, lockable where indicated, shall be of the following types: -

- Full way gate type except for valves with side pressure tapping of up to 50 mm size which shall be of the oblique type; and

- Parallel or taper plug type.

Full way gate valves shall have metal wheel handles. Wedge gates and all seating, including the top of the wedge and the associated back seat of the bonnet facing, shall be accurately machined, or alternatively provide a back seating. Plug valves shall be arranged for 90º operation with stops on the valve body to limit movement. Lubricated plug valves shall incorporate a check device in the plug for the retention of lubricant applied under pressure. A spare charge of lubricant shall be provided for each valve.

SUB-SECTION 6.2.10

SYSTEM MONITORING INSTRUMENT

6.2.10.1 GENERAL

The content related to electrical control/field devices shall be read in conjunction with Sub-sections 6.2.4, 6.2.5 and 6.2.7.

Scale ranges shall be appropriate for indicating the extreme values, on and off state, of the plant. The design maximum operating condition shall be indicated at not less than 75% of the total scale length.

All signals generated from the instruments and devices shall be suitable to work in conjunction with a Central Control and Monitoring System (CCMS) or wherever required in the Particular Specification.

6.2.10.2 PITOT STATIC TUBE

The flow sensing device shall be of the annubar type in compliance with BS ISO 3966:2008 and BS ISO 7194:2008, inserted through the wall of the pipe via suitable bush supplied by the sensing device's manufacturer.

The equipment shall be manufactured by a reputable and proven manufacturer and shall receive the Supervising Officer's approval before installation.

Each pitot static sensor shall be permanently marked externally with the direction of flow.
The flow sensing device shall be of the annubar type in compliance with BS ISO 3966:2008 and BS ISO 7194:2008, inserted through the wall of the pipe via suitable bush supplied by the sensing device's manufacturer.

6.2.10.3 ORIFICE PLATE METERING

Where these are to be installed the orifice plates shall be of stainless steel and of the well-established manufacturer's make with proven performance characteristics in compliance with ISO 5167-1:2003 or BS 7350:1990. The resistance across the plant orifice shall not exceed 5 kPa (0.05 bar).

The plate shall have two-valves tappings for connection to manometer or responder meter, etc.

6.2.10.4 ELECTROMAGNETIC AND ULTRASONIC FLOWMETER

The flowmeter shall be of the direct reading type, i.e. in l/s, and shall be suitable for the chemical and physical properties of the fluids to be measured and suitable for both horizontal and vertical installations.

6.2.10.5 ENERGY METER

The calculator unit of an energy meter shall calculate and display digitally the water enthalpy consumption in kWh with an accuracy to a maximum error of ±1.5% throughout the range of measurement. The number of digits of accumulated enthalpy consumption display shall not be less than six. The housing protection for the microprocessor and calculator unit shall not be less than IP 54. The requirement for the temperature sensors and the flowmeter shall be as specified elsewhere in this General Specification.

Signal connection facilities to the CCMS shall be provided for displaying the energy consumption computed and the flow rate and temperature readings.

The requirements of energy metering shall comply with the Code of Practice for Energy Efficiency of Building Services Installation, but not limited to the following:

A chiller, heat pump or unitary air-conditioner, of 350 kW or above cooling/heating capacity, shall be equipped with continuous monitoring facilities to measure its power (kW) & energy (kWh) input, cooling/heating power (kW) & energy (kWh) output and coefficient of performance.

A chilled/heated water plant, of 350kW or above cooling/heating capacity, shall be equipped with continuous monitoring facilities to measure its power (kW) & energy (kWh) input, and cooling/heating power (kW) & energy (kWh) output, such that the plant's coefficient of performance can be determined.

It is acceptable to make use of the manufacturer's curve or data indicating the chiller's flow rate and pressure drop relationship to obtain the chilled water flow rate based on its pressure drop through the evaporator, and likewise to obtain the heated water flow rate based on the flow's pressure drop through the heat pump's condenser.

In determining a chilled water plant's power & energy input, the inputs to all equipment for producing the cooling output, such as chiller compressors, circulation pumps of condensers or cooling towers, condenser fans, cooling tower fans, radiator fans etc. shall be included, whereas the inputs to chilled water pumps shall be excluded. Likewise for a heated water plant, the inputs to all equipment for producing the heating output, such as heat pump compressors, circulation pumps on heat input side of water source heat pumps, fans of air source heat pumps, boilers or hot water heaters etc. shall be included, whereas the inputs to heated water pumps shall be excluded.

For each of an air handling unit, with motor rated at 5 kW or above, being accommodated in plant room, metering devices or the provision of measurement shall be provided for measurement of power (kW) consumption of the air handling unit.

6.2.10.6 PROGRMMING FOR OPTIMISATION AND ENERGY CALCULATION

The energy modelling software or simulation programme shall be tested according to relevant ASHRAE Standard. Software limitations shall not excuse the limitation of accuracy of energy modelling.

SUB-SECTION 6.2.11

THERMAL INSULATION

6.2.11.1 GENERAL

6.2.11.1.1 Thermal insulation shall comply with the requirements of BS 5422:2009 and BS 5970:2012 or other statutory standards such as IEC, ISO and etc. or equivalent.

6.2.11.1.2 Unless otherwise indicated, all thermal insulating materials used within any building shall, with fire performance of Class "O" as stipulated in BS 5422: 2009. The definition of Class "O" (national class) shall be referred to Annex E of BS 5422:2009. A class "O" (national class) material is one which: -

(a) has a Class 1 surface spread of flame rating in accordance with BS 476-7:1997 and has a fire propagation index of (I) of not more than 12.0 and a sub-index (i1) of not more than 6.0 in accordance with BS 476-6:1989+A1:2009; or

(b) is of limited combustibility in accordance with "Materials of limited combustibility" (E.2 of Annex E, BS 5422:2009); or

(c) is non-combustible in accordance with Non-combustible materials (E.1 of Annex E, BS 5422:2009).

Test reports to substantiate the fire properties of the insulation material shall be issued by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved.

6.2.11.1.3 The insulation used for the air conditioning installation is "air" insulation which shall satisfy the following: -

(a) Adequate strength and rigidity to maintain the thickness of air;

(b) Creating adequate number of closed air cells within the material to minimise heat loss due to convection and conduction; and

(c) Covered on exposed surface with good quality foil to stop heat loss from radiation.

6.2.11.1.4 All insulation materials shall be free from CFC and HCFC. Statement from manufacturer and other supporting documents shall be submitted to demonstrate the products are free from CFC and HCFC.

6.2.11.1.5 Insulation materials and their finishes shall be free from asbestos. Where asbestos are suspected or identified for works in relate to existing insulation, Supervising Officer shall be immediately notified.

6.2.11.1.6 Insulation materials and finishes shall be inherently proof against rotting, mould and fungal growth and attack by vermin, be non-hygroscopic and in all respects to prevent inducing or leading to corrosion to pipework and ductwork. Proper installation shall be carried out according to the Manufacturer's recommendations under normal environmental conditions and be suitable for continuous use throughout the range of operating temperatures and for the environment indicated.

6.2.11.1.7 Relevant certificates from laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved shall be provided in order to prove the physical properties of the insulation to be used in the projects are conforming to the requirements.

6.2.11.1.8 Supporting documents or relevant test certificates from manufacturer to prove that the insulation materials are compatible with metallic elements, e.g. steel pipes and G.I sheets, and can remain constant or are stable enough throughout the working life, shall be submitted. The Supervising Officer's approval shall be obtained before installation.

6.2.11.1.9 The installation procedures and details of the insulation materials shall be as per the manufacturer's recommendation.

6.2.11.2 TYPES OF THERMAL INSULATION MATERIALS

The type of insulation required for a particular installation will generally be indicated in the Particular Specification and shall comply with the following requirements. Where there is no specific type of insulation specified in the Particular Specification, proposal shall be submitted to the Supervising Officer for approval before the order of materials.

6.2.11.2.1 Type "A" - CFC & HCFC Free Phenolic Foam Insulation

(a) Factory made phenolic foam products specification: BS EN 14314:2015 or GB/T 20974-2014;

(b) Temperature range: sub-zero to 120°C;

(c) Density: 40 kg/m^3 ±10%;

Except at pipe, ductwork and other support points where a higher density load bearing quality insulation shall be used in accordance with the manufacturers' recommendations. In general, phenolic foam sections with 80 kg/m^3 for pipe sizes of up to 125 mm and 120 kg/m^3 for pipe sizes of 150 mm or above and made to the same thickness as the adjacent pipe insulation;

(d) Compressive Strength: 140 kN/ m^2 (BS EN ISO 844:2014 or GB/T 8813-2008);

(e) Thermal Conductivity: 0.022 W/m°C (at 20°C mean temperature) (BS EN ISO 4590:2016 and BS ISO 1922:2018 or ISO 8302:1991 or GB/T 10294-2008);

(f) Closed Cell Content: 90% minimum (BS EN ISO 4590:2016 and BS ISO 1922:2012 or BS EN ISO 4590:2016 or GB/T 10799-2008);

(g) Vapour Transmission: 10 micron gram meter/Nh at 38°C 88% RH (BS EN ISO 4590:2016 and BS ISO 1922:2012 or ISO 1663:2007); and

(h) Fire Rating: shall have class "O" fire rating and test certificate from the organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS.

The above properties shall be tested independent of facings which shall be factory applied Class "O" double sided reinforced foil vapour barrier for both condensation control and mechanical protection. The external side shall be of white antiglare coating and the internal side shall be of aluminium foil fully adhered to the phenolic foam. Facing with all service jackets on the outside is also acceptable. The surface emittance of the all service jackets shall be 0.7 or greater when tested with ASTM C1371-15 with reference to ASTM E408-13.

6.2.11.2.2 Type "B" - Preformed Rigid Fibreglass Insulation

The insulation shall fit hot water pipework only and capable of accommodating the temperature range for the system without structural failure of the fibres or the bonding agency.

Preformed fibreglass sections shall have a density of not less than 64 kg/m^3 and a minimum length of 0.9 m. Butt joint tape not less than 75 mm shall be used to ensure perfect sealing of the joints between sections.

The thermal conductivity (k value) of the fibreglass shall not be more than 0.033 W/m°C at a mean temperature of 20°C. The fibre diameter of the fibreglass shall be of 4 to 10 micron and fibre length 3 to 6 cm.

All fibreglass insulation shall be completely sealed at all joints. All holes, tears, punctures, etc. made in the vapour barrier shall be completely sealed with the same specified foil tape.

6.2.11.2.3 Type "C" - Flexible (Semi Rigid) Glass Fibre Blanket Type Insulation

This form of insulation shall not be used on pipework.

Insulation used for ductwork shall be semi rigid having a density of not less than 32 kg/m^3 and thickness not less than 38 mm. The fibre diameter of the fibreglass shall be of 4 to 10 micron and fibre length shall be of 3 to 6 cm.

The thermal conductivity (k value) of the fibreglass shall not be more than 0.036 W/m°C at a mean temperature of 20°C. The thermal resistance (R value) shall be more than 1.08 m^2°C/W.

6.2.11.2.4 Type "D" - Flexible Closed Cell Elastomeric Insulation

Flexible closed Cell Elastomeric Insulation shall be in continuous lengths, with factory applied talc coating or on-site applied talc coating on inner surface. Flexible Closed Cell Elastomeric Insulation shall comply with the following requirements:

(a) Factory made flexible elastomeric foam products specification: BS EN14304:2015 or GB/T 17794-2008;

(b) Thermal Conductivity: <0.04 W/m°C (at 20°C mean temperature)

(c) Density: 50 to 65 kg/m^3;

(d) Water Vapour Permeability (without additional vapour barrier foil): 0.28 micron gram meter/Nh;

(e) Maximum Operating Temperature: > 80°C;

(f) No putrefaction and mildew shall form on the insulation material. The water absorption properties of the insulation shall be of not more than 1.5% after 28 days;

(g) The material, including adhesives and all accessories shall have fire properties to Class 'O' as stipulated in BS 5422: 2009. The insulation material shall be a "built-in" vapour barrier and achieve condensation control without any additional vapour barrier foil;

(h) Smoke Visibility (ISO 5659-2:2017) – The mean specific optical density, Dm shall be less than 500 under all test conditions. The thickness of the test specimen shall be 25 mm and the Dm shall be the maximum value of the specific optical density (Ds_{10}) of the three tests computed at 10 minutes time interval; and

(i) Smoke Toxicity – The results shall comply and in accordance with either of the following standards or equivalent: -

- International Maritime Organisation (IMO) – International Code for Application of Fire Test Procedure: Annex 1 Part 2 – Smoke and Toxicity Test, IMO MSC 307(88); or

- Naval Engineering Specification (NES) 713 (Issue 3) – Determination of the Toxicity Index of the Products of Combustion from Small Specimens of Material.

6.2.11.2.5 Type “E” - Polystyrene Insulation

Only where specified or approved preformed or slab polystyrene may be used.

Under all circumstances, the material shall be of the type which is defined as "non-self combustible".

6.2.11.2.6 Type "F" - Hydrous Calcium Silicate (HCS) and Rock Wool Pipe Insulation.

This material is more appropriate to the insulation of hot pipework and other hot metallic surfaces.

Where specified or approved, this material shall be provided in the preformed sections having a top density of 200 kg/m^3 of chemically-reacted calcium silicate combined with mineral fibre, with factory applied jacket.

6.2.11.2.7 Type "G" - Magnesia Insulation

Where specified or approved, this material is appropriate to the insulation of hot pipework and other hot surfaces. It shall consist of 85% magnesia with 15% cement bonding agent applied wet to the hot surfaces allowed to dry out and when the appropriate thickness has been achieved smoothed off, covered with 25 mm spaced wire mesh of 1 mm diameter galvanised steel wire netting reinforcement, covered further with smoothly trowelled cement plaster of 15 mm thickness and painted to an approved colour when dry.

6.2.11.2.8 Type "H" – Polyurethane (PU) Foam Insulation Panel for Pre-insulated Air Ducts

(a) Temperature range : Sub-zero to 80°C;

(b) Density : 48 kg/m^3 minimum;

(c) Compressive strength: 245kN/m^2 (BS EN ISO 844:2014) minimum;

(d) Thermal Conductivity: not more than 0.024W/m°C (at 20°C mean temperature);

(e) Close cell content: 95% minimum (BS EN ISO 4590:2003 and BS ISO 1922:2012 or BS EN ISO 4590:2003);

(f) Flexural Rigidity: Class R3 (BS EN 13430:2004)

The insulation panel shall be laminated at factory with a minimum of 60-micron thick aluminium foils on both sides. The aluminium foil shall be embossed and coupled with a 2g/m^2 layer of polyester paint.

The aluminium foil shall comply with the following requirement: -

- Aluminium with pureness : 98.8% (Aluminium Alloy ISO 8079:1984);

- Thickness :60µm;

- Tensile strength (DIN 50154:2019) : > 60N/m^2; and

- Elongation (DIN 50154:2019) : > 8%.

The insulation panel together with the above-specified aluminium foils shall achieve condensation control without any additional vapour barrier foil.

6.2.11.2.9 Type "I" – Polyurethane (PU) Foam Insulation for Pre-insulated Pipes

Polyurethane (PU) foam insulation for pre-insulated pipe shall comply with all of the following requirements:

(a) Temperature range : Sub zero to 80°C;

(b) Density: 48 kg/m^3 minimum;

(c) Compressive strength : 245kN/m^2(BS EN ISO 844: 2014) minimum;

(d) Thermal conductivity : not more than 0.024W/m^{o}C at 20^{o}C mean temperature; and

(e) Close cell content : 95% minimum (BS EN ISO 4590:2003 and BS ISO 1922:2012 or BS EN ISO 4590:2003)

Galvanised steel or other materials such as aluminium, stainless steel, etc. approved by the Supervising Officer shall be applied as outer jacket/ cladding of the pre-insulated pipe and acts as vapour barrier.

Approved pipe sleeves and pipe collars, and approved fire rated pipe sleeves, collars or barriers shall be provided where necessary and applicable, or the pre-insulated pipes itself having a fire penetration time not less than the structure through which it passes when tested in accordance with BS 476 – 20:1987 for all pre-insulated pipes passing through compartments, walls, floors and any structural openings in compliance with relevant regulations and code of practices. The fire barriers shall have the same fire resisting rating as the structure through which the pre-insulated pipe passes.

PU foam insulation of pre-insulated pipe system shall be seamless throughout the system and bond tightly with the service pipe and cladding/ outer jacket. PU foam insulation shall be smoothly and evenly bonded to the inside of the cladding outer jacket.

6.2.11.3 MEASURES TO PREVENT SMOKE, NOXIOUS & TOXIC FUMES PROPAGATION IN EVENT OF FIRE

When requested by the Supervising Officer, proof of fire classification, obtained from organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS, shall be provided.

Under circumstances, where insulation materials have been permitted which do not strictly meet with the fire properties stated in Clause 6.2.11.1, the materials shall not be construed as acceptance unless for the following exceptional conditions: -

(a) The sections are secured to the pipework or ductwork with non-flammable or toxic smoke producing adhesives; or

(b) They are wrapped over by 25 mm spaced wire mesh, of 1 mm diameter galvanised steel netting reinforcement, covered further with smoothly trowelled self-netting cement plaster of 15 mm thickness and if required (because they are exposed) painted.

Such insulation shall similarly be sealed above the ductwork that is fitted tight and adjacent to the ceilings and beams or at the points near other obstructions.

Where total sealing by 1 mm diameter galvanised steel wire netting reinforcement and cement plaster of 15 mm thickness cannot be achieved, then any form of permission expressed shall not be construed as if such forms of insulation have been permitted.

Permission to use insulation materials that shall be sealed with cement plaster in order to avoid generation of toxic fumes and smoke in the event of a fire will only be given under such circumstance that their applications are considered safe by the Supervising Officer.

6.2.11.4 VAPOUR BARRIERS

6.2.11.4.1 Where thermal insulation is applied to the outside of pipework and ductwork, equipment and plant used to convey, store or generate fluids or gases at temperatures lower than the design ambient dew point temperature indicated, a water vapour barrier shall be provided unless the Particular Specification states otherwise. The vapour barrier where deployed shall be applied such that it is continuous and gives protection to the whole surface of the insulation which it protects.

It shall not be pierced or otherwise damaged by supports or by the application of external cladding.

The insulation on continuous pipework and ductwork shall be sectionalised by vapour barriers to be applied at a maximum of 5 m

intervals to isolate condensation problems caused by perforation of external barrier to the affected section.

6.2.11.4.2 Aluminium foil vapour barriers used for insulation of all pipework and ductwork shall conform to the following requirements: -

(a) Machine Direction Tensile Strength (BS EN ISO 1924-2:2008) ≥12 kN/m;

(b) Cross Direction Tensile Strength (BS EN ISO 1924-2:2008) ≥ 9 kN/m;

(c) Bursting Force (AS2001.2.19:1988) ≥ 120N or Bursting Strength ≥ 6 kg/cm^2(BS EN ISO 2758:2014);

(d) Water Vapour Permeance (ASTM E96/E96M-16) ≤ 1.0ηg/Ns; and

(e) Surface emittance of external surface (ASTM C1371-15 or ASTM E408-13) service jacket ≥ 0.7 and aluminium vapour barrier >0.03.

6.2.11.4.3 All joints shall be either factory or on job site fabricated. All joints shall allow for 50 mm overlap of vapour barrier and the joints shall be completely sealed using foil tape with a minimum width of 75 mm conforming to the following specifications: -

(a) Tape thickness minimum 38 microns without release paper;

(b) Machine and Cross Direction Tensile Strength (ASTM D882-18 or BS EN ISO 1924-2) ≥2.0 kN/m;

(c) Peel Adhesion to steel (ASTM D3330/D3330M-04:2010) ≥ 10N/25 mm;

(d) Shear adhesion (BS7116:1990): 31; and

(e) Surface Emittance (ASTM E408-13) ≥ 0.7 or Surface Emissivity (BS 5422:2009) ≥ 0.85 (Paint, white).

Any and all punctures, holes, tears, etc. that can be seen or occur on the job site shall be completely sealed with the same tape as specified above.

6.2.11.4.4 The material chosen for the vapour barrier and its method of application shall be compatible with the thermal insulation on which it is to protect. The following shall be used: -

(a) Wet-applied vapour barriers of the cut-back bitumen type, bitumen emulsions with or without elastomer latex, vinyl emulsions and solvent based polymers;

(b) Elastomer sheets with all joints adequately overlapped and continuously sealed;

(c) Polyvinyl chlorides, polyethylene, polyisobutylene or other plastics tapes or sheets;

(d) Epoxide and polyester resins;

(e) Sheet metal with all joints adequately overlapped and continuously sealed to a vapour-tight condition; or

(f) Metal foil used alone or laminated to building paper, building sheet or plastics film with all joints adequately lapped and continuously vapour sealed.

Facing materials used on insulation materials to provide vapour barrier shall not be more than 0.8 mm thick. All metal foil vapour barrier and foil tape used shall be of Class 'O' as stipulated in BS 5422: 2009.

6.2.11.5 INSULATION THICKNESSES

All chilled water pipes, refrigerant pipes, ductwork and/or plant equipment carrying warmed or chilled air shall be insulated with minimum insulation thickness in accordance with Code of Practice for Energy Efficiency of Building Services Installation. False ceiling void, except for a return air plenum or of perforated type, shall be regarded as the unconditioned space. If the proposed insulation thickness is deviated from the Code of Practice for Energy Efficiency of Building Services Installation, calculations showing the selection of insulation materials and thickness which can effectively prevent formation of condensation and meet the energy efficiency requirement shall be submitted to the Supervising Officer for approval.

SUB-SECTION 6.2.12

UNITARY AIR-CONDITIONER

6.2.12.1 GENERAL

Unitary air-conditioners shall include: -

(a) Single package unit;
(b) Packaged unit and remote condenser;
(c) Condensing unit and blower coils;
(d) Condensing unit with variable refrigerant volume flow and indoor fan coil units;
(e) Multi-split system; and
(f) Water-cooled package and water pump package

Unitary air-conditioners shall be factory fabricated and assembled. The equipment shall be rated and tested to meet the requirements of internationally recognised quality assurance standards approved by the Supervising Officer.

Refrigerants adoption for refrigeration and air-conditioning system in government building projects shall comply with flammability safety classification in accordance with this General Specification.

6.2.12.2 EQUIPMENT SUITABLE FOR LOCAL ELECTRICITY SUPPLY

Unless otherwise specified, electrical equipment of the unitary air-conditioners shall be suitable for use with 3-phase and neutral, 4-wire, 380V, 50 Hz or 1-phase and neutral, 2-wire, 220V, 50Hz source neutral earthed system with provision of bonding.

Transformer may be used for equipment operation on voltages other than those specified above. Whenever possible, these shall be installed within the unit.

6.2.12.3 SELECTION OF AIR-COOLED CONDENSERS AND CONDENSING UNITS

Air-cooled condensers and condensing units of unitary air-conditioners shall be selected to give rated capacity with condensing temperature not exceeding 50°C for the ambient condition as specified in this General Specification.

6.2.12.4 CASING OF CONDENSING UNIT

Casings of condensing unit of unitary air-conditioners shall be constructed of rigid galvanised sheet steel and painted, suitably reinforced with channels and sections to form a robust cabinet. Casing for outdoor installation shall be of weatherproof finish, preferably galvanised, painted or anodised aluminium.

6.2.12.5 COMPRESSOR

Compressors shall be rotary, scroll or reciprocating of either the hermetically sealed type or the semi hermetically sealed type. Compressor shall be complete with internal motor protection, lubrication, crankcase heater, and internal or external vibration isolation.

6.2.12.6 SUPPLY AIR FAN AND MOTOR

Supply air fans shall be centrifugal type of ample sized for operation against the specified static pressure. Fan motors shall be permanently lubricated and have adequate power so as to be non-overloading throughout the range of the fan characteristic. The motor shall be high efficiency motor.

6.2.12.7 COOLING AND HEATING COILS

Cooling coils shall be of the direct expansion type and constructed with copper tubes and aluminium fins to give high heat transfer performance. The coils shall have sufficient number of rows of tubes to provide efficient dehumidification of the air in addition to its cooling.

Heating coil shall be constructed with copper tubes and aluminium fins to give high heat transfer performance.

6.2.12.8 AIR FILTER

Air filters shall unless otherwise specified be of the washable panel type. The filter performance of air duct connection unit shall be referred to Sub-section 6.2. Higher filter efficiency shall be adopted to meet with the IAQ objectives.

6.2.12.9 AIR-COOLED CONDENSERS

Air-cooled condensers shall unless otherwise specified be suitable for outdoor installation with ample capacity to dissipate heat from the air conditioning system. Condenser coils shall be constructed with copper tube and aluminium fins with anti-corrosion coating.

6.2.12.10 ELECTRIC DUCTWORK HEATER

Electric ductwork heaters shall be provided for winter heating or re-heating.

6.2.12.11 REFRIGERANT PIPING

External refrigerant piping when required shall include all necessary valves, fitting and insulation. All insulation shall be properly protected with mechanical means such as metallic cladding or cement plastering and painting. Size of the refrigerant pipe and

fittings shall be in accordance with the recommended standards as stated in Sub-sections 6.1.6 and 6.2.6.

6.2.12.12 CONDENSATE DRAIN PIPE

Condensate drain pipe shall be adequate insulated and mechanical protected in accordance with Sub-sections 6.1.11 and 6.2.11 of this General Specification.

6.2.12.13 SAFETY CONTROL

Controls shall be factory wired. Field wiring in conduit or trunking shall be limited to interconnections between separate pieces of equipment and power wiring. Each unit shall be protected and controlled by a factory built control panel incorporating all necessary devices, switches, indicator, etc. Functions required shall include those such as isolating switches and emergency stop facilities.

Safety protections shall include low pressure cut out, high pressure cut out, low refrigerant temperature cut out, high compressor discharge temperature cut out, and other protections necessary for the proper and safe operation of the unit. Overload protections shall be provided as well.

6.2.12.14 OPERATIONAL CONTROL

For a conventional split type A/C unit, a wired or wireless remote controller shall be provided for the selection of room temperature setting, fan speed and timer setting. For an advance multi-zone modular split type and VRF system, the remote controller shall be of the liquid crystal display (LCD) type with an on-off switch for operational features such as speed selection, timer setting, temperature setting, self-diagnosis function and auto restart function.

6.2.12.15 SINGLE PACKAGED AIR-CONDITIONER

Single package unit shall be of the completely self-contained type with factory wired controls and factory assembled components and piping. The unit shall include one/two rotary, scroll or reciprocating compressors of either the hermetically sealed or semi-hermetically sealed type, condenser coil, condenser fan and motor, direct expansion cooling coil, blower, air filters, drier of the renewable cartridge type completed with isolating valve, expansion valve, controls and safety devices all housed in a weather-proof and metal casing of robust construction yet attractive appearance.

6.2.12.16 PACKAGED AIR-CONDITIONER WITH REMOTE CONDENSER

The unit shall contain all components factory assembled, (as the single packaged unit with the exception of the condenser), in a sturdy painted G.I. metal casing arranged for vertical or horizontal mounting inside the building.

6.2.12.17 SPLIT CONDENSING UNIT AND AHU

The condensing unit shall include rotary, scroll or reciprocating compressors, air-cooled condensing coils, fans and motors control and safety devices, piping and all necessary accessories factory assembled in a weatherproof painted G.I. casing. The refrigerant circuit shall be field connected to the matched AHU or fan coil units each completed with direct expansion cooling coil, expansion valve, blower with motor and the necessary number of air filters in a well-insulated, sturdy G.I. metal casing with paint to an attractive appearance.

6.2.12.18 VARIABLE REFRIGERANT FLOW SYSTEM

The air conditioning system shall be of the multi-zone modular split type. Each zone shall consist of one air-cooled outdoor condensing unit connected to a group of indoor fan coil units in one single refrigerant circuit. For multi compressors outdoor unit, compressor shall be incorporated with a frequency inverter control to achieve the optimum flow of refrigerant in response to the actual load.

6.2.12.19 ENERGY EFFICIENCY PERFORMANCE

All unitary air conditioners shall be selected aiming for the highest operation efficiency. The minimum Coefficient of Performance (COP) for Air-Cooled Unitary Air Conditioner and Water-Cooled Unitary Air Conditioner shall comply the minimum coefficient of performance requirements specified in Code of Practice for Energy Efficiency of Building Services Installation or specified in the Particular Specifications, whichever is more stringent.

SUB-SECTION 6.2.13

WATER HANDLING EQUIPMENT

6.2.13.1 FRESH WATER PUMP

6.2.13.1.1 Type

Pump for chilled water circulation or other fresh water pumping duties unless otherwise specified, shall be of one of the following types: -

(a) Centrifugal type with volute casing split on the centreline of the shaft with suction and delivery connections flanged and fitted to the non-removable half of the casing;

(b) End suction type, the pump set shall be installed with spacer type coupling so that the pump impeller can be dismantled from the motor side for servicing without disruption of the pipework nor dismounting the motor; or

(c) Vertical spindle type centrifugal pump installed on pump plinth or supported by pipework.

Where large static heads have to be pumped against, type (a)(ii) or (a)(iii) shall be used in multi-stage configurations. Generally, the type of pump required will be specified in the Particular Specifications and/or in the Tender Drawings. However, if this is not so, the type as detailed in (a)(ii) above shall be installed if suitable.

Motor efficiency for the pumps shall be of minimum IE4 under International Efficiency (IE) classes according to IEC 60034-30-1.

Noise level of all motors shall be in accordance with or better than the recommendation of BS EN 60034-9: 2005 and shall comply with EPD's requirements.

6.2.13.1.2 Materials of Construction

Unless otherwise specified, the materials of construction of the pumps shall be as follows: -

Casing	:	Cast iron / Stainless Steel
Impeller	:	Stainless steel / Zinc free bronze (*cast iron)
Shaft	:	Stainless steel
Sleeves	:	Bronze / Stainless Steel
Casing rings	:	Bronze / Stainless Steel/(*cast iron)
Shaft nuts	:	Bronze / Stainless Steel
Stuffing box housing	:	Cast iron / Gunmetal

Alternative materials subject to the approval of the Supervising Officer

Stainless steel shall be used for water with temperature >28°C.

6.2.13.1.3 Standards

(a) Casing Material

Unless otherwise specified for the above types of pumps, cast iron shall comply with BS EN 1561:2011 or ISO 185:2020 or stainless steel to AISI 316.

(b) Impellers & Guide Rings

The impeller shall be of the enclosed type and be of stainless steel to AISI 316.

Renewable guide rings shall be bronze and shall be provided in the casing, keyed to prevent rotation.

(c) Shaft, Sleeves and Glands

Stainless steel shall be to BS EN 10095:1999, BS EN ISO 683-3:2018, BS EN 10088:2014 and BS EN ISO 683-4:2018, ground and polished.

Bronze sleeves shall comply with BS EN 1982:2017 or ISO 197-4:1983 and shall be provided through the sealing glands to protect the shaft from wear. The sleeves shall be keyed to prevent rotation and secured against axial movement.

(d) Stuffing Boxes and Drain Piping

Cast iron stuffing boxes housing shall comply with BS EN 1561:2011 or ISO 185:2020. Gunmetal stuffing boxes housing shall comply with BS EN 1982:2017 or ISO 197-4:1983.Theyshall be of ample length with bronze lined gland and neck bush, fitted with approved packing and lantern ring water seal. Drain piping to the nearest builder's drain to remove gland leakage shall be provided. Alternatively, a mechanical seal may be offered. Mechanical seals shall be of leak free operation. The mechanical seal shall be the product of specialist proprietor and the materials used shall be suitable for the pumped liquid.

6.2.13.2 SALINE WATER PUMPS

6.2.13.2.1 Type

(a) These pumps shall be utilised for pumping seawater, brackish well water, or treated effluent water wherever these applications apply.

(b) Unless otherwise specified, the configuration of saline water pumps inside a building plant rooms shall be of the split casing type while for installation in the primary harbour side sea water pump chamber, pumps shall generally be of the vertical spindle type.

6.2.13.2.2 Materials of Construction

Unless otherwise specified, the materials of construction for saline water pump shall be as follows: -

Casing	:	Stainless steel
Impeller	:	Stainless steel
Shaft	:	Stainless steel
Sleeves	:	Stainless steel
Casing rings	:	Stainless steel
Shaft nuts	:	Stainless steel
Stuffing box housing	:	Stainless steel
Glands	:	Stainless steel
Lantern rings	:	Bronze

Note 1:Stainless steel shall be used for water with temperature >28°C.

6.2.13.2.3 Standards

(a) Casing

The casing shall be of stainless steel to BS EN 10283:2010 Grade 1.4408 or better.

(b) Impeller and Shaft Sleeve

Impeller and shaft sleeve of saline water pumps shall be of Stainless steel to BS EN 10095:1999 and AISI 316.

(c) For pumping seawater in harbour area, items (b) (i) & (ii) above shall not be used.

(d) The shaft shall be of stainless steel to BS EN 10095:1999, BS EN ISO 683-3:2018, BS EN 10088:2014 and BS EN ISO 683-4:2018, AISI 316, ground and polished.

(e) Stuffing Boxes and Drain Piping

Stuffing boxes shall be of stainless steel housing and ample length completed with bronze lined gland and necks bushes, fitted with approved packing and bronze lantern ring water seal. Drain piping to the nearest builder's drain for gland leakage shall be provided. Alternatively, a mechanical seal may be offered. Mechanical seals shall be of leak free operation. The mechanical seal shall be the product of specialist proprietor and the materials used shall be suitable for the pumped liquid.

6.2.13.3 BOILER FEED PUMP

Unless otherwise specified, all feed pumps for boilers handling hot water at 175°C and above shall have the major parts, i.e. casing, impeller, shaft and wearing rings made of stainless steel to AISI 316.

6.2.13.4 SUMP PUMP

6.2.13.4.1 Materials of Construction of Dry Pit Pump

Unless otherwise specified, the materials for dry pit non-clog pumps areas shall be as follows: -

Pump casing	:	Cast iron
Impeller	:	Cast iron (*stainless steel)
Shaft	:	Stainless steel
Sleeves	:	Stainless steel (*bronze)
Packing glands	:	Ductile iron (*bronze)
Casing bolts	:	Steel
Cap screw	:	Stainless steel
Key	:	Steel

*Alternative materials subject to the approval of the Supervising Officer

6.2.13.4.2 Materials of Construction of Submersible Pump

Unless otherwise specified, the materials for submersible non-clog pump shall be as follows: -

Pump casing	:	Cast iron
Impeller	:	Cast iron /stainless steel
Motor casing	:	Cast iron
Shaft	:	Stainless steel
Impeller screw	:	Stainless steel
Mechanical seal	:	Carbon (*ceramic faces or silicon carbine)
Base plate	:	Steel
Discharge elbow	:	Cast iron
O-ring seal	:	Neoprene

*Alternative materials subject to the approval of the Supervising Officer

6.2.13.4.3 General Requirements

All bolts nuts and fasteners shall be of stainless steel and electric cable entry shall be of watertight construction.

Sump pump for rainwater application shall generally be of materials complying with standards as specified for fresh water pump. Sump pumps for pumping other fluids shall be of materials compatible with the fluid that are being handled. If sea water is pumped, the pump materials

shall comply with Standards as specified for saline water pump. The sump pump shall operate automatically by float level control.

The guide bars and brackets for wet sump installation shall be of stainless steel to AISI 316.

Cable supports shall be of stainless steel. A safety provision shall be incorporated for automatic electrical disconnection of the supply in case of cable entry seal failure.

Pumps for flammable zones shall be equipped with flameproof submersible motor in compliance with BS EN IEC 60079-0:2018 and BS EN 60079-1:2014.

6.2.13.5 BORE WELL PUMP

All bolts, nuts and fasteners shall be of stainless steel and electric cable entry shall be of watertight construction.

Bore well pumps unless otherwise specified shall be of all stainless steel construction. The stainless steel shall be of Grade 304 for fresh water application while AISI 316 stainless steel shall be used for other water applications.

6.2.13.6 PUMP BASE PLATE

The based plate shall be made of cast iron or fabricated mild steel. Couplings shall be flexible of the steel pin and synthetic rubber bushing type, and fitted with steel guards.

6.2.13.7 VALVES

Automatic air valves, butterfly valves, check (non-return) valves and float ball valves, etc., shall be of requirements as specified in Sub-section 6.2.9.

6.2.13.8 VIBRATION ISOLATORS

The bases shall be mounted on the raised housekeeping plinth using appropriate anti-vibration spring mountings that shall be individually selected according to load distribution and shall have an additional free travel equal to one half of the rated deflection as specified in Sub-section 6.2.8.

6.2.13.9 GAUGES

Gauges shall be in accordance with Sub-section 6.2.10.

6.2.13.10 DRAIN AND VENT

The drain vent shall be built-in completed with a drain plug except where the pump is inherently self-venting, the drain and drip connection valves and air cock shall comply with Sub-section 6.2.9.

6.2.13.11 FLANGED CONNECTIONS

Pumps shall have flanged connections conforming to the Table of BS EN 1515-1:2000, BS EN 1092-1:2018, BS EN 1092-2:1997, ISO 7005-1:2011 or ISO 7005-2:1988 as appropriate to the maximum working pressure. Taper pieces shall be provided where necessary for connection to pipework.

6.2.13.12 WATER FILTERS

The materials used in water filters shall not corrode or cause corrosion in the water and shall generally be as specified for water-cooled condensers and water chillers.

6.2.13.13 AUTO STRAINERS

The strainer shall be completed with a motor-controlled continuously rotating inner drum or stationary drum and equipped with an automatic backwash arrangement.

The unit body shall be provided with an inspection opening for visual checking. In addition, a drain opening with drain valve shall be provided at the lower part and connected to the nearest floor drain.

The straining element /screening drum shall be of stainless steel AISI 316 and shall be of the type and size suitable for removal of captured materials as specified in the Drawing/Particular Specification. A drip proof squirrel cage motor shall drive the inner drum, if the strainer is a rotating drum type, or to drive the rotating backwash arm if the strainer is a stationary drum type, with suitable geared facilities that shall be mounted on the top of the strainer body.

The body of the auto-strainer shall be of stainless steel AISI 316 cast iron to BS EN 1561:2011, ISO 185:2005, ASTM A278 Class 40 or carbon steel to BS EN 10095:1999, BS EN ISO 683-3:2018 or BS EN ISO 683-4:2018. Body of carbon steel shall be provided with internal coating or lining recommended by the strainer manufacturer and with zinc sacrificial anodes. It houses a rotating tapered drum attached to stainless steel shaft of AISI 316 or a stationary drum with rotating arm driven by stainless steel shaft of AISI 316 and backwash mechanism. The unit shall be suitable in operation under a pressure of 1034 kPa. Auto-strainer for handling sea water shall have its body of duplex stainless steel to ASTM A240 or EN 1.4410 or austenitic grey cast iron to ASTM A436 Grade 1B, or otherwise the materials of construction as specified in the Particular Specification of the Contract.

The automatic control of backwash arrangement shall comprise a motor-controlled valve on the outlet and an adjustable timer and differential pressure switch set to a maximum

pressure drop allowed to regulate the frequency of backwash. Such control shall interface with the Central Control and Monitoring System (CCMS) if available.

6.2.13.14 FEED AND EXPANSION FACILITY

6.2.13.14.1 General

For the purpose of this General Specification, the following definitions shall apply: -

(a) Cistern - An open top vessel; and

(b) Water Tank - A closed vessel.

6.2.13.14.2 Types of Cistern and Tank

(a) Cisterns and tanks shall be of one of the following types as below: -

(i) Welded or riveted mild steel, to BS 417-2:1987 Grade A, hot-dip galvanised after manufacture;

(ii) Pressed steel sectional to BS 1564:1975, heavily galvanised after manufacture; or

(iii) Fibreglass or plastics, for cisterns not exceeding 500 litre capacity to BS 4213:2004.

(b) Pressed steel tanks shall be of the externally flanged type and completed with all necessary tie rods. Galvanised mild steel cisterns and pressed steel tanks shall be cleaned and painted internally with two coats of an approved bituminous or epoxy solution or shall receive other such internal treatment as indicated in the contract Drawings or Particular Specification.

(c) Covers to Cisterns

Each cistern shall be provided with a loose cover formed in sections not exceeding 2 m long and 1 m wide. Covers for plastic or fibreglass cisterns shall be of the same material as the cistern body.

(d) Connections

Connections to mild steel cisterns and tanks shall be made by means of bossed, screwed flanges or pads and studs. Connections on mild steel cisterns shall be welded before galvanising. Flanges shall comply with BS EN 1092-1:2018 or ISO 7005-1:2011, ISO 7005-2:1988 and ISO 7005-3:1988.

SUB-SECTION 6.2.14

INDOOR AIR QUALITY EQUIPMENT

6.2.14.1 DESICCANT TYPE OUTDOOR AIR PRE-CONDITIONER

6.2.14.1.1 General

Dehumidifier shall comply with the minimum energy efficiency as specified in this General Specification unless otherwise specified in the Particular Specification.

6.2.14.1.2 Casing

The casing shall be constructed from 1 mm (Gauge 20) galvanised steel sheet with epoxy powder coating. The interior shall be insulated with at least 12 mm thick insulation material in order to prevent condensation on the interior and exterior of the casing.

6.2.14.1.3 Fan and Motor

The outdoor air and exhaust air fans shall be single inlet, single width, forward curve centrifugal fans. Impellers shall be statically and dynamically balanced. The exhaust air fan and the fresh air fan shall be driven by the same motor on a common shaft.

The motor shall be standard NEMA frame with open drip-proof enclosure and shall be suitable for 220V, single phase, 50 Hz electricity supply.

The motor shall have the minimum efficiency complying to Section 6.2.7 of this General Specification.

6.2.14.1.4 Total Heat Recovery Wheel

The total heat recovery wheel shall be in the form of a disc and of rotating type. The wheel is the media for sensible and latent heat transfer between fresh air and exhaust air. The wheel shall be driven by a motor and rotate across the intake and exhaust air streams.

The wheel shall be made from aluminium and coated with a layer of ceramic material to resist corrosion; and a layer of desiccant type non-migrating permanently bonded inorganic solid adsorbent.

The desiccant coating shall be sprayed on or dip-coated and shall not be required to re-apply onto the surface over the life of the wheel. The coating shall not support the growth of bacteria.

The desiccant shall be able to adsorb water vapour. The internal pore diameter distribution inherent in the desiccant being provided shall limit adsorption to materials not larger than the diameter of a water molecule

(2.8 Angstroms). The desiccant shall be potassium aluminosilicate and have a 3Å molecular sieve. Other materials will not be accepted.

The transfer media coated shall have equal sensible and latent effectiveness and the recovery efficiency shall be clearly documented through an independent test certification programme conducted in accordance with ANSI/ASHRAE Standard 84-2013 and AHRI-1060(I-P/2018) standards. The molecular sieve shall have high water pick up rate at both high and low relative humidity so as to give a constant effectiveness over the entire relative humidity range and to allow the wheel to be effective at high face velocities up to 5.5 m/s.

The media shall be able to be cleaned with low pressure steam or hot water without degrading or damaging the latent heat recovery and shall maintain a non-deliquescent state at all times. The pores of the desiccant shall be small enough to prevent from cross contamination.

The media shall induce laminar flow under all conditions inside the flutes and to enable the flutes to be self-cleaning (e.g. purging).

The wheel shall be independently tested; shall conform with the requirements of NFPA-90A:2021 and shall have a flame spread less than 25 and a smoke developed less than 50 when both rated in accordance with ASTM E84-18b.

The cross leakage of wheel shall not be greater than 5% of total air flow.

6.2.14.1.5 Filter

The filter shall be of washable type and about 25 mm in thickness.

The filter shall be listed by Underwriters laboratories as Class 2 and the filter efficiency shall be 30% to ANSI/ASHRAE Standard 52.2-2017.

6.2.14.1.6 Purge Sector

A purge sector shall be provided in the wheel so that the exhaust air shall not be carried over to the supply air.

6.2.14.2 PAPER PLATE TYPE OUTDOOR AIR PRE-CONDITIONER

The paper plate type outdoor air pre-conditioner shall be the product from a manufacturer holding the quality assurance standards of ISO 9001:2015 or products having equivalent functions or performance.

The pre-conditioner shall transfer both sensible and latent heat with same effectiveness and shall not support bacteria growth.

The casing shall be made of galvanised steel plate. The pre-conditioner shall be insulated with fire retardant, closed cell, flexible elastomeric thermal insulation in continuous length, factory applied on the inner surface. The insulation shall comply with the

requirements as stipulated in Sub-sections 6.1.11 and 6.2.11 of this General Specification.

The energy efficiency of the motor shall comply with the requirements as specified in Section 6.2.7 of this General Specification.

6.2.14.3 POLYESTER FIBRE TYPE OUTDOOR AIR PRE-CONDITIONER

The casing shall be fabricated from galvanised steel or equivalent material. Two aluminium filters shall be fitted on the air inlets of the casing.

The wheel shall be fabricated from corrosion resistant material and supported by bearings, which can be maintained or replaced without the removal of the rotor from its casing. It shall be driven by an electric motor with or without a gearbox and shall rotate across the two air streams to achieve the heat transfer. The energy efficiency of the motor shall comply with the requirements as specified in Section 6.2.7 of this General Specification.

The heat transfer media in the rotary wheel shall be polyester (P.E.) fibre of 25 to 150 μm in diameter with a surface density of 3.6 kg/m^2. The media shall not support the growth of bacteria. The calculation of efficiencies of sensible and latent heat recovery shall be based on ANSI/AHRI 1060:2018.

The media shall be securely held by a structural spoke system and shall be removable and washable. It can be cleaned with low pressure steam, water or light detergent without degrading the heat recovery effectiveness.

The unit shall have been tested to BS 476 Part 6 or equivalent and satisfied all stipulated requirements.

The unit shall have a sound pressure level less than 40 dBA at high flow measured at 1.5 m from the supply air discharge.

6.2.14.4 DESICCANT TYPE DEHUMIDIFIER AIR HANDLING UNIT

The rotor matrix is manufactured from alternative layers of flat and corrugated sheets of silica gel or lithium chloride, chemically bonded into a tissue of inorganic fibres. Rotor material shall be robust construction, incombustible, non-toxic and washable. Rotor shall be suitable for non-stop operation and the service life shall be 10 years minimum. The rotor shall be controlled by a variable speed motor in order to maintain the specified room condition. Rotor shall not have any loose powder in its structure.

Where heat pump refrigeration type dehumidifier was specified in the Particular Specification, it shall include at least evaporator, condenser, compressor and throttling device. Refrigerant shall be R-407C, R134a or other non-CFC refrigerant. The compressor shall be screw or rotary type with an electric motor. To avoid short cycling, the compressor shall be protected by a time delay during start up. Both the condenser and the evaporator coil shall be manufactured from copper tube with aluminium fins.

6.2.14.5 ELECTROSTATIC PRECIPITATOR

Electrostatic precipitators shall be of the type under the FSD's approved material list. Average efficiency of the auto clean electrostatic filter shall not be less than 90% rated at ANSI/ASHRAE 52.2-2017 "Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size".

Auto clean electrostatic filter shall consist of a washer/adhesive applicator section and an ioniser-collector section, with overspray filters, all factory assembled into a sectioned housing of overall depth not greater than 1 m in direction of airflow.

Each ioniser-collector section shall be finished with the required number of one-piece or multi-piece cells of aluminium construction. Each cell shall be fitted with stainless steel slides for mounting on the tracks which form an integral component of the side access housing and to facilitate removal of cells for servicing. Cell support framework shall be completely open beneath the ioniser-collector section to ensure complete drainage of wash water and excess adhesive, minimising the possibility of short circuits when high voltage power is restored following completion of the wash cycle. Cells shall be constructed so that high voltage input terminals and the high volt rated glass or ceramic fill polyseal insulators are located completely out of contact with the moving air-stream to avoid buildup of dirt which could permit dissipation of high voltage charge and reduce air cleaning efficiency. The high voltage bus-bars and terminals (contactors) shall be inherent to each cell and shall permit cell removal without disconnecting any high voltage wiring. Insulators shall be fully exposed, for ease of cleaning, when cells are removed for service. Cells shall be constructed for full face ionisation and have completely flat collector plates to prevent buildup of residual, inaccessible dirt accumulations.

Each washer/adhesive applicator section shall incorporate slide-in type, perforated, galvanised steel air distribution baffles and a header assembly which connected to the inlet water solenoid valve and to the adhesive pump by means of copper piping and/or non-snag, expanded PVC hose with a braided polyester exterior protective cover. Washer rams, each equipped with multi-directional, 360^{o} washer spray nozzles, shall be driven by reactive force from inlet water pressure. The removable brass adhesive nozzles shall be mounted on a separate, fixed, vertical header forming an integral component of the assembly. The filter adhesive shall be cold water soluble and made of non-flammable material. Rotary gear adhesive pump with bronze impeller and sufficient adhesive for reconditioning cycle shall be supplied.

The power shall be of solid state, having single or multi steps, relays for remote indication of status of the power and solid state voltage supply, and "fail-safe" low voltage relays to interrupt power to the ioniser circuit in the event of a malfunction in the plate circuit. Power pack covers shall each include neon glow lamps to indicate status of the power and solid state voltage supply. The power pack shall also include safety provisions of a circuit breaker, a reset button, safety type door interlock switches.

6.2.14.6 ELECTRONIC AIR CLEANER

The electronic air cleaner shall be capable of removing odours of bacteria, organic and chemical origin and shall also be capable of reducing airborne bacteria and particulate in the treated area as specified.

The electronic air cleaner shall be tested by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved to show the removal efficiency to be not less than 95% of airborne bacteria (total count), 95% of airborne particulate of 0.5 micron to 5.0 micron, 95% of cigarette smoke particles, 80% of odours and 95% of hydrogen sulphide.

The maximum output voltage of the electronic air cleaner shall be less than 3,000 volts.

The electronic air cleaner shall not generate ozone in excess of 0.05 part per million by volume(ppmv) of air circulating through the air cleaner according to the standards specified by the Food & Drug Authority (FDA) of USA.

The electronic air cleaner shall consist of a power generator and screw-in electrode tubes. The length of each electrode shall not be less than 400 mm. The number of electrodes required shall be able to handle maximum return air of system application.

The power generator of the electronic air cleaner shall be able to operate on the single phase mains power supply. The power generator shall be equipped with built-in regulator for output adjustment. The power generator shall also be fitted with on/off switch, on/off indicator lamps, output regulating rotary switch, overload circuit breaker and electrode tube sockets.

The electrode tubes shall consist of screw-in base and a glass tube. The electrode tube shall be protected with a stainless steel mesh and shall be earthen by means of a firmly fixed grounding wire to the power generator.

The air purifier shall be controlled in auto or manual mode. In auto mode, the electronic air cleaner shall be switched on/off at a pre-determined time period.

All materials used in the air supply stream shall not emit any harmful if case of fire and shall be tested to surface flammability test UL 94-5VA and BS 476 Part 6.

6.2.14.7 GERMICIDAL ULTRAVIOLET (UV) AIR STERILISER

The material and equipment specification shall refer to Section 6.1.1.16 - UV sterilising light assembly.

6.2.14.8 WATER SCRUBBER

The material and equipment specification shall refer to Section 6.2.1.19 – Water Scrubber.

SUB-SECTION 6.2.15

WATER TREATMENT SYSTEM

6.2.15.1 ELECTROCHLORINATOR FOR SEAWATER TREATMENT

Electrodes shall be made of high corrosion resistant material, in particular, anodes shall be made of titanium substrate coated with protective oxide.

Integral safety facilities in the electrolytic cells such as water flow switch and cell voltage imbalance detector shall be provided to prevent build-up of hydrogen gas by-product. Vent and other necessary facilities shall be provided to dilute and disperse the hydrogen gas from the degas tank or degas cyclone to outdoor safely according to the requirements specified in the Particular Specification and the FSD's statutory requirements.

6.2.15.2 EQUIPMENT FOR SEAWATER TREATMENT BY BIOCIDES

6.2.15.2 Chemical Tank

Chemical tank shall be completed with cover of high rigidity fibreglass or polyethylene having suitable moulded recessed or other approved arrangements to support mountings of metering pump, agitator and liquid level controller switch.

The tank shall be graduated in 10 litre steps and shall have the maximum storage capacity with its chemical name labelled on the tank body for easy identification.

The tank shall be suitable for mixing the specified chemicals and be suitable for solutions at temperatures of up to 40°C.

Each tank shall have a strong flat bottom providing adequate support when full such that the outer perimeter of the tank shall not be forced up by water pressure causing the bottom to bulge.

6.2.15.3 Chemical Metering Pump

Chemical metering pump shall be suitable for 100 : 1 output range facilitated by means of independently variable stroke length and stroke frequency. Pump housing shall be of corrosion resistant glass fibre reinforced polypropylene and all electrical/electronic components shall be encapsulated. If necessary, anti-siphon/pressure release valve mechanisms shall be provided to ensure anti-siphon protection plus priming ease, even under pressure.

The pumps shall have an acrylic/polypropylene pump head, PVC/polypropylene fittings, ceramic valve balls, metal reinforced Teflon diaphragm, Teflon seal rings and liquiform face, anti-siphon mechanism. The discharge tubes shall be 10 mm internal diameter and of suitable PVC to transport the solutions involved.

6.2.15.4 Chemical Tank Agitator

Motor casing and screws shall be manufactured in nonferrous metal.

6.2.15.5 Chemical Tank Liquid Level Switch

The liquid level switch casing shall be manufactured from corrosion resistance material.

6.2.15.3 OZONE GENERATION SYSTEM FOR COOLING WATER TREATMENT

Ozone generation system shall be constructed in modular form which shall comprise major equipment modules of pressure swing absorption type oxygen generator, high frequency ozone generator, ozone injector/contactor, solid particle separator, circulating pumps, piping, pipe fittings, all necessary accessories, wiring, controls and instrumentation. The modular enclosure shall be ease of maintenance and safe operation with demountable panels, hinged doors, visual panels and adequate electrical segregation for the high voltage section.

All components in contact with ozone produced shall be made of ozone resistant material for continuous and prolonged usage without deterioration or damage. Unless otherwise specified in the Particular Specification, all system components in contact with ozonated water shall be made of stainless steel to AISI 316. In particular, Teflon tubing shall be used for connecting ozone generator and in-line injector, Polyflo tubing for oxygen conveying pipe, UPVC piping and fittings for other interconnecting pipework.

Ozone generating equipment shall comprise, inter alia, the following component: -

(a) Pressure Swing Absorption Oxygen Generator

The oxygen generator comprises a built-in oil-free compressor for air compression, air dryer pre-chiller, an automatic high efficient desiccant air dryer with marcoporous drying agent, a nitrogen absorption tank to produce constant and stable supply of oxygen with purity 85% ±5%. Regeneration shall be accomplished by heating the desiccant material and purging it with a small flow of dried air to expel moisture when they are saturated with moisture.

A dewpoint monitoring system shall be incorporated, which comprises a control unit and measuring probe situated within the pipework leading from the air dryer to the ozone generator. The monitoring system shall automatically stop the ozone production with an visual and audible alarm in case of an increase in dewpoint over a preset value in order to prevent failure or damage to the ozone generator.

Air dryer pre-chiller shall reduce the incoming air temperature to approximately 10°C or other optimum operating temperature recommended by the manufacturer to suit the type of desiccant used.

(b) Ozone Generator

The ozone generator unit shall comprise independent solid-state high frequency ozone generator modules, air-cooled plate type and constructed of either sandwich heat dissipating structure with ceramic coated steel plate discharge electrodes or cylindrical concentric ozone generating tube.

Each module shall be equipped with built-in safety circuit to give visual and audible alarm and to switch off the generator when abnormal operation of the generator occurs. Relevant type-test or factory test certificates of the generator's high voltage transformer section as listed below shall be submitted for verification of safe operation: -

- Voltage ratio and phase relationship test;
- Induced over-voltage withstand test;
- Insulation resistance test; and
- High voltage withstand test.

The following safety controls shall be provided as minimum: -

- Door mechanically interlocked with the main isolating switch;
- Over current cut-out;
- High temperature cut-out;
- Low air flow or low cooling water cut-out as appropriate;
- High dew point cut-out;
- High/low voltage cut-out;
- External fault cut-out (if external devices connected); and
- Isolation of power supply when panel doors or side panels are opened.

(c) In-line Injector/Contactor

The in-line injector shall be venturi type completed with double check valves fabricated of Kynar or products having equivalent functions or performance.

(d) Solid Particle Separator

The separator shall be fabricated of Noryl plastic or products having equivalent functions or performance selected to suit system flow rate and requirements.

(e) Circulating Pump

The circulating pump shall be compatible with the ozone system and supplied by the same ozone equipment supplier. The pump shall comply with relevant sections of this General Specification.

SECTION 6.3

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 6.3.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

6.3.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

6.3.1.2 INDOOR AIR QUALITY ASSESSMENT AND CERTIFICATION

6.3.1.2.1 Scope of Works

Indoor air quality (IAQ) assessment, certification and registration in according to the Guidance Notes issued by the EPD shall be conducted. The scope of assessment and certification shall basically include enclosed areas for the use as offices or public places which are served by air-conditioning and mechanical ventilation system, and any other areas as specified in the Particular Specification.

The IAQ assessment and certification process shall be in according to the Guidance Notes for the Management of Indoor Air Quality in Offices and Public Places and A Guide on Indoor Air Quality Certification Scheme for Offices and Public Places issued by the EPD. The number of measurement and sampling points for each assessment shall be at least 10% more than the minimum number of sampling points required by the EPD's Guide.

IAQ assessment shall be performed as the last part of the testing and commissioning process upon completion of the ACMV installation. Further assessments shall be done six months after the building has been occupied and at two months before the expiry of the Maintenance Period, or at interval agreed with the Supervising Officer.

IAQ assessment report covering the methods of measurement, the models and serial numbers of the instruments with date of calibration used in the measurement and assessment, the locations of assessment and sampling as well as the results of the assessment shall be submitted to the Supervising Officer after each assessment. Recommendation to improve the indoor air quality condition shall be provided in the assessment report should any result fail to meet the IAQ objective for individual parameters.

IAQ Certificate Issuing Body (CIB) accredited by the Hong Kong Accreditation Services (HKAS) shall be engaged for the IAQ assessment and certification. The number and covering scope of certificates sign off by the Approved IAQ Signatory and to be issued by the IAQ CIB shall be agreed with the Supervising Officer before the IAQ assessment.

6.3.1.2.2 IAQ Assessment and Certification Process

Before IAQ measurement, the Approved IAQ Signatory of the IAQ CIB shall conduct walk-through inspections on the areas with the owner / building management of the building. The Approved IAQ Signatory shall gain visual appreciation of the areas' hygienic and maintenance condition to check whether the areas have IAQ problems, and provide recommendations and professional advices to address the IAQ problems or improving the IAQ, if any. The Approved IAQ Signatory shall also submit an IAQ certification inspection proposal to the Supervising Officer for approval before on-site inspection.

The IAQ certification inspection proposal shall be determined by the Approved IAQ Signatory based on the knowledge of the areas to be certified in terms of their usage pattern, worst case situations, configuration of the ACMV systems, and any other findings obtained from the walk-through inspection. It shall include at least the following: -

(a) IAQ parameters;

(b) Sampling criteria;

(c) Sampling period;

(d) Number of sampling points;

(e) Plan showing locations of measurement and sampling point;

(f) Measurement and assessment methods;

(g) Measurement and sampling equipment; and

(h) Personnel assigned for the activities.

The measurement and sampling equipment and methods for the certification inspection shall be those approved by the HKAS.

If there are no obvious irregularities identified during the walk-through inspection or the irregularities have been rectified, the Approved IAQ Signatory and Approved IAQ Inspectors shall conduct IAQ measurements and mould assessments at the areas to be certified. Airborne bacteria test samples shall be collected on site by the Approved IAQ Inspectors and be transported and delivered to the accredited laboratory under supervision of the Supervising Officer's representative.

Besides making IAQ measurements and mould assessments at areas to be certified, the Approved IAQ Signatory and Approved IAQ Inspectors shall conduct one outdoor air measurement at each fresh air intake to the ACMV system.

Within twelve weeks from the completion of on-site IAQ measurements and mould assessments, the IAQ CIB shall submit Hong Kong Inspection Body Accreditation Scheme (HKIAS)'s Endorsed Inspection Reports and Certificates, together with executive summary of the IAQ certification inspection signed off by the Approved IAQ Signatory directly to the Supervising Officer. The Report shall include professional advices to the owner / management of the building on measures to manage post-certificate indoor air quality in the certified areas.

The result of the IAQ certification inspection shall be kept confidential. Confidentiality clause in the agreement with the IAQ CIB shall be included to safeguard the confidentiality of the IAQ measurements and mould assessment results.

6.3.1.2.3 IAQ Audit

The representative of the Employer may carry out audit on the IAQ certification inspection, including audit of on-site IAQ measurement and mould assessment activities. Upon the request of the Supervising Officer, the IAQ CIB shall submit all the information including but not limited to details of IAQ measurement and mould assessment procedures, worksheet records, log sheet records, chain-of-custody log, records of equipment calibration and verification, etc. to the auditor assigned by the Employer. The IAQ CIB shall also cooperate with the auditor to facilitate the smooth audit exercise. Remedial actions and follow up actions resulted from the audit shall be carried out to the satisfaction of the auditor.

SUB-SECTION 6.3.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

6.3.2.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during Maintenance Period shall also comply with the specific requirements in this Sub-section.

Operation, servicing and maintenance of the Installations, if specified, shall also refer to the equipment manufacturer's recommendations and specifications.

6.3.2.2 INSTRUCTION TO OPERATION

After the Works has been successfully handed over and put into operation, full time attendance for a period of at least 20 consecutive days or as stated in the Particular Specifications, by a qualified operator(s) who shall be fully conversant with the operation and maintenance of the plant shall be provided. Their duties shall be to operate the systems and to guide and instruct the operation staff such that they will become fully conversant with the operation of the complete Installations.

6.3.2.3 WATER TREATMENT SYSTEM

No matter which type of water treatment system is offered, adequate on-site operational training and demonstration of the water treatment system operation shall be provided to the operation and maintenance staff prior to final handover of the system or after certified completion of the Installations. It shall include, but not limit to, the following: -

(a) Familiarisation of equipment and system including function of each dosing chemical;

(b) Water treatment equipment set-up/adjustment;

(c) On-site training of water sampling and testing, equipment and system operation and maintenance procedures;

(d) Precautions in handling the chemicals and the remedial actions following a spillage and accidental human contact;

Competent persons from the approved water treatment specialist and equipment suppliers shall conduct the on-site training with full day in-hand training.

6.3.2.4 ANNUAL INSPECTION AND CERTIFICATION

Annual inspection and submission of ventilation certificate for the ventilating system of the completed Installations as required under Building (Ventilating Systems)

Regulations to the Director of Fire Services shall be completed before the expiry of the Maintenance Period.

6.3.3.5 SPECIAL OPERATION AND MAINTENANCE SERVICES DURING MAINTENANCE PERIOD

Special Operation and Maintenance Services during the Maintenance Period shall be provided when specified in the Particular Specification.

The services shall be commenced upon substantial completion of the Works being certified by the Supervising Officer. Competent, experienced and qualified staff and workshop facilities to undertake the special services shall be provided. Detailed information of the organisation, workshop facilities and list of contact persons of the maintenance services team shall be submitted to the Supervising Officer for approval one month before the anticipated substantial completion.

The responsibilities and requirements of the special services are as follows: -

6.3.2.5.1 General

(a) Inspection, checking, servicing, maintenance and repair including replacement of parts and components due to normal tears and wears;

(b) Emergency inspection, checking and servicing, repair and rectification work;

(c) Provide skilled craftsmen to assist the start-up, control, performance monitoring and shut-down of the plant;

(d) Test and commissioning of the Installations after the completion of services, maintenance and repair; and

(e) Submission of services record and test report.

6.3.2.5.2 Provide labour, minor spare parts, components and consumable materials in the following services

(a) Consumable materials such as re-filling of refrigerant and lubricant, renewal of v-belts for blower motor as and when required/necessary;

(b) All cutting and waste, packing, carriage, risk, moving, hoisting and fixing at the required position;

(c) Repairs including first line attendance, emergency and miscellaneous repairs, plants, tools, vehicles for transportation of material for purposes of execution of work; and

(d) Preparation and submission of records/reports, in compliance with miscellaneous requirements.

6.3.2.5.3 Plant Log

Summary reports contain the daily record of the following data shall be submitted at three months intervals: -

(a) supply and return chilled water temperature;

(b) lubrication oil pressure gauge readings;

(c) refrigerant pressure gauge readings;

(d) system chilled water flow rate;

(e) circulation pump suction and discharge pressure;

(f) refrigerant compressor suction and discharge pressure; and

(g) dry and wet bulb temperature of supply air at designed offices, function and conference rooms and that of return air at system return and outdoor air condition.

6.3.2.5.4 Monthly Works

(a) General

- To check the general condition of the plant and equipment such as chillers, compressors, condensers, heat recovery equipment, heat pumps, IAQ equipment, coils, chilled water pumps, make-up water tanks, air handling units, fan coil units, water treatment equipment and the associated electrical, electronic, mechanical controls and circuit boards. To ensure that the plant and equipment are satisfactorily operating;

- To drain and clean the pre-filter and after-filter of the pneumatic control system, and clean the refrigerated drier and after-cooler, if any;

- To check the lubricating system of all running pumps, cooling fans, fan blowers, compressors, control mechanisms and any other running parts; cleaning, greasing and oiling where necessary;

- To check any water leakage from the pipework and to repair if required;

- To keep all supply and return grilles and louvers clean;

- To check the corrosion of metal surface, framework and support/mounting brackets, etc., and to reinstate the surface by removing rust and repaint if necessary;

- To check the operating conditions of water cooling tower including the running current, water refilling rate, water quality and other important operating parameters; to conduct water quality and bacterial test; and to make all necessary submission to the regulating authority (including monthly operational records in Form CT3 to EMSD); and

- To check and ensure that the operation conditions of the water treatment system are in accordance with the Specifications and recommendation by the manufacturer.

(b) Refrigerant Compressors, Chillers, Condensers and Heat Pumps

- To check for proper operation of the refrigeration machines and related controls, control circuit, and detect any abnormal noise and vibration, repair or adjust as necessary;

- To check and record on log sheets and where appropriate on system performance sheet the refrigerant compressor suction and discharge pressures, chilled water inlets and outlet temperature, condenser air inlet and outlet temperature and motor current;

- To check condition of operating refrigerant, liquid level and lubrication level, refill or renew as necessary;

- To examine the condition of joints, stop valves, covers and seals for leaks, repair as necessary;

- To remove debris and maintain the condenser in clean and tidy condition;

- To check driving belts for proper tension and correct alignment, adjust and renew belts and lubricate bearings; and

- To check the vibration of machines as compare to the recommendations by the manufacturer for future baseline monitoring and maintenance.

(c) Motors for all motorised devices and equipment

- To clean motor casing, grease and lubricate;

- To check and report any abnormal running noise and vibration. Replace the bearings, perform megger test on motor and repair as necessary; and

- To check, adjust and rectify/repair defect on circuit protective devices such as starters, control relay and indicators.

(d) Pumps

- To visually inspect the pumps, check for abnormal running noise and vibration;

- To check and record on log sheets and where appropriate on system performance sheet the water pump suction and discharge pressure and motor current;

- To check condition of gland for excessive wear. Replace if necessary;

- To check drains are not clogged and rectify if necessary;

- To check pump bearing temperature thermostat and repair if necessary;

- To operate the vent valves once;

- To check for proper operation of flow switch control system and safety device, rectify if necessary;

- To clean suction strainer;

- To check for proper function of makeup system to the chilled water or hot water circuit, rectify if necessary; and

- To check for correct alignment of the motor and pump, rectify if necessary.

(e) Air Handling Units

- To check that the air handling units and related controls and control circuits are operating properly. Repair or renew if necessary;

- To check and record on log sheets and where appropriate on system performance sheet the air handling units operating conditions including motor current, chilled or hot water inlet and outlet temperatures, return and mix air temperatures, off coil, and supply air temperature and humidity;

- To check condensing water drain pan, drain pipe and floor drain to ensure no clogging and flooding. Rectify if necessary;

- To clean and renew air filter as required;

- To check driving belts for proper tension and correct alignment, adjust and renew belts and lubricate bearings as required;

- To check the operation of control valves and isolating valves, rectify as required;

- To clean the fresh air inlet, exhaust air louvers, air dampers, accessible internal ductwork surfaces and fan blades; and

- To check the heaters for proper operation. Rectify if necessary.

(f) Fan Coil Units

- To check that the fan coil units and its control/sensing devices are functioning properly and inspect drain pipes to ensure no clogging and flooding. Rectify if necessary;

- To check and clean the condensing water drain pan, drain pipes to ensure no clogging and flooding. Rectify if necessary;

- To clean the supply and return air grilles and filters; and

- To check the heaters and their control/protective devices for proper operation. Rectify if necessary.

(g) Heat Exchanger (include calorifier)

- To check on all joints for leak. Rectify if necessary;

- To examine all mountings (gauge, pressure relief valve, etc.) to see that they are not damaged or leak and ensure that they are in working order; and

- To check the temperature settings and functioning of the controls and ensure compliance with manufacturers' standards.

(h) Mechanical Ventilation System

- To clean fan blade and blades for wear and damage;

- To check and if necessary to lubricate fan and motor bearings;

- To check the fan belt and to adjust and replace it, if necessary;

- To check flexible connections and that anti-vibration mountings are free to move, and function properly;

- To clean the air filters, supply and return air grilles and to renew air filters if necessary;

- To check the operation and function of the control devices;

- To check all electrical wiring and connections and circuit protection devices including switchgears and starters. Rectify if required; and

- To clear the vanes in the ductwork.

(i) Equipment

- To check and service all IAQ equipment including air cleaner, UV light chambers and other filtration and sterilising system and equipment for IAQ; and

- Take measurements of IAQ parameters and submit records to the Supervising Officer.

6.3.2.5.5 Half-Yearly Works

Half-yearly service and maintenance shall include the following items: -

(a) To inspect the condition of pipe fittings, supports, ductwork, hangers, etc., for sign of corrosion. Remove the rust and repaint with primer and finish coating as necessary;

(b) To check the performance of controls and safety cut-outs and check all control panel indication lamps, rectify as required;

(c) To clean electrical panels including wiring terminals and connection points;

(d) To touch up with finish-coating where there is any rust or sign of corrosion of the equipment by first removing the rust/corrosion;

(e) To check and adjust, if necessary, the air flow in the air-ductwork system;

(f) To clean all the air-cooled condenser coils by high-pressure water or steam jet with approved cleaning detergent to ensure that high heat transfer efficiency is maintained;

(g) To clean the cooling/heating coils (excluding fan coil units) by high-pressure water or steam jet with approved cleaning detergent to ensure that high heat transfer efficiency is maintained;

(h) To check and serve all IAQ control and sensing equipment including CO_2 sensors, air movement sensors, thermostat, humidifiers, dehumidifiers, humidistat, pressurestat and volume control dampers;

(i) To inspect all components of ventilation system for cleanliness and microbial growth and clean them as; and

(j) To clean, dislodge and disinfect cooling towers as per requirements stipulated in the Code of Practice for Fresh Water Cooling Towers published by the EMSD.

6.3.2.5.6 Annual Works

(a) To inspect the condition of pipe fittings, supports, ductwork, hangers, etc., for sign of corrosion. Remove the rust and repaint with primer and finish coating as necessary;

(b) To check the condition of pipework and ductwork. Recondition and if instructed, replace the deteriorated portion in accordance with the Specification, acceptable engineering practice and standard;

(c) To refit the isolating valves, change the valve gland and gasket, and recondition the globe valves, etc. if necessary;

(d) To examine, check and maintain the proper operation of associated electrical panels in the plant room. Repair and renew as appropriate;

(e) To check, test and recalibrate or replace as necessary, all control and safety devices;

(f) To check inlet guide vane of centrifugal compressor;

(g) To check, test, adjust, clean and repair/rectify defects if required for all electronic circuit boards and control/ sensing/ detection devices including building automation system if available in the system;

(h) To inspect and clean all internal surface of ductwork including the supply and return air plenums. The cleaning of ductwork shall not affect the normal operation of the building. The cleaning work shall be arranged after the building office hour unless otherwise agreed with the building owner;

(i) To inspect aluminium foil, paints or other concrete sealing layers and wall surface which meant to stop radon gas emission and provide all necessary touch up work;

(j) To check and re-tighten any loose bolts and nuts in proper sequence; and

(k) To arrange conducting of an annual operation and maintenance audit for fresh water cooling towers by an independent auditor as per requirements stipulated in the Code of Practice for Fresh Water Cooling Towers published by the EMSD prior to expiry of the 12 months Maintenance Period, and ensure submission of an annual audit report to EMSD.

PART 7 – ELECTRICAL INSTALLATION

SECTION 7.1

INSTALLATION METHODOLOGY

SUB-SECTION 7.1.1

GENERAL

7.1.1.1 MINIMUM SIZE OF CABLE CONDUCTOR

Cables for lighting, bell and control circuits shall have CSA of not less than 1.5 mm², and those for power circuits shall have CSA of not less than 2.5 mm². Internal wiring in factory made panel or equipment may comprise cables of different suitable CSA determined by the manufacturer.

The CSA of any cable shall not be reduced at its point of termination, junction, joints, etc.

Where stranded cables of 1.5 mm^2 are to be properly terminated, approximately 15 mm long of cable insulation shall be removed and half the length of the bare conductor shall be bent into the other half to form a solid part prior to the insertion into the termination.

7.1.1.2 USE OF PVC-INSULATED CABLE AT LOW TEMPERATURE

PVC-insulated cables shall not be installed in refrigerated space or other situations where the temperature is consistently below 0°C.

7.1.1.3 CABLE MARKERS IN ADDITION TO CABLE COLOUR IDENTIFICATION

Cable markers where necessary shall be provided to cables in addition to their colour identifications.

7.1.1.3.1 Cable markers for identification purposes shall comply with BS 3858:1992.

7.1.1.3.2 The physical dimensions of cable markers and all necessary accessories shall suit and fit the sizes of cables. Cable markers shall either be of closed type which have to be fitted to the cable before physical connection of cables or of open type which can be directly attached to the cables after connection.

7.1.1.3.3 The materials used for the cable markers and carrier strips shall be made from Halogen-free materials and flame resistance, having a service temperature range between -40°C to +70°C. They shall be of high mechanical strength, rigidity and hardness characteristics. The material shall also be chemical resistance against sodium hydroxide, seawater, detergent, petrol, diesel, sodium chloride solution, nitric acid, ammonium

hydroxide, etc. The colour of cable markers shall be yellow in accordance with the international colour-code.

7.1.1.3.4 The identification markings on the cable markers shall be printed in black colour. The printed characteristics shall withstand all the usual marker tests pertaining to resistance to smearing and scratching, and imperious to solvents such as acetone.

7.1.1.4 INSULATING MATERIAL

Insulating tapes for low voltage applications shall comply with IEC 60454-3-1:1998/AMD1:2001 pressure sensitive adhesive tape type F-PVC$_p$/90/0/T$_p$ (Plasticized PVC) and have a thickness of not less than 0.22 mm.

Non-impregnated paper, fabric, wood or press-hemp shall not be used for insulating purposes. Where synthetic resin bonded insulating boards are used, all cut edges shall be sealed with an approved varnish.

SUB-SECTION 7.1.2

WIRING SYSTEMS

7.1.2.1 WIRING IN STEEL CONDUIT SYSTEM

7.1.2.1.1 Type of Cable

Non-sheathed cable shall be installed in conduit system. Sheathed copper cable installed in conduit system is also acceptable. Cables for 3-phase circuit shall be 450/750 V grade or above.

7.1.2.1.2 Concealed Steel Conduit System

Unless otherwise specified in the Particular Specification or on the Drawings, conduits shall be concealed within walls, floor slabs, false ceilings, raised floor or other suitable space.

Chase for conduit to be concealed in wall, column or beam shall be vertical or horizontal.

7.1.2.1.3 Surface Conduit System

Unless otherwise specified in the Particular Specification or on the Drawings, surface conduit shall be run in a vertical or horizontal direction.

Conduit boxes, adaptable boxes and metal boxes for accessories shall be securely fixed to walls, ceilings or other substantial parts of a structure by means of suitable brass screws correctly spaced. The fixing of these boxes shall be independent of the fixing of the associated conduits.

7.1.2.1.4 Minimum Size of Conduit

The minimum outside diameter of any conduit shall be 20 mm.

7.1.2.1.5 Flexible Conduit

Flexible conduit shall be used as short as possible. The length of flexible conduit shall be not more than 1 m for general applications or 2 m inside false ceiling and raised floor. (Note: PVC pliable conduit may be used in place of steel flexible conduit wherever appropriate. In such case, requirements in Clause 7.1.2.3 shall apply.)

7.1.2.1.6 Conduit Continuity

The steel conduit installation shall be mechanically and electrically continuous throughout and effectively earthed.

Where the circuit protective conductor is formed by the conduits, the terminal of a socket outlet shall be connected by a separate circuit protective conductor having the same cross-sectional area and type as the

live conductor to an earth terminal incorporated in the associated metal box or enclosure.

Flexible conduit shall not be used as a circuit protective conductor. A separate circuit protective conductor having the same cross-sectional area and type as the largest live conductor shall be drawn into the flexible conduit for earth continuity. This circuit protective conductor shall be fixed to an earth terminal incorporated, at each end, in the metal boxes or enclosures onto which the ends of the flexible conduit are locked.

7.1.2.1.7 Joint in Conduits

Joint in steel conduits shall be made by means of a solid coupler into which the adjacent ends of the two conduits shall be inserted to approximately half into it and screwed up tightly in order to make the conduit run mechanically and electrically continuous. No threads on either conduit shall be exposed.

Running couplings shall not be used. In case where such a coupling cannot be avoided, approval from the Supervising Officer must be obtained before it is adopted. In this case, the coupler shall be screwed up tightly onto the short threaded portion of one conduit, the threaded portion of which shall project approximately half way into the length of the coupler. The threaded portion of the mating conduit shall also project approximately half way into the coupler. Electrical continuity shall be ensured by tightening up a hexagon locknut against the coupler. Any exposed threads on either conduit shall be painted with at least two coats of anti-rust paint.

7.1.2.1.8 Provision of Adaptable Box

An adequate number of suitably sized adaptable boxes shall be provided in all conduit runs to enable cables to be drawn in and out easily without damage. Adaptable boxes shall be provided immediately after every two bends, or after a bend plus a maximum straight run of 10 m, or after a maximum straight run of 15 m.

7.1.2.1.9 Spacing between Conduits

Adjacent or parallel conduits cast in concrete shall be separated by a spacing of not less than 25 mm so as to allow concrete aggregate to pass and set between them.

7.1.2.1.10 Termination of Conduits at Metal Casing of Equipment

Where a steel conduit terminates at a metal casing, a coupler and a brass male bush shall be used. The brass male bush shall be screwed into the coupler or adaptor from the inside of the metal casing through a clearance hole drilled in the metal casing to suit the bush. Both the conduit and the bush shall be screwed tightly into the coupler or adaptor so as to grip the metal casing securely for mechanical and electrical continuity. Threads on the steel conduit shall be at least half the coupler length. Connection

between flexible conduit and the adaptor shall be securely fixed. No threads on the metal casing shall be allowed.

In case of using flexible steel conduit, a brass adaptor together with a brass male bush shall be used. The brass adaptor shall comprise two parts, an inner core and an outer ferrule. The inner core shall screw into the bore of the conduit together with an outer ferrule which caps off the end of the conduit, so that the adaptor can provide an extremely strong joint. The core shall lock against the outer ferrule and isolate any sharp cut edges in the conduit.

Where a metal casing is painted or enamelled, the electrical continuity between the conduit and the casing shall be achieved by means of a separate circuit protective conductor of adequate size, connecting the earth terminal of the conduit and an earth terminal inside the metal casing. A copper earthing piece placed between the bush and the metal casing may be used as an earthing terminal of the conduit. Neither the paint nor the enamel shall be damaged or removed in order to achieve the electrical continuity.

7.1.2.1.11 Conduit Bend

Conduit shall not be bent more than 90 degrees. The internal radius of the bend shall not be less than 2.5 times the outside diameter of the conduit.

7.1.2.1.12 Conduit Crossing Expansion Joint

Where a steel conduit crosses an expansion joint, special arrangements shall be made to allow relative movement to occur on either side of the expansion joint. A separate circuit protective conductor (CPC) shall be installed in accordance with Clause 7.1.2.3.9 to maintain an effective electrical continuity across the expansion joint.

7.1.2.1.13 Use of Extension Piece

An extension piece shall be fitted to a conduit box where the plaster wall finish (including plaster) is more than 25 mm from the conduit box. Only extension pieces of the correct depth shall be used. Under no circumstances shall multiple extension pieces be permitted.

7.1.2.1.14 Prevention of Ingress of Foreign Matters

During the building construction, all open ends of the conduit termination, which are liable to be filled with water, moisture or other foreign matters, shall be plugged with approved conduit stopping plugs; paper, rag or similar materials shall NOT be used for this purpose. Steel conduit boxes in similar circumstances shall also be similarly plugged to prevent concrete aggregate or plaster from entering into the boxes during building construction.

7.1.2.1.15 Prevention of Accumulation of Water or Moisture

The conduits shall be so laid to prevent accumulation of condensed moisture and the ingress of water in any part of the installation.

Approved type of sealant for the prevention of condensed moisture shall be applied to ceiling conduit outlets installed in a cooled space subject to the influx of warm air.

7.1.2.1.16 Conduit Laid Direct in Ground

Steel conduits laid direct in ground or buried in soil shall be painted with two coats of bituminous paint and wrapped with self-amalgamating tapes or other wrapping materials for protection against corrosion and approved by the Supervising Officer.

7.1.2.1.17 Fixing of Distance (Spacing) Saddle

Saddles, for the support of surface conduits, shall be provided throughout the entire route at regular intervals. The spacing between adjacent saddles for steel conduits shall not be greater than those given in Table 7.1.2.1.17 (1) and Table 7.1.2.1.17 (2).

Each bend of a surface conduit shall be supported by a saddle on either side of the bend, and the saddles shall be fixed as near to the bend as practicable.

Saddles shall be fixed with brass screws in expanding plugs or other fixing devices approved by the Supervising Officer.

Table 7.1.2.1.17 (1) Spacing of Supports for Horizontal Conduit

Conduit size (mm)	Maximum distance between supports (m)		
	Rigid steel conduit	Rigid plastic/PVC conduit	Pliable/flexible conduit
20	1.75	1.50	0.40
25	2.00	1.75	0.60
32	2.00	1.75	0.60

Table 7.1.2.1.17 (2) Spacing of Supports for Vertical Conduit

Conduit size (mm)	Maximum distance between supports (m)		
	Rigid steel conduit	Rigid plastic/PVC conduit	Pliable/flexible conduit
20	2.00	1.75	0.60
25	2.25	2.00	0.80
32	2.25	2.00	0.80

7.1.2.1.18 Conduit Installed Outdoors or in Damp Situation

Where steel conduits are installed outdoors or in damp situations, all conduit fittings and conduit accessories shall not be placed in contact with other metals with which they are liable to set up electrolytic action. In addition, where the conduit installation is subject to weather, the conduit fittings and conduit accessories shall be provided with weatherproof sealant or other materials to ensure that the installation is completely weatherproof.

7.1.2.1.19 Swabbing Out of Conduit

Conduits shall be swabbed out and free from moisture before wiring work is to commence. The swabbing operation shall be witnessed by the authorised representative of the Supervising Officer. Only approved draw-in tape or steel wire of appropriate size and absorbent cloth shall be used.

7.1.2.1.20 Fire Barrier

Where a conduit passes through fire resistant structural elements, such as walls and floors designated as fire barriers, the opening made shall be sealed according to the appropriate degree of fire resistance of the wall and/or floor. In addition, where a conduit is installed in a channel, duct, ducting, trunking or shaft which pass through such elements, suitable fire-resistant barriers shall also be provided to prevent the spread of fire. Penetration seals for openings where conduit passing through the fire barrier shall be provided in compliance with Code of Practice for Fire Safety in Building.

7.1.2.1.21 Cable Capacity of Conduit

The number of cables drawn into a conduit shall be such that no damage will be caused to the cables or to the conduits during their installation.

In determining the size of the conduit, the “unit system” method shall be adopted. The sum of all factors for the cables as given in Table 14(2), 14(3) and 14(4) of the Code of Practice for the Electricity (Wiring) Regulations shall NOT be greater than the conduit factor as given on Table 14(3)(b) of the Code of Practice for the Electricity (Wiring) Regulations.

7.1.2.1.22 Method of Drawing Cables into Conduit

Conduit system shall be completely erected before cable is drawn in and there shall be adequate means of access for drawing cable in or out.

Cables shall be drawn into a conduit by using approved draw-in tape or steel wire of the appropriate size. Under no circumstances shall the use of lubricants, e.g. grease, graphite, talcum powder, etc., be permitted to assist in the drawing the cables.

Galvanised iron draw-wires of adequate size shall be provided in all empty conduits.

7.1.2.1.23 Segregation of Cables of Different Circuit Categories

Separate conduits shall be provided for cables of different circuit categories or using different voltage levels.

7.1.2.1.24 "Looping-in" Wiring System

Each cable in a run shall be of one continuous length and wired on the "loop-in" system. No joint in cable run shall be allowed.

7.1.2.1.25 Grouping of Cables in Conduit

Conduits running from a distribution board to the final distribution point may each contain all live conductors of a number of final circuits provided that the effective current-carrying capacity of all circuits, upon taking the correction factors into consideration, shall exceed the rating of their respective over-current protection devices and all conditions as stipulated in Clause 7.1.2.1.21 are satisfied.

For conduits serving final circuits direct from a distribution board or from an adaptable box used as a final distribution point, each conduit shall contain all live cables of one final circuit only except in the case of lighting final circuit where two circuits with 1.0 mm^2 or 1.5 mm^2 cables will be permitted in a 20 mm diameter conduit.

The neutral cable of a lighting final circuit using single core cables may be routed in the conduit direct to the lighting point without passing through the switch box.

7.1.2.1.26 Termination of Bonding Conductors at Conduit Installation

For surface conduit installations, the supplementary bonding conductors shall be terminated at the nearest conduit or conduit box forming an integral part of the conduit installation.

For concealed conduit installations, the supplementary bonding conductors shall be terminated at a copper earthing terminal fitted inside a metal box forming an integral part of the conduit installation. The metal conduit box shall be located as near as possible to the bonding position and the exposed part of the supplementary bonding conductor shall be made as short as possible.

7.1.2.2 WIRING IN STEEL TRUNKING SYSTEM

7.1.2.2.1 General

Where steel trunking is specified, they shall be installed neatly on the surface of the walls, columns, beams or flushed with floor screeding and shall be installed along a vertical or a horizontal plane.

The complete trunking installation shall be mechanically and electrically continuous throughout, and effectively earthed.

Wiring system in trunking installation shall consist of non-sheathed copper cables or sheathed copper cables. Cables for 3-phase circuit shall be 450/750 V grade or above.

Cables in each final circuit and/or in each sub-main shall be bunched and tied or clipped together.

Particular precaution shall be taken in situations where high temperature cables may be touched or where they may touch other materials.

Where cable trunking is required to be installed on floor to meet the site constraints and special environmental conditions, such as inside lift machine room, plant room, etc., this may be permissible subject to safety consideration, workmanship and approval by the Supervising Officer.

7.1.2.2.2 Provision of Cable Retaining Bar and Cable Support

Surface trunking, which is installed in such a position that the cables might fall out when the cover is removed, shall be fitted with cables retaining bars or other suitable devices to prevent the cables from falling out.

Surface trunking installed vertically with length exceeding 5 m shall contain sufficient supporting devices such as pin racks within the trunking to prevent strain on the cables due to the weight of the cables, and to prevent vertical movement of the cables.

7.1.2.2.3 Cable Capacity of Trunking

The number of cables put into a trunking shall be such that no damage is caused to the cables or the trunking during their installation.

In determining the size of the trunking required for a particular installation, the “unit system” method shall be adopted. The sum of all factors of the cables, as given in Clause 7.1.2.1.21 shall NOT be greater than the trunking factor as given in Table 14(4)(b) of the Code of Practice for the Electricity (Wiring) Regulations.

For sizes and types of cables and sizes of trunking other than those given in Clauses 7.1.2.1.21 and 7.1.2.2.3, the number of cables installed shall be such that the resulting space factor does not exceed 45%. The space

factor is expressed as the ratio (expressed as percentage) of the sum of the overall cross-sectional areas of cables to the internal cross-sectional area of the trunking in which the cables are installed. The effective overall cross-sectional area of a non-circular cable is taken as that of a circle of diameter equal to the major axis of the cable.

7.1.2.2.4 Correction Factor of Grouping

Where more than one circuit of single-core cables or more than one multi-core cables are enclosed in a common trunking, suitable correction factor for grouping, as recommended by IEC 60364 1:2005/COR1:2009 and other associated parts of the standard, shall be applied in determining the size of the cables to be installed. The effective current carrying capacity of all circuits, upon taking the correction factors into consideration, shall exceed the rating of their respective over-current protection devices and all conditions as stipulated in Clause 7.1.2.2.3 above are satisfied.

7.1.2.2.5 Segregation of Cables of Different Circuit Categories

Where a common trunking is used to accommodate cables for different circuit categories, they shall be effectively segregated by means of partitions or dividers except in the case where trunking is manufactured using two smaller pieces of trunking attached together with a common cover. The partitions or dividers shall be adequately secured to the body of the trunking.

For underfloor (duct) trunking, the partitions or dividers shall also be of full depth to provide support and strength to the top surface of the assembly.

7.1.2.2.6 Connection to Equipment

Connection between trunking and equipment shall be made by means of a standard flange coupling or an adaptor neck, fabricated or cast. For direct attachment of trunking to equipment, cable entries shall be provided with smooth bore bushes or grommets and the return edge of the lid of the trunking shall be left intact.

7.1.2.2.7 Connection to Distribution Board

Where connection is made between trunking and a distribution board, the connectors for cable entry shall be sized to accept all cables from all available circuits including circuits marked as “spare”.

7.1.2.2.8 Fixing of Surface Trunking

Individual pieces of trunking shall be independently supported by means of at least two fixed points per piece. On straight runs, supports for trunking shall be fixed at regular intervals with maximum spacing as given in Table 7.1.2.2.8. For runs with bends, supports shall be fixed as near to the bend as practicable.

Overhead trunking shall be suitably supported by means of mild steel hangers, brackets or other approved means, so that no visible sag is observed when loaded with cables. Unless otherwise specified the hangers or brackets shall be hot-dip galvanised, painted with anti-rust epoxy coating or the use anti-rusting material to prevent corrosion.

Table 7.1.2.2.8 Spacing of Supports for Cable Trunking

Trunking cross-sectional area (mm^2)	Maximum distance between supports (m)			
	Steel trunking		Plastic/PVC trunking	
	Horizontal	Vertical	Horizontal	Vertical
Exceeding 300 but not exceeding 700	0.75	1.0	0.50	0.50
Exceeding 700 but not exceeding 1,500	1.25	1.5	0.50	0.50
Exceeding 1,500 but not exceeding 2,500	1.75	2.0	1.25	1.25
Exceeding 2,500 but not exceeding 5,000	3.0	3.0	1.50	2.00
Exceeding 5,000	3.0	3.0	1.75	2.00

Note 1 : The spacing tabulated above assume that the trunking is not exposed to mechanical stress other than that due to the weight of the enclosed cables, and the trunking and fittings.

Note 2 : The above figures do not apply to trunking which is used for supporting luminaires or other equipment.

7.1.2.2.9 Cables through Trunking

Cables penetrating through trunking shall be protected by conduits except insulated and sheathed cables if such cables form part of a surface wiring system. In such case, the holes in the trunking, through which such cables penetrate, shall be fitted with suitable rubber grommets or insulated bushes.

7.1.2.2.10 Fire Barrier

Where a trunking passes through a fire resistant structural element, such as floor and wall, having specified fire resistance, the opening thus formed shall be internally and externally sealed with approved type of fire resisting material according to the appropriate degree of required fire resistance. Penetration seals for openings where trunking passing through the fire barrier shall be provided in compliance with Code of Practice for Fire Safety in Building.

7.1.2.2.11 Prevention of Electrolytic Action

Where a trunking is installed in a damp situation, or where a trunking is likely to be exposed to weather, the trunking shall be kept away from other metalwork with which electrolytic action is liable to incur.

7.1.2.2.12 Prevention of Ingress of Water

Every entry to a trunking shall be so placed as to prevent or to be protected against ingress of water.

7.1.2.3 WIRING IN PLASTIC CONDUIT OR PLASTIC TRUNKING SYSTEM

7.1.2.3.1 General

Wiring in plastic conduits or plastic trunking system shall comply with the relevant Clauses 7.1.2.1 and 7.1.2.2 where appropriate.

PVC conduit shall be heavy duty and shall not be used for installation where the ambient temperature exceeds 60°C or below minus 5°C.

Conduits may be corrugated, plain or reinforced. Suitable conduit cutter shall be used for cutting rigid PVC conduit.

7.1.2.3.2 Pliable Conduit

Pliable conduit shall be used as short as possible. The length of pliable conduit shall be not more than 1 m for general applications or 2 m inside false ceiling and raised floor. Pliable conduit shall not be used in situations where they would be subject to continuous flexing.

7.1.2.3.3 Joint in PVC Conduit

Joint in PVC conduit shall be made by means of a solid PVC coupler into which jointing cement shall be applied to the outer surface of the conduit to be joined in turn and then shall be inserted firmly into a coupler and twist a quarter turn to spread cement evenly in order to make the conduit run mechanically continuous.

7.1.2.3.4 Plastic Boxes

PVC adaptable boxes and PVC boxes for enclosure of electrical accessories shall be interchangeable with the steel boxes.

PVC boxes shall be provided with a brass earthing terminal complete with screw for the connection of circuit protective conductor. They shall not be used for suspension of luminaires or other equipment, where considerable heat will be produced or where the mass of the luminaire or equipment exceeds 3 kg.

Where a concealed conduit system is used in floor slab or wall, a system of PVC rigid conduit fitted with a "screwed to plain PVC converting adaptor" firmly screwed into a deep pattern type cast iron ceiling mounted "BESA" box shall be employed for the suspension of luminaires or other equipment. The system shall also be suitable for the suspended load at the expected working temperature. The threaded portion of the mating converting adaptor shall project to cover the full threaded portion of the "BESA" box and shall be screwed up tightly in order to make the conduit run mechanically continuous. Any exposed threads on the "BESA" box shall be painted with at least two coats of anti-rust paint.

7.1.2.3.5 Termination of PVC Conduit at Casing of Equipment

Where a PVC conduit terminates at a casing, a coupler and a PVC bush (i.e. a "plain to screwed" PVC coupler) with a male PVC bush or a "screwed to plain PVC converting adaptor" with a female PVC bush shall be used. In the case of flexible conduit, a rigid PVC glands or a PVC adaptor together with a PVC male bush shall be used.

Where PVC adaptor with male bush are used, the male bush shall be screwed into the coupler or adaptor from the inside of the metal casing through a clearance hole drilled in the casing to suit the bush. The bush shall be screwed tightly into the coupler or adaptor so as to grip the casing securely for mechanical continuity. Threads on the male bush shall be long enough to cover the full threaded portion of the coupler. The jointing cement shall be applied on the surface of pliable conduit prior to insertion into the coupler/adaptor and twist.

7.1.2.3.6 Conduit Bend

Conduit bend shall be made by the use of purpose made solid elbow or, for PVC conduit not exceeding 25 mm diameter, by bending the conduit itself. Conduit bend shall not be bent more than 90 degrees. The internal radius of the bend shall not be less than 4 times the outside diameter of the conduit.

In case of the conduit bend is made by bending the PVC conduit, the conduit bend shall be made by using the appropriate size of conduit bending springs. Conduit shall be fixed in position as soon as possible after bending.

7.1.2.3.7 Allowance for Thermal Expansion

Due allowance shall be made for the expansion of PVC tubing at high temperature. Expansion coupling or other fittings shall be installed in a straight run of 8 m or more. Saddles or clips shall be of sliding fit.

7.1.2.3.8 Fixing of Trunking

The trunking shall be fixed and supported in the normal way by screws, but the holes in the trunking shall always be made slightly oversize to

allow for the movement of expansion. Washers shall be used under the head of the screw which shall not be over-tightened.

The spacing between adjacent supports for trunking shall not be greater than those given in Table 7.1.2.2.8.

7.1.2.3.9 Circuit Protective Conductor

A PVC insulated cable shall be drawn into the conduit or trunking system to serve as the circuit protective conductor (CPC), the cross-sectional area of which shall comply with the Code of Practice for the Electricity (Wiring) Regulations. CPCs shall also be installed in the steel conduits and trunkings where both PVC and steel conduits are adopted in the conduit system.

7.1.2.3.10 Embedment of Concealed PVC Conduits

The installation of concealed PVC conduits shall fully comply with Code 14D of the Code of Practice for the Electricity (Wiring) Regulations. Concealed PVC conduits installed within concrete or brick walls and floor slabs shall have concrete, cement or plaster cover of thickness not less than 30 mm to prevent penetration of cables inside the conduits by nails, screws or alike.

Unless otherwise specified in the Particular Specification or on the Drawings, galvanised steel conduits shall be used instead of PVC conduits in dry wall partition and for all exposed conduits installation including those inside false ceiling and outdoor.

Chase for conduit to be concealed in wall, column or beam shall be vertical or horizontal.

7.1.2.4 SURFACE WIRING SYSTEM

7.1.2.4.1 Type of Cable

Where surface mounted wiring is specified, sheathed copper cables shall be used for fixed installation. Cables for 3-phase circuit shall be 450/750 V grade or above. Cables shall not be buried in concrete or plaster.

Flexible cables or flexible cords shall be used for connection to apparatus, appliances or equipment via an appropriate wiring accessory. Flexible cables or flexible cords shall not be used in fixed installation, except for final connection to a fixed equipment.

7.1.2.4.2 Minimum Size of Live Conductors and CPC

Cables shall have CSA not less than 1.5 mm^2 for 10 A or below circuits and 2.5 mm^2 for 16 A circuits.

Flexible cables and flexible cords shall have CSA not less than 0.75 mm^2.

The minimum CSA of a CPC shall be 1.5 mm^2 if the CPC is integrated in a cable carrying the associated live conductors. The minimum CSA of a separate CPC shall be 2.5 mm^2 if protection against mechanical damage is provided (e.g. sheathed cable), and 4 mm^2 if mechanical protection is not provided (e.g. non-sheathed cable).

CPC shall be properly sized in accordance with Clause 7.1.7.7.

7.1.2.4.3 Identification of Cable Core

All conductors shall be coloured as specified in Clause 7.2.3.7 of this General Specification.

7.1.2.4.4 Joint in Cable or Cord

Joints in cables or cords shall not be allowed unless approved by the Supervising Officer. In such case, the joints shall be electrically and mechanically sound, be protected against mechanical damage and any vibration liable to occur.

7.1.2.4.5 Installation of Non-flexible Cable

(a) General

All cables shall be run in a vertical or horizontal direction, and shall be secured flat on the surface of walls, columns, partitions or ceilings, etc. throughout the entire route, including at bends. Fixing onto the ceiling shall be avoided unless the cable is required to feed a point on the ceiling.

Where required, the cables may be run under floors, between partitions or inside ceiling voids provided that they are enclosed in ducts, conduits or trunking.

When cables are routed along or cross steel joints, beams, stanchions, etc. they shall be enclosed in steel or rigid PVC trunking/conduit.

Cables shall not be run as a span between beams, trusses, etc., without rigid support throughout their length.

(b) Protection to Cable Susceptible to Damage

Cables susceptible to damage shall be protected by means of metal channels. Where protection is required for cables running up a wall from the floor, the metal channel shall be fixed to a minimum height of 1.5 m above finished floor level.

(c) Cable Passing through a Building Structure

Where cables pass through a building structure such as a wall or column, the cables shall be drawn through PVC sleeves inserted into the building structure. The size of the PVC sleeves shall be such that the space factor shall not exceed 40%. The gap between the structure and the sleeve and that between the cables and the sleeve shall be completely filled with cement or approved fire-resisting material.

Cables crossing an expansion joint shall be formed into a loop such that any movement in the joint shall not stress the cables.

(d) Cable Passing through Metal Work

Rubber grommets or insulated bushes shall be used to protect the cables passing through metal part of a distribution board, a luminaire, a metal box or any other metal work.

(e) Segregation from Other Services

Cables shall be run at least 150 mm clear of all other non-electrical services.

(f) "Looping-in" Wiring System

The cables shall be wired on the "looping-in" system. Cable joints of any type in cable runs shall not be allowed.

(g) Neutral Conductor at Switch Position

The neutral conductor of a twin core cable for a lighting final circuit shall be looped through an insulated connector enclosed in the moulded box or pattress accommodating the switch.

(h) Termination of Cable

Cable terminated at a moulded box or pattress, a luminaire or other fittings shall have the overall protective sheath carried into the moulded box or pattress, luminaire or other fittings for a minimum of 13 mm.

The CPC shall be terminated at the earth terminal provided in the moulded box or pattress housing the wiring accessories.

Where it is not required to terminate the CPC in an accessory, it shall not be cut back or removed. Instead, it shall be coiled away from the live terminals or any bare conductors and shall be insulated and sleeved with a green-and-yellow PVC sleeve.

(i) Bending Radius of Cable

The internal bending radii of cables shall not be less than the values given in Table 7.1.2.4.5(1).

Table 7.1.2.4.5 (1) Bending Radius of Non-Flexible Cable

Overall diameter of cable (D)	Minimum internal radius of cable bend	
	Non-armoured	Armoured
Not exceeding 10 mm	3D	6D
Exceeding 10 mm but not exceeding 25 mm	4D	6D
Exceeding 25 mm	6D	6D

(j) Fixing of Cable

Cables having an overall diameter not exceeding 10 mm shall be fixed by means of buckle clips. Cables of other diameters shall be fixed by means of cables saddles.

Where a number of cables running together on the surface of walls, columns, partitions or ceiling such that their aggregated width exceeds 50 mm, a 13 mm thick hard wood batten of adequate width shall be fixed along the cable route for mounting the cables. The hard wood batten shall be finished with one coat of approved priming on front and edges, and waterproof compound treated at the back. Lengths of the batten shall be properly fitted together and fixed in position by counter-sunk brass screws in raw plugs.

(k) Fixing of Clip

Buckle clips shall be fixed and secured by pins driven into surface of wall, column, partition or ceiling. The head of every pin shall be level with the surface of the clip so that no damage to the sheath of the fixed cables can occur.

Every hole in the buckle clip shall require a fixing pin.

A separate buckle clip shall be required for every cable of size above 2.5 mm^2 twin with CPC, or of equivalent size. Not more than two cables shall be allowed in one clip under all circumstances.

Buckle clips shall be provided along the entire cable route at regular intervals not exceeding 250 mm on horizontal runs and 400 mm on vertical runs.

A clip shall also be provided at a distance not exceeding 75 mm from a termination and from both sides of a bend.

(l) Fixing of Cable Saddle

Cable saddles shall be securely fixed by fixing screws. Saddles shall be provided along the entire cable route at regular intervals. The spacing between adjacent saddles shall not exceed the values given in Table 25(3) of the Code of Practice for the Electricity (Wiring) Regulations.

A saddle shall also be provided at a distance not exceeding 150 mm from a termination and form both sides of a bend.

(m) Correction Factor to Current Rating of Cable

Where more than two twin cables are fixed together, or when the cables are installed at or in thermally insulated materials, etc., suitable correction factors, as recommended by IEC 60364-1:2005/COR1:2009 and other associated parts of the standard shall be applied in determining the size of the cables to be installed. The effective current carrying capacity of each cable shall be calculated and ensured that it is within the intended operating value of the circuit.

7.1.2.4.6 Installation of Flexible Cable and Flexible Cord

(a) Connection to Portable Equipment

Flexible cables or flexible cords for connections to portable appliance or equipment shall have suitable length (preferably 1.5 m to 2 m) to avoid undue risk of mechanical damage.

(b) Connection to Fixed Equipment.

Exposed lengths of flexible cable or flexible cord used for final connections to fixed equipment or appliance shall be as short as possible.

(c) Connection to Luminaire

Where a flexible cord supports or partly supports a pendant luminaire, the maximum mass acting on the cord shall not exceed 3 kg for flexible cord of 0.75 mm^2, and shall not exceed 5 kg for flexible cord of larger conductor CSA.

7.1.2.5 TOOL AND WORKMANSHIP

7.1.2.5.1 Approved Tool

Only tools which are proven to be suitable shall be used.

Conduit bushes, couplers and similar items shall be tightened with bush spanner or other suitable tools approved by the Supervising Officer.

Conduit bends shall be formed on an approved bending machine, and the conduits shall not be flattened or with protective coating damaged at the bends.

Suitable cutters shall be used for cutting PVC conduits or trunking.

7.1.2.5.2 Cutting in Metal Work for Conduit or in Trunking

Holes in metal work for the termination of conduits shall be drilled on site with a twist drill of the correct size or by means of an approved hole cutting device.

Holes in trunking shall be drilled, punched or cut by ring saw.

After cutting, burrs and sharp edges on the metal work or trunking shall be removed to prevent abrasion of cables.

7.1.2.5.3 Making Good of Damaged Coating

Where the protective coating on a steel conduit or trunking has been damaged after installation, such surface shall be effectively restored by at least two coats of anti-rust paint or other suitable coating to prevent corrosion.

SUB-SECTION 7.1.3

POWER CABLES, CABLE TRAYS AND CABLE LADDERS

7.1.3.1 GENERAL

7.1.3.1.1 Scope

This Sub-section covers the installation of power cable, which includes those listed in Clause 7.2.3.2. It also covers the installation of the associated cabling facilities, including cable trays and cable ladders.

Unless otherwise specified elsewhere, all cables shall have copper conductors.

7.1.3.1.2 Electromagnetic Interference

To minimise the electromagnetic interference generated from single core cables, the following arrangements shall be adopted:

(a) All the single core cables of a circuit shall be of the same conductor, same cross sectional areas, same type, same construction and from the same manufacturer;

(b) All the single core cables of a circuit shall be of equal length, and shall follow the same route of installation;

(c) The single core cables shall not be able to operate individually; and

(d) The layout of single core cables shall be arranged as shown in Figure 7.1.3.1.2 at the end of this Sub-section 7.1.3.

7.1.3.2 CABLE MOUNTED ON SURFACE

Unless otherwise specified, power cables shall be mounted on the surface of wall or ceiling or other building structure. They shall be cleated in position by approved type cable cleats or cable saddles. Cable cleats or cable saddles shall be provided along the entire cable route according to the Table 25(3) of the Code of Practice for the Electricity (Wiring) Regulations.

When specified, power cables may be supported on cable trays or cable ladders.

For vertical cable runs exceeding 100 m, tension releasing sections shall be provided in accordance with the recommendation of the cable manufacturer, failing which, a tension releasing section shall be provided for every 100 m vertical run.

7.1.3.3 CABLE LAID IN ENCLOSED TRENCH

When power cables are laid in an enclosed trench, the cables shall be installed in accordance with the installation methods 118, 119 and 120 of Appendix 7 of the Code of Practice for the Electricity (Wiring) Regulations. Rating factors shall be applied to the current-carrying capacities as indicated in Table A5(6) of the Code of Practice for the Electricity (Wiring) Regulations, where applicable.

7.1.3.4 CABLE ENCLOSED IN DUCT

7.1.3.4.1 General

Cables laid in ducts shall be sheathed and armoured. Where mineral insulated cables are specified, they shall be with PVC or XLPE outer cover as specified.

Where the ducts are formed from wood, cables shall be held in position by clips, saddles, or approved fixings.

The space factor in a cable duct shall not exceed 35%.

7.1.3.4.2 Drawing-in of Cables

Prior to the drawing-in of the cables, the cylindrical ducts shall be cleaned with a cylindrical brush of appropriate size.

Attachment to facilitate the pulling of cables through a duct shall be made to the cores, insulation, inner and outer sheaths and not to the armour in order to avoid twisting. Attachment to the armour will only be permitted for small cables with the approval of the Supervising Officer. When pulling power cables into small ducts, cable lubricant which shall not negatively interact with the cables they lubricate and shall not increase the flame spread or decrease the fire resistance properties of the cable may be used for brushing onto the cable surfaces where they enter the duct to reduce friction during pulling.

When pulling-in lead-sheathed insulated power cables, the following precautions shall be taken:

(a) Maximum stress in sheath - 10,000 kPa (with stocking pulling grip);

(b) Maximum stress in conductors - 70,000 kPa (with pulling eye attached to conductors); and

(c) Maximum pull shall be limited to 220,000 Newtons.

7.1.3.4.3 Internal Barrier

In every vertical duct, which is designed as totally enclosed without ventilation, internal barriers shall be provided to prevent the air at the top

of the duct from attaining an excessively high temperature. The distance between adjacent barriers shall be the distance between floors. Where the floor to floor distance exceeds 5 m, additional barriers shall be provided at an interval not exceeding 5 m.

7.1.3.4.4 Fire Barrier

Where a cable duct passes through fire resistant structural elements, such as floor or wall designated as fire barriers, the opening thus formed shall be sealed with fire resistant materials having the same degree of fire resistance as the structural element. In addition, suitable internal fire barriers shall also be provided. An internal fire barrier may also serve as an internal barrier. Penetration seals for openings where ducts, cables and the like passing through the fire barrier shall be provided in compliance with Code of Practice for Fire Safety in Building.

7.1.3.4.5 Draw-in Pit

Where cables in a duct are inaccessible for the greater part of their length, adequate number of draw-in pits shall be provided at every turning point and at regular intervals of not greater than 15 m. Sufficient room shall be available in the draw-in pits to enable the cables to be manoeuvred without damage. In the case of armoured cables, the draw-in pits shall be concrete or brick lined and shall be fitted with a waterproof heavy cast iron lid. Draw-in pits shall not be filled with sand or other materials.

Where a change in direction in a duct occurs, provision shall be made to enable the cables in the duct to have adequate radii of curvature in accordance with the relevant requirements in this Section.

7.1.3.4.6 Segregation of Cables of Different Circuit Categories

Separate ducts shall be provided for cables of different circuit categories. However, cables of different categories may be allowed to pass through the same draw-in pit provided that they are properly and appropriately segregated in accordance with the requirements specified in the Code of Practice for the Electricity (Wiring) Regulations.

7.1.3.4.7 Sealing of Duct Entry to Building

After the cables have been installed, both the cables and the exposed duct end shall be sealed to form a gas, water and fire barrier. Open ends of spare ducts shall be closed with tapered hardwood plugs and then sealed similarly.

7.1.3.5 CABLE BURIED DIRECT IN GROUND

7.1.3.5.1 Protection of Cable

Power cables buried direct in ground shall be armoured. They shall be buried at a depth of not less than 450mm and 900mm for non-carriageway and carriageway respectively and shall be protected by means of approved cable cover tiles. The bottom of the cable trench shall be covered, to a depth not less than the diameter of the largest cable, with a bedding layer of sand or fine soil. On top of the cables, an after layer of sand or fine soil, to a depth of 100 mm, shall again be provided. The sand or fine soil shall not be larger than 13 mm sieve. Particular care shall be taken to ensure that there shall be no pebbles or small stones in the bedding layer or after layer of the fine sand or soil. The cables shall then be covered, throughout the entire route, by approved type cable cover tiles which shall be laid on top of the after layer.

7.1.3.5.2 Cable Marker

The route of all power cables buried direct in ground shall be clearly indicated by cable markers laid on the ground. The cable markers shall be engraved with the following wording:

"DANGER - ELECTRIC CABLES"

Cable markers shall be placed at regular intervals not exceeding 60 m apart and also at positions where the cable route changes direction.

At the position of each underground junction box, a cable marker shall also be installed. Such markers shall be engraved, in addition to the wordings mentioned above, the appropriate information, such as "3 way Joint Box".

7.1.3.6 BENDING RADIUS OF CABLE

The internal bending radius of every power cable shall not be less than the appropriate values given in Table 7.1.2.4.5 (1) of this General Specification.

7.1.3.7 CABLE JOINT AND CABLE TERMINATION

7.1.3.7.1 General

Unless otherwise specified in the Particular Specification and approved by the Supervising Officer, cable joint for power cable shall not be used for new electrical installation.

Joints and terminations of all power cables shall be made by skilled cable jointers who shall be approved by the Supervising Officer before work commences.

No reduction in the number of strands of a cable core shall be allowed at a cable joint or termination.

Ferrules, compression connectors and bare portions of cable core resulting from a jointing or terminating process shall be insulated with an approved type of insulating tape, heat shrinkable tubing or approved means of insulating material after completion of process. Such insulating material shall have equal or better electrical and mechanical properties as those of the original insulation removed, and shall be adhered to the cores, securely and permanently. The final thickness shall be in a smooth contour throughout the whole length.

Every compression joint shall be of a type which has been the subject of a test certificate as described in IEC 61238-1-1:2018, IEC 61238-1-2:2018, IEC 61238-1-3:2018 and other associated parts of the standards. When a compression joint is made, the appropriate tools specified by the manufacturer of the joint connectors shall be used.

7.1.3.7.2 Joint Box and Terminating Box

Boxes for joints in all power cables shall be of cast-iron, compound filled and of adequate size. The boxes shall be fitted with suitable armouring clamps and glands. The armouring of the cables shall be terminated at the armouring clamps and the inner sheath shall pass through the gland.

The box shall be warmed thoroughly before the compound is poured to allow total adhesion between the compound and the box. The compound shall then be allowed to cool and topped up before the box is closed. No air locks shall be formed within the box.

Plastic shells fitted with suitably sized armour bond and filled with approved type cold pouring encapsulating compound may be used as alternative for jointing PVC insulated power cables. The complete jointing kit, including plastic shell, compound, insulating tape, etc. shall be from the same proprietary manufacturer who is specialised in manufacturing products for this purpose. The jointing method and procedure as laid down by manufacturer shall be followed strictly.

7.1.3.7.3 Identification at Joint or Termination

At each joint or termination, a non-ferrous metallic label shall be fixed to the cable giving the size and identification of the cable, e.g. 50 mm^2 4-core XLPE/SWA/PVCS copper cable to "Services Block".

7.1.3.7.4 Earth Continuity across Joint

A circuit protective conductor having adequate cross sectional area shall be installed and connected to maintain the effectiveness of the earth continuity across every cable joint.

7.1.3.7.5 Straight-through Joint for Copper Conductors

In such joint, the two conductors shall be butted together after the strands have been soldered solid and shall be joined by means of a weak back ferrule, soldered to the cores. Soldering shall be carried out by pouring tin-man's solder over the cores and weak back ferrule. Under no circumstances shall direct flame from a blow lamp be used for soldering.

As an alternative, conductors may be joined by approved type compression connectors using the appropriate tools and connectors.

7.1.3.7.6 Tee-joint for Copper Conductor

When two cables with copper conductors are tee-jointed, the branch conductor shall be connected to the main conductor by means of claw type or weak back ferrules. The strands in both branch and main conductors are to be sweated solid before sweating to the ferrule. Soldering shall be carried out as detailed in Clause 7.1.3.7.5 above.

As an alternative, conductors may be joined by approved type compression connectors using the appropriate tools and connectors.

7.1.3.7.7 Joint for Aluminium Cables

(a) Soldered Joint

Prior to making a soldered joint, each conductor shall be cleaned by means of steel wool or similar abrasive and then tinned by pouring solder, specially made for use with aluminium, over the cores. Both cores shall then be inserted in a weak-backed aluminium ferrule and butted together. The ferrule shall then be closed. Soldering shall be completed by pouring the solder over the ferrule, after applying a layer of flux recommended by the cable manufacturer for this purpose.

(b) Compression Joint

Alternatively, the aluminium cores may be joined by means of an approved type compression joint. A compression joint shall be made by inserting the aluminium cores to be jointed into the opposite ends of an aluminium compression jointing tube, which shall have the correct size for the conductors. The tube shall then be compressed onto the cores by means of a compressing tool. The tool used and the working procedure adopted shall be as recommended by the cable manufacturer.

7.1.3.7.8 Termination of PVC-insulated or XLPE-insulated Cable with Copper Conductors

PVC-insulated or XLPE-insulated cables shall be terminated in a gland fitted with an armour clamp. Provision shall be arranged to enable a watertight seal to be made between the gland and inner sheath. The gland

body shall be provided with an internal conical seating to receive the armour clamping cone and a clamping nut which shall secure the armour clamping cone firmly to the armour wires ensuring that the armour wires are tightly clamped between the armour cone and conical armour seating. The spigot on the gland body shall be threaded to suit standard conduit accessories. A shroud of PVC or alternative approved materials shall be fitted to cover the body of the gland and the exposed armour wires.

The copper cores shall be soldered to the cable lugs or cable sockets by the "damp sweat" method as described in Clause 7.1.3.7.5 above.

As an alternative, conductors may be terminated by approved type compression terminations using the appropriate tools and terminations.

7.1.3.7.9 Termination of PVC-insulated or XLPE-insulated Cable with Aluminium Conductors

Terminating gland and armour clamp for power cables with aluminium conductors shall be made from aluminium. Termination of gland and clamping of armour shall be the same as for copper core armoured cables as described in Clause 7.1.3.7.8 above. Cores shall be terminated in a hot tinned brass or copper lug, which shall be shaped in a vice or by means of a hammer to suit the sector shape of the conductor. The core shall be tinned, and then soldered into the lug.

As an alternative to terminating cores in a tinned brass or copper lug, a compression termination may be used. In such case, the cores shall be inserted into the sleeve of an aluminium compression type cable lug. The sleeve shall then be compressed onto the cores by means of a compressing tool. The tool used and the working procedure adopted shall be as recommended by the cable manufacturer.

Prior to connection to the terminal, the cable lug shall be painted with an anti-oxidising paste. The anti-oxidising paste shall be suitable for preventing the creation of electrolytic action due to contact between the aluminium lug and copper or brass terminal, for an indefinite period. Alternatively, copper/aluminium bimetal cable lugs may be accepted

7.1.3.7.10 Use of Heat Shrinkable Tubing

All heat shrinkable tubing and accessories used for cable joints or terminations shall be suitable for use with the type and construction of cable to be jointed or terminated.

The heat shrinkable materials shall have electrical and mechanical properties equal to or better than those of the cable insulation and sheath, where applicable. After the application of the heat, the heat shrinkable materials shall seal the interfaces between the heat shrinkable materials or between the heat shrinkable materials and the cable surfaces.

Whenever heat shrinkable tubing and accessories are used, the complete kit shall be from the same proprietary manufacturer who is specialised in

manufacturing products for this purpose. The method and procedures adopted shall be strictly as those laid down by the manufacturer.

7.1.3.7.11 Other Methods of Joint and Termination

Methods for jointing or terminating a power cable, other than those specified in this Sub-section, will not be precluded provided:

(a) that the method used shall be proven to be capable of affording the degree of safety, reliability, durability and efficiency not less than that achieved by those specified in this Sub-section,

(b) that the method used shall satisfy the requirements of IEC 60364-1:2005/COR1:2009 and other associated parts of the standard and other relevant Standards, and

(c) that prior agreement of the Supervising Officer has been obtained.

7.1.3.8 SPECIAL REQUIREMENTS FOR MINERAL INSULATED CABLES

7.1.3.8.1 Cable Route

Mineral-insulated cables shall be run neatly on the surface of the walls, columns, beams or ceilings in a vertical or horizontal direction, and at least 150 mm clear of all plumbing and mechanical services. The use of conduit and/or cable trunking to enclose such cables shall be kept to the minimum.

7.1.3.8.2 Cable Support

Mineral-insulated cables shall be adequately supported by saddles which shall be of the same manufacturer as the cables. Saddles shall be provided throughout the entire cable route at regular intervals. The spacing between adjacent saddles shall not exceed the values given Table 7.1.3.8.2. Saddles shall also be provided at a distance not exceeding 150 mm away from a termination and from both sides of a bend.

Table 7.1.3.8.2 Spacing of Saddles for Mineral-insulated Cable

Overall diameter of cable (d) mm	Maximum spacing	
	Horizontal run	Vertical run
$d \leq 9$	600 mm	800 mm
$9 < d \leq 15$	900 mm	1,200 mm
$d > 15$	1,500 mm	2,000 mm

7.1.3.8.3 Bending Radius

The minimum internal bending radius for a mineral-insulated cable shall be 6 times the overall diameter of the cable.

7.1.3.8.4 Cable Loop for Prevention of Vibration and Low Temperature Cold Store

A loop shall be introduced in a cable immediately before its entry into an equipment which is subject to vibration or occasional movement. A clear space of at least 10 mm shall be maintained at the point in the loop where the cable passes over itself.

Cable loop or similar means shall be provided for mineral-insulated cables serving and running inside low temperature cold store.

7.1.3.8.5 Cable Termination

Cable terminations shall generally comply with IEC 60702-2:2002/AMD1:2015.

The cable to be terminated shall be cut, screwed, sealed with cold compound and fitted with brass terminating glands, nuts, compression ring, gland body, sealing pot, disc and sleeves. The conductors shall be carried unbroken through the sealing pot to the terminal sockets or clamping screws.

Sealing shall be properly carried out to protect the cable ends from moisture and the insulation shall be thoroughly dry before the sealant is applied. The sealing material and material used to insulate the conductors when they emerge from the insulation shall have adequate insulating and moisture-proofing properties which shall be retained throughout the range of temperature they may be subjected to in service.

Where a mineral insulated cable is terminated at an insulating casing or enamelled/painted metal casing, the sealing pot shall be provided with a copper circuit protective conductor, complying with the requirements of IEC 60228:2004, and of an appropriate size in accordance with IEC 60702-2:2002/AMD1:2015.

Where more than one cable terminates at a galvanised or zinc coated enclosure, the gland plate shall be of brass or insulating materials.

PVC shrouded terminating glands shall be used when the cables are fitted with PVC outer covering.

Only tools recommended by the manufacturer of the cables shall be used and the manufacturer's recommended methods of cable termination shall be adopted in all cases.

7.1.3.8.6 Insulation Resistance

The insulation resistance between the cores and between each core and the sheath shall be measured before the cable end is sealed. The measured resistance shall be infinity on a 500 V insulation resistance tester. If the reading is less than infinity, the cable shall be heated by means of a blow lamp or similar device so that moisture is driven out to the open end of the cable. Heating shall be continued until the measured insulation

resistance reaches infinity, and sealing shall be applied immediately. The insulation resistance shall be measured again when the cable end has been sealed to ensure infinite resistance.

For mineral-insulated cable with outer covering, adequate length of the outer covering shall be cut out in the event of low insulation resistance to allow dehydration by the application of blowlamp as described above. After the process is completed, the section of outer covering shall be re-installed as specified.

7.1.3.8.7 Bonding of Cable Sheath to Metalwork

Where a mineral-insulated cable passes through or makes contact with any metal, the metal and cable sheath shall be effectively bonded together.

7.1.3.8.8 Laying of Single-core Cables

Single-core mineral-insulated cables running together shall be laid with the cable sheaths in contact. Mineral-insulated cables for 3 phase circuits shall be laid in trefoil formation. Where cables used are rated at 100 A or above, gland plates of apparatus shall be of brass.

7.1.3.8.9 Protection from Mechanical Damage

Mineral-insulated (MI) cables shall be protected by steel sleeves where they are exposed in vulnerable positions (e.g. passing through floors, ceilings and walls). Insert material between copper oversheath of cable and steel sleeve shall be dielectrically isolated form one another to prevent galvanic action. The openings or holes through which the cables pass shall be made good with cement or other non-combustible material.

7.1.3.9 INSTALLATION OF PERFORATED CABLE TRAYS

7.1.3.9.1 Connection between Adjacent Lengths of Tray

Connections between adjacent lengths of tray, tee or bend pieces, shall be made by butt joints and fixed by mushroom-head steel roofing bolts and nuts.

The connection shall be mechanically strong so that no relative movement between the two lengths can occur.

7.1.3.9.2 Cutting of Tray

Cable trays shall be cut along a line of plain metal only, i.e. they shall not be cut through the perforation. All cut edges of the galvanised cable tray shall be prepared and treated with a cold galvanised paint.

7.1.3.9.3 Hole in Tray

Holes cut in a cable tray for the passage of cable shall be provided with grommets. Alternatively, they shall be bushed or lined.

7.1.3.9.4 Fixing of Tray

The cable tray except those of short run less than 300 mm long where at least 1 set of hanger or bracket is required, shall be supported by at least 2 sets of hangers or brackets of adequate mechanical strength securely fixed to the walls, ceiling or other structure. Unless otherwise specified the hangers or brackets shall be hot-dip galvanised, painted with anti-rust epoxy coating or the use anti-rusting material to prevent corrosion. Fixings for cable trays shall be disposed at regular intervals not exceeding 1.2 m for straight run and at a distance not exceeding 225 mm on both sides from a bend or intersection.

A minimum clear space of 20 mm shall be left behind all cable trays.

7.1.3.9.5 Fixing of Cable on Tray

Saddles for securing multi-core cables to the cable tray shall be made from PVC covered metal strip, and shall be shaped to the form of the cables to be secured. The saddles shall be fixed to the cable tray by means of corrosion resistant cheese-headed screws and nuts. The shanks of the screws shall not protrude beyond the nuts by more than three threads. Where saddles exceed 150 mm in length, intermediate fixings shall be provided such that the maximum spacing between screws shall not exceed 150 mm.

Single-core cables shall be secured to the cable tray by clamps made of wood or other non-ferrous materials to suit the dimension of the cables. The clamp shall be secured to the cable tray by means of bolts, washers and nuts.

Cable saddles or cable clamps shall be provided along the entire cable route with their spacing in accordance with the manufacturer's recommendation.

7.1.3.10 INSTALLATION OF WIRE MESH CABLE TRAYS

7.1.3.10.1 General

Unless otherwise specified, the installation of wire mesh cable tray system shall be generally in accordance with the manufacturer's installation instruction.

7.1.3.10.2 Supports

The wire mesh cable tray except those of short run less than 300 mm long where at least 1 set of hanger or bracket is required, shall be supported by at least 2 sets of hangers or brackets. Supports shall be properly spaced at distance not exceeding 1,500 mm for straight run to satisfactorily support the weight of the tray and cables.

7.1.3.10.3 Bends

In general, large radius bend shall be used for the wire mesh cable tray system. 90°bend shall not be installed unless otherwise approved by the Supervising Officer.

7.1.3.10.4 Earthing

The wire mesh cable tray shall be bonded and earthed throughout in order to maintain the earth continuity for equipotential bonding.

7.1.3.10.5 Safety Working Load

The weight of cables per span of the wire mesh cable tray shall be uniformly distributed and shall not exceed the maximum working load specified by the manufacturer.

7.1.3.11 INSTALLATION OF CABLE LADDER

7.1.3.11.1 Dropout Plate for Cable Exit

Dropout plate of width same as the cable ladder shall be provided to support the cables locally as they exit a ladder down between the rungs.

7.1.3.11.2 Flexible (Expansion) Couplers across Building Expansion Joint

The cable ladders shall be joined by flexible (expansion) couplers across the expansion joints of the building structure. The selection and installation details of such flexible couplers shall be recommended by the manufacturer and submitted to the Supervising Officer for acceptance. Rigid fitting across the expansion joints shall not be allowed.

7.1.3.11.3 Ladder Covers

Unless otherwise specified, proprietary ladder covers (ventilated or closed as specified) shall be fixed onto the cable ladder following the installation details recommended by the manufacturer.

7.1.3.11.4 End Connectors

The end of a run of cable ladder shall be fixed to the wall or slab with proprietary end connectors. If it is far from the wall or slab, a proprietary "stop end" connector shall be fixed to the end of a cable ladder run in order to give a neater appearance. Installation details shall follow the manufacturer's recommendation.

7.1.3.11.5 Earthing

The cable ladders shall be bonded and earthed throughout. Across all joints of the cable ladder, copper connectors shall be fixed onto the cable ladder in order to maintain the earth continuity. Factory-made attachment points shall be provided near the joints for fixing the earth continuity connectors. The length of the copper connectors shall be slightly longer than the length between the two attachment points to allow for movement at the joints due to expansion or some other reasons.

7.1.3.11.6 Minimum Inside Radius of All Bends

The inside radius of all bends of the cable ladder system shall not be less than 300 mm.

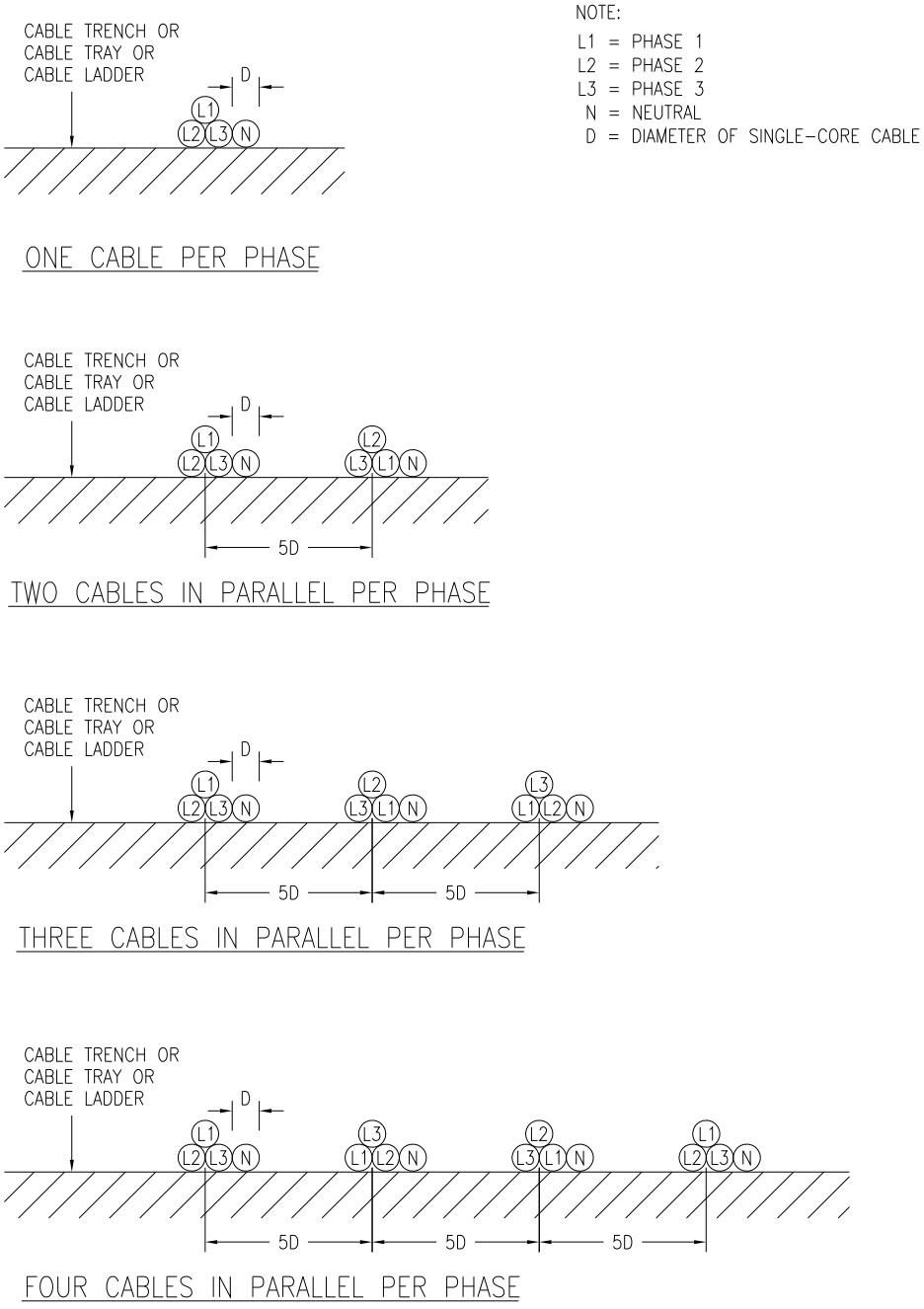
7.1.3.11.7 Supports

The cable ladder except those of short run less than 300 mm long where at least 1 set of hanger or bracket is required, shall be supported by at least 2 sets of hangers or brackets. Supports shall be properly spaced at distance not exceeding 1,500 mm for straight run to satisfactorily support the weight of the ladder and cables. Unless otherwise specified the hangers or brackets shall be hot-dip galvanised, painted with anti-rust epoxy coating or the use anti-rusting material to prevent corrosion. They shall also be provided at a distance not exceeding 300 mm on every side from a bend or intersection.

7.1.3.11.8 Safety Working Load

The weight of cables per span of the cable ladder shall be uniformly distributed and shall not exceed the maximum working load specified by the manufacturer.

Figure 7.1.3.1.2 Installation of LV Single-core Cable to Minimise Electromagnetic Interference



SUB-SECTION 7.1.4

GENERAL LIGHTING AND POWER

7.1.4.1 INSTALLATION OF LIGHTING SYSTEM AND LUMINAIRES

7.1.4.1.1 Pendant

Tube pendant shall comprise a dome cover and a biscuit ring and a piece of screwed steel conduit of suitable length to give the required mounting height of the luminaire.

Plain pendant shall comprise a ceiling rose and a cord-grip lampholder connected by a flexible cord having a suitable length to give the required mounting height of the lamp shade.

7.1.4.1.2 Luminaire Mounted on Pattress

When a luminaire is not provided with facility for a surface cable entry, the luminaire shall be mounted on pattress. The cable shall then enter the luminaire from the rear through a slot and a hole formed in the pattress.

7.1.4.1.3 Ceiling Rose

Ceiling rose shall not be used for the attachment of more than one outgoing flexible cord or cable unless it is specially manufactured for multiple pendants.

7.1.4.1.4 Painting

Unless otherwise specified, lighting equipment and luminaires other than those indicated to be self-finished such as stainless steel, anodised aluminium, etc, shall have factory-finished.

Metal parts such as cover plates for adaptable boxes, blanking plate for any boxes and surface conduit, etc. shall be painted white or a suitable colour to match the interior finish of a particular location.

7.1.4.1.5 Special Requirements for Outdoor Luminaires

Outdoor luminaires shall be able to withstand the weather. Metal work shall be protected against corrosion, and parts which have to be removed for access to the interior shall be provided with proper gaskets to restrict the entrance of moisture and dirt. Mounting brackets shall be heavily galvanised and stainless steel or galvanised bolts and nuts shall be used.

The adjustment bolts and nuts of a luminaire which is mounted on high level shall be captive to prevent accidental loss during servicing. Safety chains shall be provided to hold the luminaire from falling. A luminaire installed in a location within hand reach shall be of robust construct, fitted with an impact-resistant transparent or diffusing front panel, and shall

have secret key fixings for the panel to the body of the luminaire. Where necessary, wire guards shall be fitted over the front panel to give extra protection or vandal proof luminaire shall be used.

Cables within the outdoor luminaire shall be such a type that it can sustain the lamp operation at a high ambient temperature due to the waterproof/airtight natures of the luminaire. Heat resistant cable is considered as an acceptable mean of internal cable for outdoor luminaire. Any other cable type with appropriate type test certification demonstrating satisfactory use for outdoor luminaire shall be submitted for approval by the Supervising Officer. Heat resistant sleeve shall be used for external cable entering the luminaire for wiring connection as far as practicable. Where installation of heat resistant sleeve is found impracticable due to environmental constraints, alternative mean avoiding cause of adverse effect as a result of high internal operating temperature shall be submitted for Supervising Officer's approval.

Where the heat resistant sleeves is required, the sleeves within the luminaire shall be extended to a distance of 150 mm outside the luminiare.

7.1.4.2 INSTALLATION OF WIRING ACCESSORIES

Wiring accessories, including lighting switches, socket outlets and domestic type switches for electrical appliances and corresponding adaptable boxes, shall be flush mounted.

Where surface wiring installation is specified, wiring accessories shall be fixed onto moulded boxes or pattresses. In conduit installation, they shall be fixed onto moulded, galvanised steel or cast iron boxes.

Where a waterproof or flameproof configuration is required, wiring accessories shall be mounted as the particular circumstances demand.

The front plate of a switch or socket outlet shall be labelled.

7.1.4.3 INSTALLATION OF DOMESTIC SWITCHES

7.1.4.3.1 General

Switch for domestic and similar purposes shall be mounted at a height of 1350 mm above finished floor level unless otherwise specified.

7.1.4.3.2 Lighting Switch

When lighting switches are mounted adjacent to one another, they shall be grouped in a single enclosure (single or multi-gang box) and shall share a common switch plate, subject to a maximum of three lighting switches per single-gang plate.

Lighting switches installed adjacent to a door shall be located on the handle side of the door, and shall be as near to the door as practicable.

7.1.4.3.3 Time Switch

Time switch shall be housed in a factory or purpose made metal enclosure provided with a removal cover of durable clear plastic material.

7.1.4.3.4 Application in Bathroom

No switch shall be installed inside a toilet or a room containing a fixed bath or shower. All control switches shall be located immediately outside the room.

This restriction does not apply to insulating cord switches, remotely operated switches using mechanical actuators with linkage incorporating insulating components, switched supplied from Separated Extra Low Voltage (SELV) and shaver units.

7.1.4.4 INSTALLATION OF SOCKET OUTLETS

7.1.4.4.1 General

Socket outlet intended for supplying a fixed or stationary appliance shall be located as near as possible to the appliance.

Socket outlet shall be mounted at a height of 1350 mm above finished floor level in kitchens, sculleries, ironing rooms, areas for elderly use and the like. In other locations, they shall be mounted at 300 mm from finished floor level, 75 mm from surface top measured from bottom of socket outlet or as specified.

7.1.4.4.2 Shaver Supply Unit

The complete unit shall be enclosed in a galvanised metal box for flush mounting, or a galvanised cast iron or plastic surface box for surface mounting.

7.1.4.4.3 Socket Outlet at Hazardous Area

The installation of socket outlets in hazardous areas shall be avoided as far as possible. Where it is absolutely essential to install a socket outlet in such area, the socket outlet shall comply with IEC 60079-0:2017/ISH2:2019 and other associated parts of the standard and shall be controlled by a sparkless switch. The socket outlet shall be interlocked with the plug so that removal or insertion shall not be possible unless the controlling switch is in the OFF position. The plug shall have shrouded pins and the pin contacts shall be such as to guard against development of hot spots or sparking. Requirements for wiring installation in hazardous areas are specified in Sub-section 7.1.8.

7.1.4.4.4 Socket Outlet of Surface Conduit System

In plant room, switch room or similar area where surface conduits are installed, socket outlets shall be metalclad or bronze front plate.

7.1.4.4.5 Socket Outlet for Different Voltage System

Socket outlet and plug shall not be interchangeable with those for use at other voltage and/or frequency systems in the same installation.

7.1.4.4.6 Application in Bathroom

Shaver supply units complying with IEC 61558-2-5:2010 can be installed inside a room containing a fixed bath or shower and inside a toilet. Socket outlets inside such a room, if so required under the Contract, shall be installed in accordance with Code 26A(3)(j) of the Code of Practice for Electricity (Wiring) Regulations.

7.1.4.4.7 Universal Serial Bus (USB) Outlet

Installation of USB outlet shall comply with Clause 7.1.4.4 as applicable.

USB outlet shall conform to Code 6F of Code of Practice for Electricity (Wiring) Regulations and comply with IEC 60950-1. 13A socket outlets incorporated with USB circuits shall conform to Code 6E of the Code of Practice for Electricity (Wiring) Regulations and comply with BS 1363-2:2016+A1:2018.

7.1.4.5 INSTALLATION OF MEASURING INSTRUMENT

7.1.4.5.1 Mounting of Current Transformers Associated with Watt-hour Meter

Current transformers, if required to be associated with a watt-hour meter, may be mounted inside meter chamber or in a separate chamber. When current transformers are mounted in meter chamber, separate compartments with separate front access covers for the current transformers and meters respectively shall be provided.

7.1.4.5.2 Identification of Instrument

Each measuring instrument shall be identified by means of a label fitted under the associated instrument. This label shall denote the function of the circuit connected to the meter.

7.1.4.5.3 Mounting Position of Selector Switch

Selector switch for ammeter or voltmeter shall be mounted immediately below the meter with which it is associated.

SUB-SECTION 7.1.5

DOMESTIC APPLIANCES

7.1.5.1 GENERAL

7.1.5.1.1 Connection to Appliances

Domestic appliances shall each be connected to the electrical supply through a suitable wiring accessory and a suitable length (preferably 1.5 m to 2 m) of flexible cable or PVC insulated cables enclosed in a flexible conduit.

For portable appliance, plug and socket shall be used. For fixed appliances, the wiring accessories shall be opened or removed only by means of a tool.

Wiring accessories shall meet the requirements of Section 7.2.4 and shall be installed as near as practicable to the appliances to be connected. Fuse-links shall comply with IEC 60127-1:2006/AMD1:2011/AMD2:2015 and the other associated Parts of the Standard and shall have current ratings suitable for the appliances to be controlled.

Flexible cables for final connection to domestic appliances shall be white in colour unless otherwise specified, and shall be circular, sheathed, twin core with circuit protective conductor (CPC) to IEC 60189-1:2018 and the associated parts of the standard; and IEC 60227-1:2007 and the associated parts of the standard (PVC-insulated) or to IEC 60245-1:2003/AMD1:2007 and the associated parts of the standard (rubber-insulated), all with copper conductors. Twin core cables without earth wire are only allowed for double insulated appliances classified as Class II appliances under IEC 61140:2016. The cores of the flexible cables shall have identification colours in accordance with Clause 7.2.3.7 in Section 7.2.3.

7.1.5.1.2 (NOT USED)

7.1.5.1.3 Engraving for Identification

The front plate of every switched socket outlet, fused connection unit or control switch feeding a fixed domestic appliance shall be engraved to indicate correctly its function.

7.1.5.1.4 Earthing of Appliance

All domestic appliances except Class II equipment to IEC 61140:2016 shall be effectively earthed to the main earth via a circuit protective conductor. Where the cables for final connection to a fixed appliance is enclosed in a flexible conduit, effective earthing shall be achieved by means of a separate circuit protective conductor drawn into the flexible conduit.

7.1.5.1.5 Appliances Requiring Exclusive Circuit

The following types of domestic appliances shall be supplied from an exclusive final circuit:

(a) Household electric cooker

(b) Water heater other than oversink water heater

(c) Water boiler

(d) Room cooler

(e) Appliance having a normal power rating of 3 kW or above

7.1.5.2 CEILING FAN AND CEILING-MOUNTED ROTARY FAN

7.1.5.2.1 Method of Supply

Supply to a ceiling fan or a ceiling mounted rotary fan shall be by means of a 2 A fused connection unit with earthing facilities and controlled by a 5-20 A D.P. switch with pilot light for maintenance purpose.

The fuse connection unit shall be suitable for mounting either on a conduit box to IEC 60670-1:2015 and the associated parts of the standard for concealed conduit installation or on a moulded box or plastic pattress to IEC 60670-1:2015 and the associated parts of the standard for surface conduit and surface wiring installation.

7.1.5.2.2 Fixing of Fan

Every ceiling fan shall be suspended from a substantial hook fixed securely to the ceiling structure.

Rotary fans shall be fixed direct to the ceiling structure.

7.1.5.2.3 Fan Regulator

Fan regulators shall each be controlled by a 5-20 A D.P. switch with pilot light and shall be fixed on the surface of walls.

In a concealed conduit installation, the fan regulator shall be mounted on a back-plate over a recessed 35 mm deep box to IEC 60670-1:2015 where the conduit shall be terminated. The back-plate shall be made of galvanised sheet steel of 3 mm thick with suitable grommet hole for cable entry.

In a surface conduit installation, the fan regulator shall be mounted on a special fabricated box of 1.5 mm thick galvanised sheet steel and having the same size as the regulator or proprietary fabricated box by the fan

manufacturer. The conduit shall be terminated at this specially made surface mounted box which the cables shall enter the fan regulator.

In a surface wiring installation, the fan regulator shall be mounted on a wooden block. Groove shall be formed at the back surface of the wooden block to suit the cables, and holes shall be drilled to enable the cables to enter the fan regulator from the rear.

7.1.5.3 WALL-MOUNTED FAN

Supply to a wall mounted fan shall be by means of a 2 A fused connection unit and shall be controlled by a 5-20 A D.P. switch with pilot light.

Wall mounted fans shall each be fixed by means of wall mounting bracket supplied with the fan or sit on a mounting bracket or batten made of teak wood or other material approved by the Supervising Officer.

7.1.5.4 EXHAUST FAN

7.1.5.4.1 Fixing of Fan

Exhaust fans, where appropriate, shall each be installed on the structural opening by means of a steel mounting plate. Where an exhaust fan is intended to draw exhausted air through a fume cupboard, the fan shall be ducted to the fume cupboard by means of a pipe made of low smoke emission and halogen free PVC of suitable size and length.

7.1.5.4.2 Method of Supply

Supply to a domestic type/fume cupboard exhaust fan shall be by means of a 2 A fused connection unit similar to that for a ceiling fan, and shall be controlled by a 5-20 A D.P. switch with pilot light.

Supply to an industrial type exhaust fan shall be by means of a fused connection unit with suitably sized fuse and shall be controlled by a 20 A D.P. switch with pilot light.

7.1.5.5 ELECTRIC FIRE OR HEATER

7.1.5.5.1 Wall-mounted Radiator

Supply to wall-mounted radiators shall be obtained through a fused connection unit with suitably sized fuse and shall be controlled by a 20 A D.P. switch with pilot light.

7.1.5.5.2 Panel Fire

Panel fires rated at 3 kW or less shall each be supplied and controlled by a 15 A 3-pin switched socket outlet with pilot light. The switched socket outlet shall be installed at a height of 300 mm above finished floor level unless otherwise specified.

7.1.5.5.3 Tubular Heater

Tubular heaters shall be supplied and controlled by a 13 A 3-pin switched socket outlet with pilot light. A wire guard complete with end plates made of hot-dip galvanised steel shall be provided to prevent falling fabric from contact with the heater tube as to create a fire risk.

7.1.5.6 WATER HEATER AND WATER BOILER

7.1.5.6.1 Oversink Water Heater

Supply to an oversink water heater shall be by means of a 13 A fused connection unit controlled by a 20 A double-pole switch with pilot light at a distance not less than 2 m from any water taps. The front plate of the fused connection unit shall have an outlet hole and the necessary cord-grip for the flexible cable.

In a surface wiring installation, the fused connection unit and the 20 A D.P. switch shall each be mounted on a moulded box or plastic pattress to IEC 60670-1:2015 and the associated parts of the standard.

7.1.5.6.2 Other Type of Water Heater

Supply to a domestic thermal storage or instantaneous water heater shall be connected to an individual final circuit. Single phase water heater shall be controlled by a double-pole switch of adequate rating and with pilot light. Three-phase water heater shall either be controlled by a 4-pole switch of adequate rating and with pilot light or by a 20 A double-pole switch with pilot light through a 4-pole contactor of adequate rating.

In a concealed or surface conduit installation, the PVC insulated cables shall be enclosed in a conduit from the control switch to a standard circular conduit box fitted with a dome cover and then through a flexible conduit from the dome cover to the water heater. The dome cover and the conduit shall be fixed as near to the water heater as practicable.

In a surface wiring installation, the control switch shall be mounted on a moulded box or plastic pattress. Final connection to the water heater shall be taken from the control switch via a flexible cable, twin with CPC. The control switch shall be fixed as near to the water heater as practicable.

7.1.5.6.3 Water Boiler

The installation of a water boiler shall be similar to that for water heater. The control switch shall be a double-pole switch of 30 A rating and with pilot light.

7.1.5.7 TEA URN

Tea urns having a rating of 3 kW or less shall be supplied and controlled by a 15 A 3-pin switched socket outlet with pilot light, while those of ratings higher than 3 kW is to be supplied and controlled by fused connection unit completed with separate double-pole control switch with pilot light. The switched socket outlet shall be fixed at a height of 1350 mm above finished floor level unless otherwise specified.

7.1.5.8 HOUSEHOLD ELECTRIC COOKER

Supply to a household electric cooker shall be controlled by a cooker control unit of rating not less than 45 A unless otherwise specified. The control unit shall be installed at a height of 1350 mm above finished floor level.

In a concealed or surface conduit installation, the PVC insulated cables from the control unit shall be enclosed in a conduit and terminated at an insulated terminal block inside a 47 mm deep conduit box to IEC 60670-1:2015 and the associated parts of the standard. The PVC insulated cables shall then be changed into PVC insulated and sheathed cable twin core with CPC before connecting to the cooker. The insulated terminal block shall be mounted on the wall at 300 mm above finished floor level. The PVC insulated and sheathed cable twin core with CPC shall be 1.5 m to 2 m long to allow the cooker to be moved for cleaning purpose.

In a surface wiring installation, PVC insulated and sheathed cable twin with CPC shall be used throughout.

7.1.5.9 FACE/HAND DRYER

The supply to an electric face/hand dryer shall be by means of a fused connection unit complete with an integrated 20 A double-pole switch and pilot light. The front plate of the fused connection unit shall have an outlet hole and the necessary cord-grip for the flexible cable. Face/hand dryer shall be installed at such a height so as to allow the nozzle to be 1,100 mm above finished floor level.

7.1.5.10 ROOM COOLER

7.1.5.10.1 Method of Supply

Supply to a room cooler shall be by means of a connection unit and a control switch, both of which shall have a current capacity of not less than the rated value of the room cooler. The control switch shall be double-pole with pilot light, installed at a height of 1,350 mm above the finished floor level.

7.1.5.10.2 Position of Connection Unit

The connection unit shall be installed adjacent to the room cooler and shall be on the same side of the room cooler as where the flexible cable enters the room cooler. In case it is not possible to ascertain where the flexible cable enters the room cooler, the connection unit shall be installed on the left side of the room cooler, as viewed from the front.

7.1.5.11 REFRIGERATOR

Supply to a refrigerator shall be by means of a 13 A switched socket. For general purpose, the socket shall be mounted at a height of 1,350 mm above finished floor level.

SUB-SECTION 7.1.6

BUSBAR TRUNKING SYSTEM

7.1.6.1 GENERAL

Busbar trunking including accessories shall be tailor-made to suit the actual site measurements, and working drawings shall be submitted for perusal by the Supervising Officer. Adequate clear space shall be allowed for inspection and maintenance of the installation.

7.1.6.2 SITE STORAGE AND PROTECTION

Busbar trunking shall be stored in a dry clean location with adequate air circulation to prevent condensation. The storage area shall be free from dirt, fumes, water and physical damage.

Work on the busbar trunking installation shall not commence unless the builder's work on the accommodation for the busbar trunking has been completed and is in a dry and clean condition with lockable door and kerb.

Busbar trunking shall be handled with great care to avoid damage to internal components, enclosure and finish. Busbar shall not be dragged across floor and shall not be subjected to torsion, denting, impact or rough handling.

7.1.6.3 BUSBAR IDENTIFICATION

Each bar shall be painted to indicate the phase to which it is connected, at each accessible position to the busbars and in each tee-off unit.

7.1.6.4 JOINT IN BUSBAR

Joints shall be properly clean and free from contamination before joint. Joints in busbars shall not cause any loss in mechanical strength, electrical continuity, current carrying capacity and short circuit capacity of the busbars compared with an unjoined busbar.

Joints shall be properly aligned before the final tightening of all joint bolts. Bolts shall not be over or loosely tightened. Bolt tightening shall be done either by means of a torque wrench to a strength figure as specified by the manufacturer or in accordance with the manufacturer's special procedure.

7.1.6.5 EXPANSION UNIT

Expansion units shall be provided to take up the axial expansions or contractions of the busbar trunking system under normal service conditions. In particular, expansion units shall be provided where both ends of the busbar trunking system are fixed and normal expansion or contraction is restricted, and where the busbar trunking system is installed across a building expansion joint. For every 30 m of busbar trunking, an expansion unit shall also be provided or else the manufacturer's recommendation shall be followed.

7.1.6.6 FEEDER UNIT

A feeder unit shall be provided for each busbar trunking system for connection of incoming supply.

7.1.6.7 TAP-OFF UNIT CONNECTION

Interconnecting conductors if provided between the busbars and tap-off units shall have a current rating not less than that of the tap-off units. The temperature rise of interconnecting conductors under normal service conditions shall not exceed that of the busbars specified in Clause 7.2.6.4.

7.1.6.8 FIRE BARRIER

Where busbar trunking passes through compartmentation wall or slab, a proper fire barrier made of non-hygroscopic material having a fire-resistance period of not less than that of the corresponding compartmentation wall or slab shall be provided. Penetration seals for openings where busduct trunking passing through the fire barrier shall be provided in compliance with Code of Practice for Fire Safety in Building.

7.1.6.9 BUSBAR TRUNKING ACCESSORIES

Bends, tees and intersection units shall be installed in such a way that no loss in mechanical strength, electrical continuity, rated current and rated short-circuit capacity shall be incurred due to insertion of bends, tees or intersection units.

7.1.6.10 SUPPORT OF BUSBAR TRUNKING SYSTEM

Busbar trunking system shall be securely fixed to the building structure according to manufacturer's recommendations. For horizontal run of busbar trunking system the hanger support shall be suitable for heavy mechanical load as stated in IEC 61439-6:2012. All fixing bolts, nuts and screws of hangers/brackets shall be heavily electroplated or galvanised.

The supports shall be spaced at regular intervals such that the clearance and creepage distances be maintained under normal service and short-circuit conditions.

7.1.6.11 EARTHING

A 25 mm x 3 mm copper tape shall be fixed to and run along the full length of the busbar trunking system to ensure earth continuity. The copper tape shall be supported at intervals not more than 400 mm horizontally and not more than 500 mm vertically. It shall be connected to the main earthing terminal on each floor. A warning notice bearing the words "Safety Earth Connection - Do not Remove" with Chinese translation shall be displayed in a conspicuous position for every 10 m horizontal run and/or one label per floor for rising main. Provision of copper tape may be exempted if the enclosure of busbar trunking can satisfy the second paragraph of Clause 7.1.7.7.4 that follows.

7.1.6.12 REQUIREMENTS FOR AIR-INSULATED BUSBAR TRUNKING SYSTEM

7.1.6.12.1 Application

Unless otherwise specified in the Particular Specification, air-insulated busbar trunking system shall not be used. However, if such a system is used, then the following requirements shall be followed.

7.1.6.12.2 Busbar Supports

(a) For vertical busbar trunking system, suspension units shall be provided at the top of each run. A built-in thrust block and an intermediate suspension unit shall be provided at every 30 m interval. Insulated thrust blocks or other thrust-absorbing device shall be provided at the bottom of each run and after each flexible joint.

(b) The busbar trunking system shall be terminated in a stop-end unit.

7.1.6.12.3 Tap-off

Branch circuits shall be connected to the busbars by tap-off units or cable clamping devices. Drilling of busbars shall be permitted only if the mechanical strength will not be impaired and the current density of the busbars will not exceed the permissible level after drilling.

7.1.6.12.4 Fire Barrier

At the position of the fire barrier, the busbars shall be insulated with self-extinguishing heat shrinkable insulating sleeves of suitable operating temperature extended to approximately 150 mm on each side of the fire barrier. Penetration seals for openings where busbar trunking passing through the fire barrier shall be provided in compliance with Code of Practice for Fire Safety in Building.

7.1.6.12.5 Mounting Brackets

Mounting brackets shall be provided for supporting the busbar trunking from the building structure. The brackets shall have the same finish as the enclosure and shall allow not less than 20 mm adjustment clearance from the wall. Unless otherwise specified the hangers or brackets shall be hot-dip galvanised, painted with anti-rust epoxy coating or the use anti-rusting material to prevent corrosion.

7.1.6.13 REQUIREMENT FOR ALL INSULATED BUSBAR TRUNKING SYSTEM

7.1.6.13.1 Application

All insulated busbar trunking system shall be generally used for a combination of extensive vertical and horizontal run of busbar mains or in an environment where weather-proofing or water-proofing of the system is required.

7.1.6.13.2 Busbar Jointing

Busbar trunking shall be joined by connecting the joint-ends of the busbars in an interleaved manner. The contact interconnection pressure shall be maintained by insulated bolts inserted through the joint. Bolts shall be tightened up either by means of torque wrench to a strength figure recommended by the manufacturer, or in accordance with the manufacturer's provision of special torque-indicating tightening device.

The joint shall be covered up by metal cover plates of same material and finish as the busbar casing so that the degree of protection against ingress of dust will not be less than that of an unjoined busbar trunking system.

7.1.6.13.3 Expansion Unit

Expansion units shall be so constructed that any change in length on both the conductors and the casing so caused by thermal expansion and contraction in all direction can be absorbed easily and cause no distortion of the busbar trunking whatsoever.

7.1.6.13.4 Tap-off Unit

Bolt-on tap-off unit shall be properly fixed on the busbars in accordance with the manufacturer's instructions. Drilling of the busbars for connection of cables will not be permitted.

7.1.6.13.5 Supporting Hangers and Fixing Brackets

Supports for busbar trunking shall be by means of hangers and brackets supplied by the same manufacturer of the busbar trunking. Unless otherwise specified the hangers or brackets shall be hot-dip galvanised, painted with epoxy coating or anti-rusting material. Unless otherwise specified, the hangers shall be spaced at intervals of not more than 2 m for horizontal mounting and 3 m for vertical mounting, or in accordance with the manufacturer's recommendation. In addition, for vertical mounting, the busbar trunking system shall be supported on every floor.

Hangers and brackets shall be properly aligned with building structure and adjusted to ensure the alignment and leveling of the busbar trunking as required in the manufacturer's standard and recommendation. Additional guide brackets in the intermediate position between two supports shall be provided, if necessary, to balance the offset loading of the tap-off unit.

SUB-SECTION 7.1.7

EARTHING SYSTEM

7.1.7.1 GENERAL

All metalworks associated with an electrical installation but not forming part of a live conductor, including exposed conductive parts and extraneous conductive parts, shall be solidly and effectively bonded and earthed in accordance with IEC 60364-1:2005/COR1:2009 and the associated parts of the standard and the Code of Practice for the Electricity (Wiring) Regulations.

7.1.7.2 MAIN EARTHING TERMINAL

A solid copper main earthing terminal of ample size shall be provided for every electrical installation at a position near the main incoming switch or switchboard for the connection of: -

(a) the circuit protective conductors;

(b) the main equipotential bonding conductors;

(c) the functional earthing conductors;

(d) the earthing conductors; and

(e) the lightning protective system bonding conductors.

To create the equipotential zone, the main earthing terminal shall be connected to earth via an earthing conductor to an earth electrode or a group of earth electrodes.

Where an installation distributes to a number of buildings or units, a separate main earthing terminal shall be provided for each individual building or unit at the point of intake thereby creating a separate equipotential zone in each building or unit.

7.1.7.3 EARTH ELECTRODE

7.1.7.3.1 Types of Earth Electrode

The following types of earth electrode are permitted:

(a) rod electrode;

(b) tape electrode; or

(c) plate electrode.

Unless otherwise specified in the Particular Specification or Drawings, rod electrode shall be installed.

Metalwork of public gas or water services shall not be used as the sole protective earth electrode.

7.1.7.3.2 Rod Electrode

Rod electrode shall be of copper with overall diameter not less than 12.5 mm or of stainless steel or galvanised steel of not less than 16 mm. A hardened steel point may be fitted to the penetrating end of the rod electrode. Additional lengths of rod, whenever required, should each be connected together by coupling.

Rod electrode shall be driven into the ground within an earth pit. Only approved tools e.g. electric hammer or pneumatic hammer shall be used for this installation.

In case the earthing resistance achieved by one rod is not sufficiently low for the purpose required, additional lengths or additional rods shall be installed. For the latter application, additional rods shall be driven into the ground outside the resistance area of the previously installed rod(s). Under normal circumstances, a mutual separation of 3.5 m is considered adequate.

7.1.7.3.3 Tape Electrode

Tape electrode shall be untinned copper strip of not less than 25 mm x 3 mm in cross section. Tape electrode shall be used only if specified by the Supervising Officer.

In case where several tapes are required for connection in parallel to achieve a low earthing resistance, they may be installed in parallel lines or they may radiate from a point.

7.1.7.3.4 Plate Electrode

Plate electrode shall be of copper not less than 3 mm in thickness, having dimensions as indicated on the Drawings or Particular Specification subject to a maximum of 1,200 mm x 1,200 mm.

In case the earthing resistance achieved by one plate is not sufficiently low for the purpose required, additional plates shall be installed. The plates shall be installed outside the resistances area of the previously installed plate(s).

7.1.7.3.5 Electrode in Deep Bored Hole

As an alternative, electrode may be buried in a deep bored hole of 20 to 30 m deep and of about 100 mm diameter provided by the Building Contractor where the soil conditions are unfavourable. In such case, a 12.5 mm diameter copper inner core rod electrode or 16 mm galvanised or stainless steel inner core rod electrode (connected together to form the required length) or annealed copper tape of 25 mm x 6 mm shall be inserted into the full length of the deep bored hole. The clearance between the electrode and the surrounding of the deep bore hole shall be filled completely by a mixture of 60% bentonite and 40% of gypsum to 125% (by volume) mixed to give

a thick slurry, which shall be grouted into the deep bored hole and then allowed to solidify. The grouting shall not trap any air in the deep bored hole.

7.1.7.3.6 Connection between Electrodes

All electrodes shall be inter-connected together to form a complete earthing system by means of 25 mm x 3 mm annealed copper tapes or stranded bare copper conductors of 70 mm^2. The copper tapes or conductors shall be enclosed in PVC sleeve or pipe laid at a minimum depth of 600 mm below the ground surface. The connecting copper tapes or conductors shall be run in direct lines between the rods.

Connections shall be brazed to achieve good and reliable joints to withstand the anticipated fault current.

7.1.7.4 EARTHING CONDUCTOR

7.1.7.4.1 Conductor Material

Earthing conductor shall be copper tapes 25 mm x 3 mm in cross section. For outdoor applications, copper tapes shall be tin plated. Aluminium conductors shall not be used as earthing conductors.

7.1.7.4.2 Connection to Electrodes

Earthing conductor shall be connected to the earth electrode(s) by means of approved copper connector-clamps such that the connection can only be disconnected by means of a tool. The connection shall be contained within a concrete lined earth pit with a substantial removable cover to ensure accessibility and maintainability.

7.1.7.5 MAIN EQUIPOTENTIAL BONDING CONDUCTOR

7.1.7.5.1 Conductor Material

Unless otherwise specified, main equipotential bonding conductor shall be of copper.

7.1.7.5.2 Bonding Position

Main equipotential bonding conductor shall connect the extraneous conductive parts of other services within the premises to the main earthing terminal of the installation. Such extraneous conductive parts shall include main water and gas pipes, other service pipes and risers and exposed metallic parts of the building structure liable to transmit a potential. Connection shall be made as near as practicable to the point of entry of the non-electrical services into the premises concerned, and shall be on the installation side of the possible breaks in the system, such as gas meter or water meter. Where practicable, the connection shall be made within 600

mm from the meter outlet union or at the point of entry to the building if the meter is outside the building.

7.1.7.5.3 Bonding Method

Main equipotential bonding conductor shall be securely and reliably connected to extraneous conductive parts of the non-electrical services by means of a copper connector-clamp of an approved type suitable for the particular application. All contact surfaces shall be cleaned and free from non-conducting materials, such as grease or paint, before the connector-clamp is installed.

7.1.7.6 SUPPLEMENTARY BONDING CONDUCTOR

7.1.7.6.1 Conductor Material

Unless otherwise specified, supplementary bonding conductor shall be of copper.

7.1.7.6.2 Application in Bathroom

In a room containing a fixed bath or shower, all simultaneously accessible conductive parts (either exposed or extraneous) shall be locally connected by means of supplementary bonding conductors.

7.1.7.6.3 Application in Other Areas

Supplementary bonding of extraneous conductive parts shall be required whenever such conductive parts are likely to be accessible simultaneously with other extraneous conductive parts or exposed conductive parts, and are not electrically connected to the main equipotential bonding by means of permanent and reliable metal-to-metal joints of negligible impedance.

7.1.7.6.4 Bonding Method

Supplementary bonding conductor shall be solidly and effectively connected to the extraneous or exposed conductive parts by means of a copper connector-clamp of an approved type suitable for the application. All contact surfaces shall be cleaned and free from non-conducting materials, such as grease or paint, before the connector-clamp is installed.

For surface steel conduit installation, the supplementary bonding conductor shall be terminated at the nearest steel conduit or conduit box forming an integral part of the conduit installation.

For concealed steel conduit installation the supplementary bonding conductor shall be terminated at, via a telephone cord outlet plate, a copper earth terminal fitted inside a metal conduit box to IEC 60670-1:2015 and the associated parts of the standard forming an integral part of the conduit installation. The metal conduit box shall be located as near as possible to

the bonding position and the exposed part of the supplementary bonding conductor shall be made as short as possible.

7.1.7.7 CIRCUIT PROTECTIVE CONDUCTOR (CPC)

7.1.7.7.1 General

CPC may be formed by a separate cable, the metallic sheath or armour of a cable, part of the same cable as the associated live conductor, rigid steel conduits, trunking or ducting, or the metal enclosure of the wiring system. Flexible conduits and the exposed conductive parts of equipment shall not form part of the circuit protective conductor.

7.1.7.7.2 CPC for Socket Outlet

For every socket outlet, a separate circuit protective conductor shall be provided connecting the earth terminal of the socket outlet and that inside the enclosure accommodating the socket outlet.

7.1.7.7.3 CPC for Flexible Conduit

For every length of flexible conduit, a separate circuit protective conductor shall be provided inside the conduit to ensure the earth continuity of the installation between the two ends of the flexible conduit.

7.1.7.7.4 CPC for Busbar Trunking

A copper tape, 25 mm x 3 mm in cross section shall be provided for the entire length of a busbar trunking. The copper tape shall be bonded to the busbar trunking at intervals not exceeding 3 m and at the position of each tape-off point.

Subject to the prior agreement of the Supervising Officer, the provision of copper tapes for a busbar trunking may be exempted provided that the enclosure of the busbar trunking can be proven to satisfy the full requirements of the circuit protective conductor in accordance with relevant regulations of IEC 60364-1:2005/COR1:2009 and the associated parts of the standard.

7.1.7.7.5 CPC for Ring Final Circuit

For wiring system using PVC insulated, PVC sheathed cables, the circuit protective conductor of every ring final circuit shall also be run in the form of a ring having both ends connected to the earth terminal at the origin of the circuit.

7.1.7.8 JOINTS IN PROTECTIVE CONDUCTORS

Provision shall be made in an accessible position for disconnecting a protective conductor from the main earthing terminal or the earth electrode to permit testing and measurements of earthing resistance. Such joints shall only be disconnected by means of a tool, shall be mechanically strong and shall be tinned to maintain the electrical continuity reliably.

No switching device shall be inserted in a protective conductor except for the following: -

(a) Where an installation is supplied from more than one source of energy, one of which requires a means of earthing independent of the means of earthing of other sources and it is necessary to ensure that not more than one means of earthing is applied at any time, a switch may be inserted in the connection between the neutral point and the means of earthing, provided that the switch is a linked switch arranged to disconnect and connect the earthing conductor for the appropriate source, at substantially the same time as the related live conductors.

(b) Multipole linked switching or plug-in devices in which the protective conductor circuit will not be interrupted before the live conductors are disconnected and will be re-established not later than when the live conductors are re-connected.

7.1.7.9 IDENTIFICATION AND LABELLING

7.1.7.9.1 Colour Identification

All cables used as protective conductors, including earthing conductors, main equipotential bonding conductors, supplementary bonding conductors and circuit protective conductors shall be identified by the colour in accordance with the Code of Practice for the Electricity (Wiring) Regulations.

Bare conductor used as protective conductor shall also be made similarly identifiable, where necessary, by the application of tapes, sleeves or discs, or by painting with the above colour combination.

7.1.7.9.2 Label for Earthing and Bonding Connections

Every point of connection for earthing and bonding shall be provided with a warning notice.

7.1.7.10 SIZING OF PROTECTIVE CONDUCTOR

7.1.7.10.1 General

The cross sectional area of a protective conductor, other than an equipotential bonding conductor, shall be determined by the Code of Practice for the Electricity (Wiring) Regulations Clause 11C, Table 11(1) to 11(2).

Where a protective conductor does not form part of a cable and is not formed by or not contained in steel conduit, trunking, ducting or other metallic enclosure of a wiring system, the cross sectional area shall not be less than 2.5 mm^2 copper or equivalent if protection against mechanical protection is provided (e.g. sheathed cable), and 4 mm^2 copper or equivalent if mechanical protection is not provided (e.g. non-sheathed cable). When a separate cable is used as a CPC, the cable shall be insulated to IEC 60189-1:2018 and the associated parts of the standard (BS 6004:2012, Table 1a) or better unless its CSA is greater than 6 mm^2.

7.1.7.10.2 Equipotential Bonding Conductor

The cross sectional area of a main equipotential bonding conductor shall not be less than half of the cross-sectional area of the associated earthing conductor of the installation subject to a minimum of 6 mm^2 and a maximum of 25 mm^2.

The cross sectional area of a supplementary bonding conductor shall be determined in accordance with relevant Regulation of IEC 60364-1:2005/COR1:2009 and the associated parts of the standard.

7.1.7.11 EARTH FAULT LOOP IMPEDANCE

7.1.7.11.1 Automatic Disconnection Time

For the purpose of automatic disconnection, means of protection shall be provided at the main switch. The type and setting of the protective devices shall be so selected that they can properly discriminate from the Electricity Supplier's protection.

For installation other than socket outlet circuit where fault protection (previously named protection against indirect contact) is afforded by an overcurrent protective device, the earth fault loop impedance of a final circuit and the characteristic of the protective device shall be so co-ordinated that the automatic disconnection of supply shall occur within 0.2 second, 0.4 second and 5 seconds as appropriate in case of an earth fault in accordance with Code 11B(b) of the Code of Practice for the Electricity (Wiring) Regulations.

7.1.7.11.2 Maximum Earth Loop Impedance

For installation other than the socket outlet circuit where fault protection (previously named protection against indirect contact) is afforded by overcurrent protective device, the earth fault loop impedance of any final circuit shall not exceed the maximum values given in the relevant tables in Code 11 of the Code of Practice for the Electricity (Wiring) Regulations.

7.1.7.11.3 Condition for Compliance

To comply with the requirement, the following formula shall be fulfilled for each circuit:

$R_A I_a \leq 50$ V

where: **R_A** is the sum of the resistances of the earth electrode and the protective conductor(s) connecting it to the exposed conductive part; and

I_a is the current causing the automatic operation of the protective device within 5 seconds. When the protective device is a residual current device, Ia is the rated residual operating current.

7.1.7.12 USE OF RESIDUAL CURRENT-OPERATED CIRCUIT BREAKER

7.1.7.12.1 General

Every socket outlet circuit shall be protected by a residual current device. The residual current device shall have a rated residual operating current not exceeding 30 mA and an operating time not exceeding 40 ms at a residual current of 150 mA as governed by IEC 61008-1:2010/AMD1:2012/ COR1:2016 and the associated parts of the standard / IEC 60755:2017.

Residual current-operated circuit breaker (RCCB) shall be installed for any final circuit where the earth fault loop impedance is too high to allow sufficient earth fault current to operate the overcurrent protective device within the specified automatic disconnection time of 0.2 second, 0.4 second or 5 seconds in accordance with Code 11B(b) of the Code of Practice for the Electricity (Wiring) Regulations. In such case, the product of the rated residual operating current in amperes of the residual current-operated circuit breaker and the earth fault loop impedance of the circuit shall not exceed 50 V.

7.1.7.12.2 Application in Household Installation

RCCD used for protecting socket outlet circuits in a household or similar installation shall have a rated operating residual current not exceeding 30 mA.

7.1.7.12.3 Equipment Outside an Equipotential Zone

For equipment used outdoors or outside an equipotential zone and supplied via a socket outlet rated at 32 A or less or via a flexible cable or cord having a similar current carrying capacity, protection shall be afforded by a residual current-operated circuit breaker having a rated residual operating current not exceeding 30 mA.

7.1.7.12.4 Circuits in Bathroom

All circuits inside a room containing a fixed bath or shower shall be protected by one or more residual current devices with a residual operating current not exceeding 30 mA.

SUB-SECTION 7.1.8

MISCELLANEOUS INSTALLATIONS

7.1.8.1 TELECOMMUNICATION SYSTEMS

7.1.8.1.1 Scope

This Section covers the conduit installation for the following systems:

(a) Telephone;
(b) Computer Network;
(c) Inter-communication and Public Address (PA) Systems;
(d) Staff Paging; and
(e) Broadcast Reception System.

Separate conduits shall be provided for each of these systems. Galvanised draw-wires of adequate size shall be provided in all empty conduits.

7.1.8.1.2 Conduit for Telephone, Computer Network, Inter-communication and PA Systems

7.1.8.1.3 Outlet Box for Telephone Point

At each telephone outlet position, the conduit shall be terminated at a 35 mm deep conduit box to IEC 60670-1:2015 and the associated parts of the standard with a moulded blank plate labelled with the type of installation unless otherwise specified. Outlet boxes shall be located at 300 mm above finished floor level measured from the bottom of the box unless otherwise specified.

7.1.8.1.4 Outlet Box for Computer Point

At each computer outlet, the conduit shall be terminated at a 35 mm deep conduit box to IEC 60670-1:2015 and the associated parts of the standard with moulded blank plate labelled with the type of installation unless otherwise specified. Outlet boxes shall be fixed at positions as specified on the Drawing.

Computer sockets will be provided and installed by others.

7.1.8.1.5 Outlet Box for Inter-communication and PA System

At each inter-communication or PA outlet position, the conduit shall be terminated at a 35 mm deep conduit box to IEC 60670-1:2015 and the associated parts of the standard with moulded blank plate labelled with the type of installation unless otherwise specified. The box shall be fixed at positions as stated on the Drawing.

7.1.8.1.6 Conduit for Staff Paging System

Unless otherwise specified, conduits for staff paging system shall be not less than 20 mm in diameter and shall be installed in accordance with Section 7.1.2 of this General Specification. Clause 7.1.8.1.5 shall also be applicable to this type of installation.

7.1.8.1.7 Conduit for Broadcast Reception System

Conduits for Broadcast Reception System shall be not smaller than 25 mm in diameter unless otherwise specified, and shall be installed generally in accordance with Sub-section 7.1.2. They shall be kept clear of power and telephone conduits and shall be arranged to cross them at right angles whenever possible. Bends shall have an internal radius of not less than 115 mm. Draw-in boxes shall be provided at intervals of not exceeding 6 m and at all 90° change of direction.

7.1.8.1.8 Outlet Box for Broadcast Reception System

At each broadcast reception outlet position, the conduit shall be terminated in a 47 mm deep, 75 mm square box with blank plate labelled with the type of installation unless otherwise specified. The box shall be fixed at skirting level or otherwise as stated on the Drawing. The cover plate shall be finished as the wall colour.

7.1.8.2 BELL AND AUDIBLE WARNING SYSTEM

7.1.8.2.1 Class-change Bell System for Schools

“Class-change” bell system shall be suitable for use on mains voltage, and shall normally be located in the General Office of the school unless otherwise specified. The supervisory panel of the bell system shall be engraved with the words "Class-change" in English and Chinese characters.

7.1.8.2.2 Bell for Mains Voltage

Bells for operation at mains voltage shall be ironclad, weatherproof, with approximately 150 mm diameter round gong suitable for conduit entry.

7.1.8.2.3 Call Bell and Door Bell Systems

Bells and buzzers shall operate at extra low voltage obtained from a double wound transformer which shall be connected to the mains supply through a 2 A fused connection unit. Unless otherwise specified, cables shall be 1.0 mm^2 PVC insulated for conduit wiring installation, or 0.75 mm^2 PVC twin flexible cable for surface wiring installation.

7.1.8.2.4 Bell and Buzzer for Extra Low Voltage

Bells shall be of the underdome type having a gong of approximately 75 mm diameter and shall be fixed to a substantial frame. Buzzers shall be contained within an insulating plastic case, and shall be approximately 75 mm square in size. Both the bells and buzzers shall have large solid terminals and rubbing contacts.

7.1.8.2.5 Bell Transformer

Bell transformers shall be air-cooled and double wound complying with BS EN 61558-2-8:2010. One side of the secondary (extra low voltage) winding shall be earthed. The reactance of the transformer winding shall be of such a value that a continuous short circuit across the terminals of the secondary winding shall not damage the transformer, or cause dangerous overheating.

The windings, core and terminals of the transformer shall be contained within an insulating plastic case.

7.1.8.2.6 Call Bell Push

Call bell pushes for indoor use shall be of flush pattern with white or ivory colour front plate.

Call bell pushes for outdoor use, or for areas where they may be subjected to rain or water, shall be weatherproof.

7.1.8.2.7 Mounting of Call Bell Push

In conduit installations, bell pushes shall be fixed in 35 mm deep conduit box to IEC 60670-1:2015 and the associated parts of the standard. In surface cable installations, bell pushes shall be fixed on a plastic pattress.

Bell pushes shall not be mounted on doors without the written approval of the Supervising Officer.

7.1.8.2.8 Table-type Push

Table-type pushes shall be single or multiple way as specified. They shall have a plastic base, and a plastic or metal top plate with adequate and approved holders for labels.

7.1.8.2.9 Table-type Push in Concealed Conduit Installation

Table-type pushes in concealed conduit installations shall be connected to a length of 0.75 mm^2 PVC insulated and sheathed flexible cord, comprising sufficient number of cords to suit the number of ways in use on the push panel. The flexible cords shall be taken to a conduit concealed in the floor slab. One end of the conduit shall terminate underneath the desk, and the other end shall enter a 35 mm deep concealed conduit box to IEC 60670-1:2015 and the associated parts of the standard, mounted

just above skirting level on the wall. The flexible cord shall enter the conduit through a compression gland, and shall be connected to a terminal block mounted in the conduit box to IEC 60670-1:2015 and the associated parts of the standard, to which the extra low voltage wiring shall be connected. Where spare conduits are placed in floor slabs, they shall be plugged with a metal screwed plug to keep out dirt and moisture.

The conduit box to IEC 60670-1:2015 and the associated parts of the standard shall form part of the extra low voltage conduit system.

7.1.8.2.10 Bell Indicator

Bell indicator shall be in a form of flashing light or indication light as specified. The indicators shall be fixed onto a cabinet of approved type with proper labels. Reset facilities shall be provided to resume the normal operation after acknowledge the bell indication.

7.1.8.2.11 Segregation of Circuits

Cables for operation at extra low voltage shall not be routed in the same conduit where other cables are operating at higher voltages.

7.1.8.3 INSTALLATION IN HAZARDOUS AREAS

7.1.8.3.1 General

(a) Electrical equipment and wiring of electrical installations exposed to potentially explosive atmospheres shall be constructed and protected to the requirements specified for hazardous areas in IEC 60079-0:2017 and relevant FM (Factory Mutual) or UL (Underwriters Laboratory) standards under ANSI or equivalent standard acceptable by relevant authorities.

(b) Electrical equipment and wiring of electrical installations in buildings and premises for the storage, manufacture or packing of dangerous goods in Categories 1 to 10 shall comply with the provisions of (Cap.295B) Dangerous Goods (General) Regulations.

(c) Electrical equipment and wiring of electrical installations in building and premises for Categories 2 and 5 Dangerous Goods including those in building and premises for liquid petroleum gas storage and for petrol filling stations shall, in addition to the requirements in Clause 8.3.1 (a) and (b) above, comply with the requirements specified for hazardous areas in the Electricity Safety Code Part 1 and 15 of the Institute of Petroleum Model Code of Safe Practice in the Petroleum Industry or Marketing Safety Code of the Institute of Petroleum or equivalent such as IEC 60079:2019 SER series and relevant FM (Factory Mutual) or UL (Underwriters Laboratory) standards under ANSI or equivalent standard acceptable by relevant authorities.

7.1.8.3.2 Electrical Equipment Selection

(a) Attention shall be paid to the Zone of Risk and to adopt the most appropriate type of protection. Type of protection of electrical equipment for achievement of safety shall be in accordance with the zone of risk listed in Table 7.1.8.3.2(a).

Table 7.1.8.3.2 (a) Selection of Electrical Equipment and Systems according to Zone of Risk

	Type of Protection	Zone in which the protection may be used
'ia' 's'	intrinsically-safe apparatus or system special protection (specifically certified for use in Zone 0)	0, 1, 2
'p' 'd' 'e' 'ib' 'm' 's'	Pressurised apparatus flammable enclosure increased safety intrinsically-safe apparatus or system encapsulation special protection	1, 2
'o' 'q' 'N'	oil-immersion powder filling non sparking	2

Notes:

Zone 0 Zone in which an explosive atmosphere is continuously present or present for long periods;

Zone 1 Zone in which an explosive atmosphere is likely to occur in normal operation; and

Zone 2 Zone in which an explosive atmosphere is not likely to occur in normal operation, and if it occurs it will exist only for a short time.

(b) The maximum surface temperature of the T (Temperature) class of an electrical equipment shall not exceed the ignition temperature of the gases or vapours involved. Relationship between T class and maximum surface temperature is shown in Table 7.1.8.3.2(b).

Table 7.1.8.3.2(b) Relationship between T Class and Maximum Surface Temperature

T Class	Maximum Surface Temperature (°C)
T1	450
T2	300
T3	200
T4	135
T5	100
T6	85

(c) The gas and vapour classification of electrical equipment which provides guidance for the safety usage of equipment in the type of gaseous prevalent environment shall conform with ISO/IEC 80079-20-1:2017/COR1:2018 and the associated Parts of the Standard.

7.1.8.3.3 Wiring System

The wiring system shall be:

(a) PVC insulated cables drawn into steel conduits; or

(b) Flame retarding PVC outer sheathed fire retarding cable enclosed in conduits or trunking; or

(c) Multi-core armoured cables; or

(d) Mineral insulated copper sheathed cables with copper conductors.

Where single core metal sheathed or armoured cables are used, precautions shall be taken to avoid dangerous sheath voltages or currents.

7.1.8.3.4 Conduit Fitting, Cable Glands, Terminal Box and Enclosure

Unless otherwise specified, conduit fittings, cable glands, terminal boxes and enclosures of apparatus (including accessories) shall be suitable for use with Group IIA and Group IIB inflammable gases and vapours as specified in ISO/IEC 80079-20-1:2017/COR1:2018 with temperature classification of T6 (85°C). Conduit fittings, cable glands and terminal boxes shall carry the registered flameproof mark and manufacturer's certificate number.

7.1.8.3.5 Screw or Bolt

Screws or bolts for securing individual components of apparatus and luminaires shall only be removed by the using of a tubular box spanner complying with BS 2558:1954 or a hexagon wrench key complying with BS 4168-7:1982.

7.1.8.3.6 Luminaire

Unless otherwise specified, luminaires shall comply with IEC 60079-0:2017 and shall be suitable for use in Zone 1 where gases exist is of Group IIA or Group IIB classification as specified in ISO/IEC 80079-20-1:2017/COR1:2018 with temperature classification of T6 (85°C). Where tubular fluorescent luminaires are specified, they shall have starterless ballasts.

7.1.8.3.7 Conduit Pendant

At all tube pendant points, a three-way (tee) circular or rectangular junction box shall be provided. The conduit down drop shall be fitted direct to the threaded spout of the box. Screwed pendant covers shall not be used.

7.1.8.3.8 Cables or Conduits Passing through Floor, Wall or Partition

Where cables or conduit passing through a floor, wall or partition that forms a gas or fire barrier, the hole provided for them shall be made good with material determined as incombustible in accordance with the method of BS 476-4:1970 to the full thickness of the floor, wall or partition. Alternatively, cable glands or cable transits may be used for this purpose.

Where a run of conduit, irrespective of size, passes from a hazardous area to a non-hazardous area, a stopper box or sealing device shall be inserted at the hazardous area boundary or, failing this, on the side remote from the hazardous area.

7.1.8.3.9 Precautions to Prevent Passage of Inflammables Gases or Vapours

Where trunking, ducts, pipes or trenches are used to accommodate cables, precautions shall be taken to prevent the passage of inflammable gases or vapours from one area to another and to prevent the collection of inflammable gases or vapours in trenches. Such precautions shall involve the sealing of trunking, ducts and pipes and the adequate ventilation or sand filling of trenches.

7.1.8.3.10 Equipotential Bonding of Conduit

The metallic portion of conduit shall be electrically bonded to the rigid system by either a separate conductor or terminating devices.

7.1.8.4 EXTERNAL LIGHTING SYSTEM

7.1.8.4.1 Scope

This Sub-section covers lighting installations (mainly pole mounted) for street lighting, security lighting, floodlighting and general area lighting.

7.1.8.4.2 Specification and Drawing

External lighting installations shall be installed in accordance with the Particular Specification and Drawings.

7.1.8.4.3 Luminaire

The type of lamps and luminaires to be used shall be as specified in the Particular Specification and Drawings. The luminaires shall be securely mounted on the poles.

For those not mounted on poles, they shall be fixed on wall or hanger, plinth or the like dedicated for the mounting of the luminaires.

Where specified in the Particular Specification, a safety chain shall be provided between the luminaire and the lamp pole to ensure that the luminaire will not be dropped down in case the luminaire support fails. The chain shall be galvanised steel and of adequate strength to support at least three times the weight of the luminaire.

7.1.8.4.4 Construction of Lamp Pole

Unless otherwise specified, lamp poles shall be constructed of mild steel pipe. The lamp poles shall be hot dipped galvanised to BS EN ISO 1461:2009. Material samples and working drawings shall be submitted when requested by the Supervising Officer. The poles shall be finished overall with at least two coats of primer and two coats of finishing paint after erection. The colour of the finishing paint shall be as directed by the Supervising Officer.

Evidence to substantiate that the lamp poles are structurally sound and are suitable for use in the local environment, in particular under typhoon conditions at a wind speed of up to 80 m/s shall be submitted. Such evidence shall be by means of manufacturer's calculation and certificates.

All lamp poles shall be earthed by approved means such as the armour of the underground armoured cables.

7.1.8.4.5 Foundation of Lamp Pole

Lamp poles shall be securely bolted down in an upright position to the foundations. Structural calculations through a registered structural engineer to substantiate the foundation is structurally sound and is suitable for use in the local environment, in particular under typhoon conditions at a wind speed up to 80 m/s shall be submitted. Should there be any queries on the construction of the foundations, the Supervising Officer's advice shall be sought.

7.1.8.4.6 Service Box

A galvanised steel service box shall be provided on each pole at an appropriate height above ground level to accommodate the MCB control box. The service box can be integrated with the lamp pole.

Each lamp circuit shall be protected by an MCB. Where the CSA of the incoming/outgoing cable cores are larger than that which can be accommodated by the terminal of the MCB, a fixed insulated connector block of adequate rating shall be installed with a tail to the MCB. Alternatively, a copper busbar may be used.

Where the service box serves more than one circuit, the supply to the MCB shall be by means of a copper busbar of adequate rating. The phase conductors of the incoming/outgoing cables shall then be terminated to the busbar by means of cable sockets.

Each control box shall be fitted with a neutral block of adequate rating and having sufficient number of ways for the incoming/outgoing cable cores. It shall be securely fixed to the base of the control box by means of a 6 mm thick paxolin block.

The service box shall be fitted with a 3 mm thick galvanised steel cover made waterproof with a 3 mm thick soft rubber or neoprene gasket. The cover shall be fixed by means of four M6 brass fixing bolts and washers and shall be hinged. Provision shall be made in the batten plate of the box for supporting and terminating up to three numbers of incoming/outgoing XLPE or PVC/SWA & PVCS cables by means of suitable cable glands. The cable sizes shall be as specified in the Particular Specification or on the Drawings.

7.1.8.4.7 Underground Cable to Pole

Underground cables for external lighting systems shall be copper cored, XLPE or PVC insulated, steel wire armoured and PVC sheathed cables (XLPE or PVC/SWA & PVCS) unless otherwise specified. Cables shall enter and leave the pole below ground level and each cable shall terminate in a gland fixed to the MCB control box. The cable cores between the glands and the terminals shall not be in tension.

Underground straight through joint will not be permitted without written agreement of the Supervising Officer.

All underground cables shall be laid inside cable trenches or ducts. If these ducts are provided by the Building Contractor, the contractor carrying out the electrical installation works shall ascertain that the quantity, size and associated arrangement of the ducts are suitable for drawing of cables in future. Draw pits of adequate sizes shall be provided for a straight run of approximately 15 m, at position where cable route changes direction or as and where required.

7.1.8.4.8 Cable between Service Box and Luminaire

Cables from the neutral terminal block and the MCB to the luminaires shall be PVC insulated and PVC sheathed having CSA as specified. Arrangements shall be made to prevent the cores from being under tension where they are attached to terminals. All cables shall be contained within the poles. Rubber grommets shall be installed where cable passes through metal work.

Where sustained arc voltage of a discharge lamp exceeds 250 V, the cables used for connecting the lamp and the control-gear shall be of 600/1,000 V grade to IEC 60502-1:2004+AMD1:2009 CSV and the associated parts of the standard or as recommended by the lamp manufacturer. The length of cables shall not exceed the limit as recommended by the manufacturer.

Where flexible cables are recommended by manufacturer for termination at the luminaire, PVC insulated and PVC sheathed flexible cables shall be used. Such cables shall enter the luminaire by means of suitable waterproof compression glands.

Where four or more floodlights are mounted on a pole, the flexible cables shall be connected to the luminaires by means of a mild steel connector box with waterproof hinged cover. The connector box shall be fitted near to the top of the pole.

7.1.8.4.9 Switch Fitted to Pole

Where specified switches may be mounted on the pole for local control. Switches mounted on the pole shall be fixed onto it by tapped holes and brass fixing screws. The switches shall be waterproof or contained within a waterproof type galvanised metal case, with an external galvanised metal operating knob or handle. Switches shall be fitted at least 2 m above finished ground level.

7.1.8.4.10 Control Gear for Discharge Lighting

Control gear for discharge lamps shall be contained within a galvanised steel box mounted on the pole or inside the concrete gear-cabinet provided by others as shown on the Drawings. When mounted on the pole, the steel box shall be watertight and positioned at a height higher than normal working level in such a way that a ladder is needed for access. The box shall be of adequate size to accommodate all control gear, cable and connections. The method of construction shall be similar to the service box.

7.1.8.4.11 Numbering of Lamp Pole

All lamp poles shall be marked with appropriate identification numbers. The numbers shall commence consecutively from the source of power supply in the clockwise direction. The numbering proposal shall be submitted with the shop drawings to the Supervising Officer for approval.

The number shall be etched on a stainless steel plate which shall be fixed onto the pole by tapped holes and two brass fixing screws. The numbers shall not be less than 50 mm tall.

A framed drawing indicating the location of lamp poles and pole numbers shall be provided in the appropriate switch room. The framed drawing shall be fixed onto the wall in such a manner that it can easily be removed for reference.

7.1.8.5 LIGHTNING PROTECTION SYSTEM

7.1.8.5.1 Installation of Lightning Protection System

Lightning protection systems shall be installed in accordance with the Particular Specification and Drawings, and as directed by the Supervising Officer.

7.1.8.5.2 Scope

This Sub-section covers lightning protection systems applicable to buildings and similar structures. It does not cover the protection of overhead lines and other specialised applications. The installation shall conform to the requirements and recommendations set out in IEC 62305-1:2010 and the associated parts of the standard.

7.1.8.5.3 Type of Lightning Protection System

A lightning protection system shall comprise air termination connected by down conductors to earthing electrodes. In larger schemes more than one of any or all of the above items may be used. Air terminations may be interconnected by means of roof horizontal conductors.

7.1.8.5.4 Air Termination

Air termination shall consist of vertical or horizontal conductor(s) or combination of both.

On a reinforced concrete structure, the air termination shall be connected to the designated reinforcing bars in the number of positions required for down conductors.

All metallic projections on or above the main surface of the roof which are connected, intentionally or fortuitously, to the general mass of the earth shall be bonded to, and form part of, the air termination network.

7.1.8.5.5 Down Conductor

The dimensions of down conductors to be used shall be either of the following:

(a) annealed tinned copper strip 25 mm x 3 mm;

(b) annealed copper rod 12 mm diameter; or

(c) steel reinforcement bar 12 mm diameter.

Where the steel work of the structure is used as down conductor, co-ordination with the Building Contractor is required to ensure the continuity of the steel work. In this connection the ends of the steel work shall be connected to the lightning protection system by a jointing method which is suitable for bonding dissimilar metals and approved by the Supervising Officer. A test joint shall be provided at each connection.

When down conductors adhered on the external wall are specified, they shall be fixed by means of suitable spacer saddles at regular intervals of not exceeding 1 m apart. The down conductor shall follow the most direct path possible between the air termination network and the earth termination network. When more than one down conductors are installed, they shall be arranged as evenly as practicable around the outside walls of the structure starting from the corners.

Each down conductor shall be connected to an earth termination.

7.1.8.5.6 Test Joint

Test joints shall be of phosphor bronze, gunmetal or copper. They shall comprise a heavy circular base, to which a heavy circular cover of the same material shall be bolted. The flat copper conductor shall be overlapped and placed so that they are clamped between the cover and the base by means of at least four screws or studs.

The test joints shall be positioned so that they shall not be tampered with by unauthorised persons. In cases where this is not possible, the earth tape/rod connector clamp shall be used as an alternative test point in place of the test joint.

7.1.8.5.7 Earth Termination

Unless otherwise specified, earth termination shall be of rod electrodes.

Each earth termination shall have a resistance to earth not exceeding the product given by 10Ω times the number of earth terminations to be provided. The whole of the lightning protection system shall have a combined resistance to earth not exceeding 10Ω. Where, due to local conditions, it is difficult to obtain a value of less than 10Ω by the sole use of rod electrodes, alternative or additional methods, e.g. the use of deep bore holes, the installation of tape or plate electrodes may be used at the discretion of the Supervising Officer.

7.1.8.5.8 Spacer Saddle

Spacer saddles shall be of high quality metal. For copper conductors, brass or gunmetal shall be used.

Non-metallic spacer saddles shall only be used when down conductors are provided with PVC sheathing.

7.1.8.5.9 Connection to Earth Termination

Down conductors and bonding conductors shall be connected to the earth electrode. Each connection shall be separately clamped and shall be fitted with a warning notice.

7.1.8.5.10 Bonding to Other Services

Lightning protection systems shall normally be kept segregated from the metalwork of other services. Minimum isolation clearances as given in IEC 62305-1:2010 and the associated parts of the standard shall be maintained. However, in certain circumstances, e.g. where fortuitous contact with other systems cannot be avoided, earth electrodes for lightning protection may, at the discretion of the Supervising Officer, be bonded to other such services including the metal sheath and armouring of low voltage cables, the consumer's low voltage earth system, metal water pipes and steel reinforcement for the foundation and structure. Cables and earthing systems belonging to the Supply Authorities, the Telephone Company and other authorities shall not be bonded except with the written permission of such Authorities. Gas pipes shall not normally be connected to any earth electrode.

7.1.8.5.11 Bond

Bonds for use in connecting the lightning protection system of other metal work shall be of soft annealed copper strip of 25 x 3 mm. Bonds connecting movable items to the lightning protection system shall be of flexible copper strand 475/0.5 mm diameter or equivalent. Connections to other metalwork shall be of negligible resistance, metal to metal and mechanically sound with non-ferrous nuts, bolts and washers using clamps where necessary.

7.1.8.5.12 Joint in Conductors

Joints in roof conductors and/or down conductors shall be made by double riveting or by suitable tape clamps. When clamps are used, the tape clamps shall each be provided with at least 4 screws or bolts. Joints shall be tinned, having negligible resistance and of good mechanical strength.

Alternatively, connectors may be jointed together by means of exothermic or thermal welding utilising the high temperature reaction of powdered copper oxide provided that the proper material and equipment are used in accordance with the manufacturer's recommended process.

SUB-SECTION 7.1.9

ELECTRIC MOTORS

7.1.9.1 LOW VOLTAGE-ELECTRIC MOTORS

7.1.9.1.1 Maintenance Access and Safety

Adequate access to the motors and their associated facilities shall be allowed such that the necessary periodical testing, cleaning and maintenance can be carried out. The motors shall not be installed in a position where surrounding plant or building work may obstruct in meeting such requirements.

Each electric motor, electric air heater battery or other electrical device which is controlled from the main control panel and is so situated that the panel is at a distance and/or out of sight from the equipment. A local 'stop-lock' control circuit switch (where there is a separate control circuit) shall be provided, plus a local main power supply circuit isolator in all such cases. Emergency stop shall be provided adjacent to each motor unless such emergency stop is provided for the equipment.

7.1.9.1.2 Terminals

Exception for armoured cables, all other cables appearing above floor level shall be enclosed in approved trunking, solid or flexible conduit, with approved provision for movement of the motor. The terminal boxes for cable connection shall be suitably arranged to make a neat joint with the conduits or cables.

7.1.9.1.3 Anti-Condensation Heater

The anti-condensation heater shall be controlled such that the heater shall be de-energised when the starter is switched on and vice versa. Heaters shall be wired from the motor control panel.

7.1.9.1.4 Belt Drives and Pulleys

Pulleys shall be correctly aligned and any holding down bolts or fixings shall be positioned to ensure correct alignment.

Slide rails shall be provided for all motors driving through belts. Purpose-made adjusting devices shall be provided to adjust the belt tension and to secure the motors.

7.1.9.1.5 Protective Guards

The protective guards shall be rigidly constructed. It shall not be possible to remove any guard without the aid of a tool.

7.1.9.1.6 Warning Label

Motor arranged for automatic restart shall have a label of durable material permanently fixed to it and in a prominent position clearly inscribed as shown below:

DANGER THIS MOTOR IS AUTOMATICALLY CONTROLLED AND MAY START WITHOUT WARNING. ISOLATE BEFORE INSPECTION. 危 險 此機乃自動操作，維修前請先關掣

7.1.9.2 MOTOR SWITCHGEAR, STARTER AND CONTROL PANELS

7.1.9.2.1 General

The motor switchgear, starters and controls shall be housed in wall-mounted local motor control panels, or floor-standing motor control switchboard as required.

7.1.9.2.2 Local Motor Control Panels

The local motor control panel shall be of wall-mounted type, unless otherwise specified, to house the motor starter and switchgear. The panel shall be mounted at a height of not exceeding 2.4m above finished floor level.

7.1.9.2.3 Motor Control Switchboard

The motor control switchboard (hereafter called the “MC Switchboard”) shall be a free-standing floor-mounted low voltage switchboard to group centrally the motor starters, controls and switchgear for the equipment.

The switchboard shall be installed on a raised concrete 'housekeeping' base provided by others. Precautions shall be taken to prevent damage or deterioration of panels during transit and to afford physical protection on site prior to final acceptance.

SECTION 7.2

MATERIAL AND EQUIPMENT SPECIFICATION

SUB-SECTION 7.2.1

GENERAL

7.2.1.1 SELECTION OF MATERIAL AND EQUIPMENT

An assessment shall be conducted for any characteristics of equipment likely to have harmful effects upon other electrical equipment or other services, or impair the supply. Those characteristics include the following: -

(a) overvoltages;

(b) undervoltages;

(c) fluctuating loads;

(d) unbalanced loads;

(e) power factor;

(f) starting currents;

(g) harmonic currents;

(h) D.C. feedback;

(i) high-frequency oscillations; and

(j) necessity for additional connection to earth.

Where items of equipment are interconnected to form an integral part of the complete electrical installation, their characteristics of performance and capacities shall be so matched as to give safe, reliable, efficient and economical operation of the complete electrical installation.

SUB-SECTION 7.2.2

WIRING SYSTEM: CABLES, CONDUITS, TRUNKING AND ACCESSORIES

7.2.2.1 CABLES IN WIRING SYSTEM

7.2.2.1.1 General

Wiring cables shall be manufactured under a recognised quality surveillance scheme (e.g. British Approvals Service for Cables (BASEC) licence or the HAR scheme recognised by the European Committee for Electrotechnical Standardization, CENELEC, etc.) and bear the appropriate marking (e.g. BASEC mark or HAR mark, etc.) of the quality surveillance scheme.

Cables in wiring system shall be one or a combination of the following types.

7.2.2.1.2 Non-sheathed Cables

Non-sheathed cables shall be to:

(a) 450/750 V PVC insulated, single-core, non-sheathed copper cables, with solid or stranded conductor for general purpose, suitable for conductor operating temperature not exceeding 70°C – code designation 60227 IEC 01 of IEC 60227-3:1993/AMD1:1997;

(b) 450/750 V PVC insulated, single-core, non-sheathed copper cables with flexible conductor for general purpose, suitable for conductor operating temperature not exceeding 70°C – code designation 60227 IEC 02 of IEC 60227-3:1993/AMD1:1997;

(c) 300/500 V heat resistant ethylene-vinyl acetate rubber or other equivalent synthetic elastomer insulated, single-core, non-sheathed copper cable, with solid conductor, suitable for conductor operating temperature not exceeding 110°C – code designation 60245 IEC 06 of IEC 60245-7:1994/AMD1:1997;

(d) 450/750 V heat resistant ethylene-vinyl acetate rubber or other equivalent synthetic elastomer insulated, single-core, non-sheathed copper cable, with solid or stranded conductor, suitable for conductor operating temperature not exceeding 110°C – code designation 60245 IEC 04 of IEC 60245-7:1994/AMD1:1997;

(e) 450/750 V thermosetting insulated, single-core non-sheathed, copper cable, with solid or stranded conductor, with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90°C – code designation H07Z-U and H07Z-R of BS EN50525-3-41:2011;

(f) 450/750 V, fire resistant, thermosetting insulated, single core, non-sheathed copper cable, with solid or stranded conductor, with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90°C;

(g) 450/750 V single core non-sheathed cables with thermoplastic PVC insulation – BS EN 50525-2-31:2011; or

(h) 450/750 V single core non-sheathed cables with crosslinked EVA insulation – BS EN 50525-2-42:2011.

7.2.2.1.3 Sheathed Cables

Sheathed cables shall be to:

(a) 600/1,000 V PVC insulated, single-core or multi-core, PVC sheathed, with or without armour, copper cables with solid or stranded conductor, suitable for conductor operating temperature not exceeding 70°C – IEC 60502-1: 2004/AMD1:2009;

(b) 600/1,000 V PVC insulated, single-core or multi-core, thermoplastic polyethylene (PE) sheathed, with or without armour, copper cables with solid or stranded conductor, suitable for conductor operating temperature not exceeding 70°C – IEC 60502-1: 2004/Amd 1:2009;

(c) 600/1,000 V cross-linked polyethylene (XLPE) insulated, single-core or multi-core, PVC sheathed, with or without armour, copper cables with solid or stranded conductor, suitable for conductor operating temperature not exceeding 90°C – IEC 60502-1: 2004/AMD1:2009;

(d) 600/1,000 V ethylene propylene rubber (EPR) insulated, single-core or multi-core, PVC sheathed, with or without armour, copper cables with solid or stranded conductor, suitable for conductor operating temperature not exceeding 90°C – IEC 60502-1:2004/AMD1:2009;

(e) 300/500 V light PVC insulated, multi-core, PVC sheathed copper cable with solid or stranded conductor, suitable for conductor operating temperature not exceeding 70°C – code designation 60227 IEC 10 of IEC 60227-4:1992/AMD1:1997;

(f) 300/500 V PVC insulated, single-core, flat twin or 3-core, PVC sheathed copper cable with solid or stranded conductor, suitable for conductor operating temperature not exceeding 70°C – national type (Table 3) of BS 6004:2012;

(g) 300/500 V PVC insulated, single-core, flat twin or 3-core, PVC sheathed copper cable with solid or stranded conductor and circuit protective conductor, suitable for conductor operating temperature not exceeding 70°C – national type (Table 4) of BS 6004:2012;

(h) 300/500 V PVC insulated, single-core or flat twin, PVC sheathed copper cable with stranded conductor and with or without circuit protective conductor, suitable for conductor operating temperature not exceeding 70°C – national type (Table 5) of BS 6004:2012;

(i) 450/750 V thermosetting insulated, twin, 3-core, 4-core or 5-core, sheathed copper cable with solid or stranded conductor, with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90°C – national type (Table 4) of BS 7211:2012;

(j) 300/500 V thermosetting insulated, single-core, flat twin or flat 3-core, sheathed copper cable with solid or stranded conductor and circuit protective conductor, with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90°C – national type (Table 5) of BS 7211:2012;

(k) 300/500 V fire resistant, thermosetting insulated, twin, 3-core or 4-core, sheathed copper cable with solid or stranded conductor, metallic layer, un-insulated full size circuit protective conductor, with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90°C – BS 7629-1:2015+A1:2019. The cable shall be of Category Standard 30 as a minimum. Cable of Standard 60 or Enhanced 120 shall be provided as specified or as required to comply with the FSD's requirement. In addition, the cable shall also comply with the fire performance requirement specified in Clause 7.2.2.1.6;

(l) 600/1,000 V cross-linked polyethylene (XLPE) insulated, single-core or multi-core, sheathed with or without armour, copper cables with solid or stranded conductor and with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90°C – IEC 60502-1: 2004/AMD1:2009;

(m) 450/750 V, fire resistant, thermosetting insulated, single-core or multi-core, sheathed with or without armour copper cables, with solid or stranded conductor and with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90°C;

(n) 600/1,000 V and 1,900/3,300 V, thermosetting insulated, armoured cables – BS 5467:2016;

(o) 600/1,000 V, thermosetting insulated, non-armoured cables up to and including conductor size of 1,000 mm^2; 2/C to 5/C non-armoured cables up to and including conductor size of 120 mm^2 – BS 7889:2012;

(p) 600/1,000 V and 1,900/3,300 V, thermosetting insulated, armoured cables, having low emission of smoke and corrosive gases when afftected by fire – BS 6724:2016;

(q) 600/1,000 V, thermosetting insulated, non-armoured cables with 1/C non-armoured cables up to and including conductor size of 1,000 mm^2; 2/C to 5/C non-armoured cables up to and including conductor size of 120 mm^2– BS 8573:2012; or

(r) 600/1,000 V, thermosetting insulated, armoured cables, fire-resistant cables having low emission of smoke and corrosive gases when affected by fire – BS 7846:2015.

7.2.2.1.4 Flexible Cables

Flexible cables shall be:

(a) 300/500 V ordinary PVC insulated, multi-core, PVC sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 70°C – code designation 60227 IEC 53 of IEC 60227-5:2011;

(b) 300/500 V ordinary tough rubber insulated, multi-core, rubber sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 60°C – code designation 60245 IEC 53 of IEC 60245-4:2011;

(c) 450/750 V rubber insulated, single-core or multi-core, heavy polychloroprene or other equivalent synthetic elastomer sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 60°C – code designation 60245 IEC 66 of IEC 60245-4:2011;

(d) 300/500 V PVC insulated, single-core or twisted twin, non-sheathed flexible copper cable, suitable for internal wiring and conductor operating temperature not exceeding 70°C – code designation H05V-K of BS EN50525-2-31:2011;

(e) 300/500 V PVC insulated, single-core or twisted twin, non-sheathed heat resisting flexible copper cable, suitable for internal wiring and conductor operating temperature not exceeding 90°C – code designation H05V2-K of BS EN50525-2-31:2011;

(f) 300/500 V braided, silicone rubber insulated, single core, non-sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 180°C – code designation H05SJ-K of BS EN50525-2-41:2011;

(g) 300/500 V flexible copper cable, suitable for use with appliance and equipment intended for domestic, office and similar environments to BS EN50525-2-11:2011;

(h) 300/500 V ordinary duty rubber insulated, 3-core or 4-core, sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 60°C – code designation H05RR-F of BS EN50525-2-21:2011;

(i) 450/750 V heavy duty rubber insulated, single-core, twin, 3-core, 4-core or 5-core, PCP or equivalent synthetic elastomer sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 60°C – code designation H07RN-F of BS EN50525-2-21:2011;

(j) 450/750 V heavy duty heat resisting ethylene propylene rubber (EPR) or equivalent synthetic elastomer insulated, single-core, twin, 3-core, 4-core or 5-core, and CSP or equivalent synthetic elastomer sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 90°C – code designation H07BN4-F of BS EN50525-2-21:2011;

(k) 300/500 V heat resistant, ethylene-vinyl acetate rubber or other equivalent synthetic elastomer insulated, single-core, non-sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 110°C – code designation 60245 IEC 07 of IEC 60245-7:1994/AMD1:1997;

(l) 450/750 V heat resistant, ethylene-vinyl acetate rubber or other equivalent synthetic elastomer insulated, single-core, non-sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 110°C – code designation 60245 IEC 05 of IEC 60245-7:1994/AMD1:1997; or

(m) 300/500 V heat resistant, silicone rubber insulated, single-core, non-sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 180°C – code designation 60245 IEC 03 of IEC 60245-3:1994 /AMD2:2011.

7.2.2.1.5 Conductor

Conductors of wiring cables shall be of high-conductivity copper and all meet the requirements of IEC 60228:2004.

The CSA of the neutral conductor shall not be less than that of the phase conductors, unless otherwise specified.

7.2.2.1.6 Fire Performance of Fire Resistant Cables

The materials for insulation and outer covering, if any, of fire resistant cable shall emit low level of smoke and corrosive gases when affected by fire. The cable shall be type tested to the following fire performance requirement: -

Circuit integrity :	BS 6387:2013; BS 8491:2008, or BS EN 50200:2015
Flame propagation :	BS EN 60332-1-2:2004/AMD11:2016 or BS EN IEC 60332-3-24:2018
Smoke emission :	BS EN 61034-2:2005/AMD1:2013; and
Acid gas emission :	BS EN 60754-1:2014 or BS EN 60754-2:2014.

7.2.2.1.7 Prefabricated Branch Cables

Prefabricated branch cables shall be:

(a) 600/1000V, XLPE-insulated, PVC-sheathed type or low smoke zero halogen-sheathed type, main and branch cables shall be of copper conductors and complied with BS 7889:2012 or IEC 60502-1:2004+AMD1:2009 CSV or relevant specification as specified in Clause 7.2.2.1.3;

(b) Each branch joint shall take the form of main and branch cables bound together to a compression connector that complies with either BS EN IEC 61238-1-1:2019 and BS EN 61238-1-2:2019, BS EN 61238-1-3:2019, JIS C 2810 or BS EN 50393:2015;

(c) Each branch joint shall be assembled and encapsulated in a thermoplastic moulding, which is compatible with the cable sheath. The entire production process shall be under a quality management system to ISO 9001:2015;

(d) Cable ends for main and branch cables shall be sealed at factory before delivery to site;

(e) Type test certificate on the following tests shall be submitted:

Heat cycle test according to the method given in one of the following:

(i) JIS C 2810 Class A;

(ii) BS EN 50393:2015;

(iii) BS EN IEC 61238-1-1:2019 and BS EN IEC 61238-1-2:2019; and

(iv) BS EN IEC 61238-1-3:2019

(v) Total 125 test cycles undergone - after the 25th cycle, the surface temperature of the thermoplastic moulding shall

not exceed 75°C. This temperature shall also not reach more than 8°C plus that at the 25th cycle when measurements are taken at the end of the 50th, 75th, 100th and 125th cycles.

Resistance to flame propagation according to one of the following standard:

(i) JIS C 3005;

(ii) IEC 60332-1-1:2004+AMD1:2015 or BS EN 60332-1-1:2004+A1:2015 and BS EN 60332-1-2:2004+A11:2016;

(iii) IEC 60332-1-2:2004+AMD1:2015; and

(iv) IEC 60332-3-24:2018 Category C

Tensile strength test

Cables shall withstand without breakage twice the specified weight of main and branch cables for the duration of not less than 24 hours.

Insulation resistance test

The cables in water shall have a minimum insulation resistance of 50MΩ.

(f) Prior to delivery to site, a factory test report on the following tests shall be submitted:

Voltage withstand test

The cables in water shall withstand a minimum voltage of 3.5kV for 1 minute without breakdown.

Connector resistance or conductivity test according to one of the following method:

(i) JIS C 3005;

(ii) The resistance measured between the connector before and after the tensile test mentioned above shall agree to each other within 12%; and

(iii) $R1/R2 \leq 1.2$ where

R1 is the cable resistance measured across the connector between the main and one of the branch cables; and

R2 is the summation of the resistance of individual cables having the same length of cable up to the connector and conductor sizes as the main and branch cables respectively.

(g) Insulation resistance test shall be conducted after installation. The cables in air shall have a minimum insulation resistance of 2MΩ.

(h) Manufacturers' recommendations shall be followed and special tools/accessories shall be used in the installation of prefabricated branch cables on site.

7.2.2.2 STEEL CONDUIT AND ACCESSORIES

7.2.2.2.1 Steel Conduit

Steel conduits, except flexible conduits, shall be of heavy gauge, screwed and longitudinally welded. All steel conduits shall comply with IEC 61386-21:2002 or BS EN 61386-21:2004+A11:2010.

7.2.2.2.2 Steel Flexible Conduit

Steel flexible conduits and solid type brass adaptors shall comply with IEC 61386-23:2002 or BS EN 61386-23:2004+A11:2010. In addition, the steel flexible conduits shall be metallic type with PVC oversheath. Oversheath materials of low emission of smoke and corrosive gas characteristics shall be provided where specified. However, neither oversheath of PVC nor materials with low emission of smoke and corrosive gas characteristics shall be required for installations within ventilated ceiling void.

The flexible conduit adaptor shall comprise two parts, an inner core and an outer ferrule. The inner core screws into the bore of the conduit together with an outer ferrule which caps off the end of the conduit, so that the adaptor can provide an extremely strong joint. The core shall lock against the outer ferrule and isolate any sharp cut edges in the conduit.

7.2.2.2.3 Steel Conduit Fitting

All steel conduit fittings shall comply with IEC 60670-1:2015 and other associated Parts of the Standard.

Adaptable boxes complete with covers shall be of cast iron or galvanised steel. Boxes of the preferred sizes as given in IEC 60670 1:2015 and other associated Parts of the Standard shall be used.

Circular boxes, dome covers and hook covers shall be of galvanised malleable cast iron complying with IEC 60670-1:2015. Ceiling mounted boxes shall be of deep pattern type having an internal depth of not less than 60 mm.

Bushes and tube ends shall be of brass.

Distance (spacing) saddles shall be of galvanised cast iron. The screws for tightening and fixing the saddles shall be of brass.

Solid or inspection tee-pieces or elbows shall NOT be used on any conduit installation.

7.2.2.2.4 Metal Boxes for Electrical Accessories

Metal boxes complete with covers for enclosure of electrical accessories in conduit installation shall comply with IEC 60670 1:2015. Boxes used to house accessories such as domestic switches, socket outlets, spur units, etc. shall be 35 mm and 47 mm deep. The depth chosen shall be suitable for the accessories to be housed.

7.2.2.2.5 Class of Protection against Corrosion

Steel conduits and couplers shall be hot-dip zinc coated or sheradised both inside and outside against corrosion and shall be tested to comply with IEC 61386-1:2008/AMD1:2017.

Steel or ferrous conduit fittings shall be hot-dip zinc coated or sheradised both inside and outside against corrosion and shall be tested to comply with IEC 61386-1:2008/AMD1:2017.

Metal boxes complete with covers for the enclosure of electrical accessories shall have heavy protection both inside and outside in accordance with IEC 60670-1:2015 (e.g. hot-dip galvanised coating or sheradising).

7.2.2.2.6 Screw

Screws used for fixing boxes and spacing saddle, and for tightening covers and spacing saddles shall have ISO metric threads. They shall be of brass or steel and if of steel they shall be protected against corrosion by a finish at least equal to the zinc coating specified in BS 7371-12:2008. Electro-brass plated screws or self-tapping screws shall NOT be used.

7.2.2.3 PLASTIC OR PVC CONDUIT AND ACCESSORIES

7.2.2.3.1 Rigid Conduit and Conduit Fittings

Rigid plain PVC conduits shall comply with IEC 61386-21:2002 or BS EN 61386-21:2004+A11:2010 and rigid plain PVC conduit fittings shall comply with IEC 61386-1:2008/AMD1:2017 and other associated Parts of the Standard. Conduits shall have classification as below:

(a) According to mechanical properties - for heavy mechanical stress; and

(b) According to temperature - with a permanent application temperature range of -5°C to +60°C.

7.2.2.3.2 Pliable Conduit

Pliable conduits shall be formed of self-extinguishing plastic materials and shall comply with IEC 61386-22:2002 and pliable conduit fittings shall comply with IEC 61386-1:2008/AMD1:2017 and other associated Parts of the Standard. Conduits shall be suitable for installation, storage or transport at temperature range of -5°C to +60°C.

7.2.2.3.3 Plastic or PVC Conduit Boxes

Plastic or PVC adaptable boxes and plastic or PVC boxes for enclosure of electrical accessories shall be of heavy duty having dimensions complying with IEC 60670-1:2015. They shall be interchangeable with the steel boxes complying with the same IEC standard. The minimum wall thickness of boxes shall be 2 mm.

7.2.2.3.4 Plastic Couplers

Plain, moulded slip-type couplers and expansion type couplers to IEC 61386-1:2008/AMD1:2017 shall be used in the jointing of conduits. Adhesive/jointing cement for jointing shall be the type recommended by the manufacturer.

7.2.2.4 STEEL TRUNKING AND ACCESSORIES

7.2.2.4.1 Steel Trunking

The steel trunking shall be manufactured in a process conforming to the relevant quality assurance standard ISO 9001:2015. Valid manufacturer's certificate of accreditation to the recognised Quality Assurance System issued within three years before the material delivery to site shall be submitted.

Steel surface and raised floor trunking systems shall be compatible to the requirements laid down in IEC 61084-1:2017. The body and cover of the surface and raised floor trunkings shall be fabricated with sheet steel having a minimum thickness as indicated in Table 7.2.2.4.4(1).

Steel flush floor and underfloor trunking shall be compatible to the requirements laid down in IEC 61084-1:2017 and IEC 61084-2-2:2017. The body and access cover of the flush floor and underfloor trunkings shall be subjected to external mechanical loads and fabricated with sheet steel having a nominal thickness as indicated in Table 7.2.2.4.4(2).

Manufacturer’s standard fittings such as tee or angle pieces, connectors, junction boxes, end caps, modular service outlet boxes and panels, etc. shall be used throughout the trunking system unless prior approval has been obtained from the Supervising Officer.

7.2.2.4.2 Protection against Corrosion

Steel trunking and associated fittings, except service outlet panel of modular service outlet box, shall have continuous hot-dip zinc coating on both sides to BS EN 10346:2015 with a minimum coating designation of Z275. The service outlet panel of modular service outlet box shall be epoxy coated unless otherwise specified. Test report of trunking materials showing the compliance with the above standard issued by an organisation accredited under HOKLAS of the HKAS, or an organisation accredited by an accreditation body mutually recognised by HKAS, shall be submitted. The test results shall be traceable with clear identification in the Delivery Note and marked on the trunking indicating that the material tested is of the same batch as material used for the project.

On-site non-destructive sample tests by coating thickness gauge as specified in BS EN ISO 2178:2016 shall be conducted as part of the inspection and acceptance procedures for coating of steel trunking. Additional samples shall be tested if the material failed in the first round of non-destructive tests. The Contractor may arrange destructive test at their own cost for verification if the results in both rounds of non-destructive tests do not comply with the coating requirements, otherwise the whole batch of material would not be accepted.

7.2.2.4.3 Construction

Steel surface and raised floor trunkings shall be of square or rectangular cross section. One side of the trunking shall be removable or hinged. No projection from screw or other sharp object will be allowed inside the trunking.

Steel flush floor and underfloor trunkings shall be constructed to permit the laying of the trunking on a structural floor without ingress of water or cement whilst the floor is screeded or is cleaned by wet-treatment. The trunking systems shall be constructed with a degree of protection against water at least IPX4 according to IEC 60529:1989/AMD2:2013/COR1:2019.

The flush floor and underfloor trunkings shall be embedded in floor screed. The access cover surface of the flush floor trunking shall be flushed with the finished floor level.

7.2.2.4.4 Dimension

Unless otherwise specified, the sizes, body and cover thickness, and preferred length of steel and raised floor trunking, are given in Table 7.2.2.4.4(1).

Unless otherwise specified, the sizes, body and cover thickness and preferred lengths for flush floor and underfloor trunking shall be as given in Table 7.2.2.4.4(2).

The dimensions of the trunking for the installation shall be the same throughout.

Trunking to special order having dimensions differing from the Tables 7.2.2.4.4(1) and 7.2.2.4.4(2) may be used, provided that they meet all the requirements as stated in this General Specification and prior approval has been obtained from the Supervising Officer.

Table 7.2.2.4.4 (1) Size, Body and Cover Thickness, and Preferred Length of Steel Surface and Raised Floor Trunkings

External dimension (mm)	Minimum thickness of body with return flange (mm)	Minimum thickness of body without return flange (mm)	Minimum thickness of cover (mm)
50 x 50	1.0	1.0	1.0
75 x 50	1.2	1.2	1.2
75 x 75	1.2	1.2	1.2
100 x 50	1.2	1.2	1.2
100 x 75	1.2	1.2	1.2
100 x 100	1.2	1.4	1.2
150 x 50	1.2	1.4	1.2
150 x 75	1.2	1.4	1.2
150 x 100	1.2	1.4	1.2
150 x 150	1.4	1.6	1.2
200 x 50	1.6	--	1.4
200 x 75	1.6	--	1.4
200 x 100	1.6	--	1.4
200 x 150	1.6	--	1.4

Table 7.2.2.4.4 (1) Size, Body and Cover Thickness, and Preferred Length of Steel Surface and Raised Floor Trunkings (Cont'd)

External dimension (mm)	Minimum thickness of body with	Minimum thickness of body without	Minimum thickness of cover (mm)

	return flange (mm)	return flange (mm)	
200 x 200	1.6	--	1.4
300 x 50	1.6	--	1.6
300 x 75	1.6	--	1.6
300 x 100	1.6	--	1.6
300 x 150	1.6	--	1.6
300 x 300	2.0	--	1.6
Preferred lengths: 3 m (minimum: 2 m; maximum: 3 m) Minimum thickness of partitions or dividers: 1.0 mm.			

Table 7.2.2.4.4 (2) Body and Cover Thickness and Preferred Lengths of Steel Flush Floor and Underfloor Trunkings

	Minimum thickness of cover (mm)	Minimum thickness of body (mm)	Minimum thickness of partition (mm)
Flush Floor Trunking			
For office applications	2.5	1.5	1.5
For mechanical plant room applications	6	1.5	1.5
Underfloor Trunking			
External width (excluding flange projections)			
Up to 100 mm	1.2	1.2	1.0
Above 100 mm and up to 300 mm	1.6	1.6	1.0
Preferred length: 3 m (minimum: 2 m; maximum: 3 m)			

7.2.2.4.5 Connection between Lengths of Trunking

Connection between adjacent lengths of trunkings, tee or angle pieces, accessories, etc. shall be made by connectors. The two adjacent ends of

trunking shall be fixed so that no relative movement can occur between them.

Electrical continuity shall be achieved by means of connecting a continuity bonding link of adequate size across the two adjacent ends of the trunking. The continuity bonding link shall be of such materials to as to prevent electrolytic corrosion.

7.2.2.4.6 Steel Surface Trunking Cover

Trunking and fittings shall have removable or hinged covers extending over the entire length. The covers shall be of the same material and finish as those of the trunking body.

Removable covers shall be held in position on the trunking either by the natural elasticity of the material of the cover (e.g. spring capped trunking) or by other approved means which hold the covers tightly onto the trunking body and cause no damage to the cables inside.

Bends, tee junctions, etc. shall also be fitted with removable or hinged covers of the same construction as that of the trunking.

7.2.2.4.7 Screw

Screws used for securing a cover or connector and for fixing a trunking shall have ISO metric threads. They shall be of brass or steel. Steel screws shall be protected against corrosion by a finish at least equal to the zinc coating specified in BS 7371-12:2008. Electro-brass plated screws or self tapping screws shall NOT be used. Projection of screws inside a trunking or a trunking fitting will not be allowed.

7.2.2.5 PLASTIC OR PVC TRUNKING AND ACCESSORIES

PVC trunking and fittings shall comply with IEC 61084-1:2017. The nominal dimensions of PVC cable trunking shall be selected from any of the following numbers in mm:

12.5, 16.0, 20.0, 25.0, 32.0, 37.5, 40.0, 50.0, 75.0, 100.0 and 150.0

Cover for trunking shall be secured either by purpose-made rivets or clip-on mechanism to manufacturer’s standard.

SUB-SECTION 7.2.3

POWER CABLES AND ASSOCIATED CABLING FACILITIES

7.2.3.1 GENERAL

Power cables are mainly for electricity supply and distribution. They shall be manufactured under a recognised quality surveillance scheme (e.g. British Approvals Service for Cables (BASEC) licence or the HAR scheme recognised by the European Committee for Electrotechnical Standardization, CENELEC, etc.) and bear the appropriate marking (e.g. BASEC mark or HAR mark, etc.) of the quality surveillance scheme.

Cabling facilities will include cable ducts, cable trays and cable ladder.

7.2.3.2 TYPES OF POWER CABLES

Power cables for supply and distribution shall be one or a combination of the following types as specified in the Particular Specification or on the Drawings:

(a) 600/1,000 V cross-linked polyethylene (XLPE) insulated, single-core, two-core, three-core or four-core, PVC sheathed with armour copper cables, with solid or stranded conductor, suitable for conductor operating temperature not exceeding 90°C – IEC 60502-1: 2004/AMD1:2009;

(b) 600/1,000 V cross-linked polyethylene (XLPE) insulated, single-core, two-core, three-core or four-core, sheathed with armour copper cable, with solid or stranded conductor, with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90°C – IEC60502-1: 2004/AMD1:2009;

(c) 600/1,000 V fire resistant, cross-linked polyethylene (XLPE) insulated, two-core, three-core or four-core, sheathed with armour copper cable, with solid or stranded conductor, with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90°C - Category F2 of BS 7846:2015. Cable of Category F30, F60 or F120 shall be provided as specified or as required to comply with FSD requirement. In addition, the cable shall also comply with the fire performance requirement specified in Clause 7.2.2.1.6;

(d) 500 V (light duty grade) mineral insulated, single-core, two-core, three-core or four-core, copper sheathed copper cable with – IEC 60702 1: 2002/AMD1:2015 and IEC 60702 2:2002/AMD1:2015;

(e) 750 V (heavy duty grade) mineral insulated, single-core, two-core, three-core or four-core, copper sheathed copper cable – IEC 60702 1: 2002/AMD1:2015 and IEC 60702 2:2002/AMD1:2015;

(f) 600/1000 V PVC insulated, single-core, two-core, three-core or four-core, PVC sheathed with armour copper cables, with solid or stranded

conductor, suitable for conductor operating temperature not exceeding 70°C – IEC 60502 1:2004/AMD1:2009;

(g) 600/1,000 V and 1,900/3,300 V, thermosetting insulated, armoured cables – BS 5467:2016;

(h) 600/1,000 V and 1,900/3,300 V, thermosetting insulated, armoured cables having low emission of smoke and corrosive gases when affected by fire – BS 6724:2016; or

(i) 750 V mineral insulated cables and their terminations – BS EN 60702-1:2002+A1:2015 and BS EN 60702-2:2002+A1:2015.

7.2.3.3 CONDUCTOR

Conductors of wiring cables shall be of high-conductivity copper and all meet the requirements of IEC 60228:2004.

The CSA of the neutral conductor shall not be less than that of the phase conductors, unless otherwise specified.

7.2.3.4 ARMOUR

The armour shall be of galvanised steel wire for multi-core cables. Single core armoured cables shall be provided with non-ferrous armour. Use of steel armour for single core cable is not accepted.

7.2.3.5 CABLE TERMINATIONS

Cables shall be terminated in approved non-ferrous mechanical glands which comply with BS EN 62444:2013 complete with compression devices for securing the cable sheath. An armour clamp shall be required for bonding to metal sheaths. Where the cables are installed in entirely dry situations, the gland shall have a compressible gasket or packing for securing the inner sheath and means of anchoring the armour. For cables installed wholly or partly in outdoor or damp conditions compressible sealing and clamping features shall be provided for securing the inner and outer sheaths and also the armour; barriers shall be incorporated to prevent the ingress of moisture.

7.2.3.6 FIRE PERFORMANCE OF FIRE RESISTANT CABLES

The requirements as stated in Clause 7.2.2.1.6 shall apply.

7.2.3.7 IDENTIFICATION OF CORE

Each core of a PVC or XLPE power cable shall be identified continuously throughout its entire length.

For a mineral-insulated cable each core shall be identifiable at its termination by the application of sleeves or discs of appropriate colours as prescribed below. Identification sleeves shall comply with BS 3858:1992, Type 3, where appropriate and shall have temperature rating similar to that of the sealant.

The identification shall take the form of appropriate colour or number codes in accordance with Table 13(2) of the Code of Practice for the Electricity (Wiring) Regulations or the relevant Specifications.

7.2.3.8 SPECIAL REQUIREMENTS FOR MINERAL INSULATED (MI) CABLE

7.2.3.8.1 MI cables shall have plastic outer covering when installed under the following conditions where:

(a) the cables are exposed to weather;

(b) the atmosphere is likely to cause corrosion;

(c) the cables are laid upon or fixed direct to a concrete or stone surface subject to dampness;

(d) the cables are laid upon or fixed to a zinc coated surface, e.g. a galvanised cable tray or corrugated sheeting, subject to dampness; or

(e) the cables are buried direct in the ground.

MI cables buried in concrete brick or other building structure, installed in refrigerated space or areas where the temperature is persistently below 0°C shall be without plastic outer covering.

The outer covering shall be of low smoke halogen free, or low smoke zero halogen, i.e. evolving very low content of smoke or corrosive gases during combustion when tested to IEC 60754-1:2011+AMD1:2019 and other associated Parts of the Standard.

7.2.3.8.2 Restriction of Use

MI cables shall not be used in discharged lighting circuits unless suitable precautions, approved by the Supervising Officer, have been taken to avoid excessive voltage. MI cables shall also not be used for earthed concentric wiring system.

7.2.3.8.3 Cable Saddle and Clip

Saddles and clips for fixing MI cables shall be purpose-made by the cable manufacturer for this purpose. Cables with plastic outer covering shall be fixed by saddles or clips having also plastic covering.

7.2.3.9 CABLE DUCT

Cable ducts shall be formed from concrete, PVC, metal or such other materials as may be specified by the Supervising Officer relating to a particular job. Ducts cast in-situ in concrete shall be so formed that the radial thickness of the concrete or screed surrounding the cross-section of the complete ducting shall not be less than 15 mm at every point.

Metallic ducting shall comply with the same requirement as metal trunking.

7.2.3.10 PERFORATED METAL CABLE TRAY

7.2.3.10.1 Material

Perforated metal cable trays shall be formed from plain steel sheet complying with BS EN 10149-1:2013, and shall be hot-dipped galvanised to ISO 1460:1992 and ISO 1461:2009 after perforation.

7.2.3.10.2 Dimensions of Tray

Cable trays shall have typical dimensions as shown on Table 7.2.3.10.2.

Table 7.2.3.10.2 Typical Dimensions of Cable Tray

Nominal Width (mm)	Minimum height of upstand (mm)	Thickness of steel sheet (mm)	Minimum height of return flange (mm)
100 and 150	12	1.2	--
225 and 250	12	1.5	--
300 and 350	20	1.5	12
400 and 450	20	1.5	12
500 and 550	20	2.0	12
600 and 700	20	2.0	12
800 and 1,000	20	2.0	12
1,200	20	2.0	12

7.2.3.10.3 Bend Piece

Bend pieces shall be of the same material, thickness and finish as the main body of the cable tray and shall have an inner radius of 50 mm and a straight length of 100 mm at each end.

7.2.3.10.4 Perforation on Bend

No perforation shall be made in the circular portion of all bend pieces having a nominal width of 150 mm or 100 mm. Perforation may be allowed in bend pieces having a nominal width of 225 mm or above provided that the perforation is made along a line passing through the centre of curvature of the bend pieces and set at an angle θ to the normal of the axis of the cable tray. The values of θ are shown in Table 7.2.3.10.4.

Table 7.2.3.10.4 Location of Perforation in Bend Piece of Cable Tray

Nominal width of cable tray	Value of θ
225 mm to 350 mm	45°
400 mm and above	30° and 60°

7.2.3.10.5 Tee Piece

Tee pieces shall be of the same material, thickness and finish as the main body of the cable tray. The distance measured between the point of intersection and the end of the tee piece shall not be less than 100 mm.

7.2.3.10.6 Cable Tray Accessories

Manufacturer's standard items of accessories shall be used. Site fabrication of accessories will only be allowed upon approval of the Supervising Officer and shall be kept to a minimum.

Where special sections are required, the material, thickness and finish shall be as specified for the standard items.

7.2.3.11 WIRE MESH CABLE TRAY (CABLE BASKET)

7.2.3.11.1 General

The wire mesh cable tray system shall be provided for the support and accommodation of data and/or telecommunication cables where specified in the Contract or on the Drawings. The wire mesh cable tray system shall be of proprietary product complying with IEC 61537:2006.

7.2.3.11.2 Material

Unless otherwise specified, the wire mesh cable tray shall be manufactured from steel wires and hot dipped galvanised to ISO 1461:2009 after formation of the cable tray.

7.2.3.11.3 Fittings and Accessories

All fittings and accessories associated with the installation of the wire mesh cable tray system shall be supplied by the same manufacturer with the same finish. All the accessories and tools for the connection of straight run pieces, formation of bends, risers, reducers, T-branch, etc. shall be provided by the manufacturer.

7.2.3.11.4 Construction of Wire Mesh Cable Tray

The steel wires of wire mesh cable trays shall be welded together and bent into rigid basket shape. The up-stand edges shall have a minimum height 50 mm to contain the cables. The surface of all system components, which

come into contact with cables, shall not cause damage to the cables when installed according to the manufacturer's recommendation.

7.2.3.12 CABLE LADDER

7.2.3.12.1 Material

Generally, unless otherwise specified, all cable ladder fittings and accessories mentioned below shall be manufactured from hot rolled steel to BS EN 10149-1:2013 and then hot dipped galvanised to ISO 1460:1992 and ISO 1461:2009 after fabrication.

For heavily corrosive environments where specified in the Contract, Specification or on the Drawings, cable ladder fittings and accessories shall be manufactured from ANSI 316 stainless steel.

7.2.3.12.2 Fittings and Accessories

All fittings and accessories applied to the same cable ladder system shall be supplied by the same manufacturer to the same finish. In addition to straight ladders, the standard product range of the same cable ladder system shall at least include 90° bends, equal tees, four-way crossovers, 45° internal risers, 45° external risers, 90° internal risers, 90° external risers, straight reducers, left-hand offset reducers, right-hand offset reducers, various jointing couplers, various supporting brackets and hangers, various connectors, and various bolt and nuts.

7.2.3.12.3 Construction of Cable Ladder

Cable ladder shall be of "heavy duty" type. The two rails shall be 90 mm minimum in height with top and bottom flanges of sufficient strength. The rungs shall be spaced at 300 mm centres maximum and shall have slots for cable fixing. The working depth (depth between top edge of rail and top surface of rung) shall be 60 mm minimum.

SUB-SECTION 7.2.4

WIRING ACCESSORIES AND MEASURING INSTRUMENTS

7.2.4.1 GENERAL

Wiring accessories shall meet the general requirements of BS 5733:2010+A1:2014. Unless otherwise specified, they shall be white or ivory in colour, uniform in colour and appearance throughout an installation.

Moulded box or pattress and steel or cast iron box for the enclosure of wiring accessories shall comply with IEC 60670-1:2015 and other associated Parts of the Standard and shall meet the requirements specified in this General Specification where appropriate.

7.2.4.2 DOMESTIC SWITCHES

7.2.4.2.1 General

Switch for domestic and similar purposes shall comply with IEC 60669-2-1:2002/AMD2:2015.

Switch mounted outdoor, or in positions where it may be exposed to rain or water, shall be of watertight construction with minimum IP54 protection in accordance with IEC 60529:1989/AMD2:2013/COR1:2019

7.2.4.2.2 Lighting Switch

Lighting switch shall be suitable for use in A.C. circuits, and shall be of the quick make-and-break type when used in D.C. circuits. The front plate shall be of plastic insulating material. Suspension pear type switches shall not be used.

Lighting switch shall be single pole of rated load not less than 5 AX or 10 AX as specified in the Particular Specification or Drawings.

7.2.4.2.3 Double Pole Switch for Appliance

Double pole switch shall be integrated with a pilot light formed by a neon lamp with a resistor and a red coloured lens.

7.2.4.2.4 Sparkless Switch

Sparkless switch shall be of the tilting mercury type. The contacts of a sparkless switch shall be contained in a sealed glass capsule.

7.2.4.2.5 Time Switch

Time switch shall be manufactured for 7 days, 24-hour operation and shall be driven by electromechanical or electronic operated clock. For electromechanical operated clock, time setting shall be accomplished by

plugging in setting pins and a minimum setting period of 15 minutes shall be achievable. The whole unit shall be encompassed in metal or moulded box with ingress protection not less than IP53 to IEC 60529:1989/AMD2:2013/COR1:2019. The box shall be suitable for wall mounting and entry of a 20 mm conduit. An inspection glass window and quick action fastener shall be fitted on the front lid of the box.

Time switch shall incorporate the following features: -

(a) The clock shall be of direct reading type with minute adjustable knob to set time precisely to the minute. Accuracy of the clock shall be within ± 15 sec per month;

(b) Battery back-up device shall be incorporated to provide 360 hours continuous operation upon power failure;

(c) The switch shall consists of single pole, single throw silver contacts capable of accommodating a minimum load of 20 A at 250 V AC resistive, 7.5 A inductive at 0.7 power factor or 10 A incandescent lamps. The contacts shall be capable of being isolated for external circuit connection;

(d) A changeover switch shall be provided for selecting the ON/AUTO/OFF mode of operation; and

(e) Rated power consumption of the whole unit shall not exceed 2.5 W.

7.2.4.3 SOCKET OUTLETS

7.2.4.3.1 General

All socket outlets shall be of 3-pin shuttered type. Socket outlet and plug rated at 13 A shall comply with BS 1363-2:2016+A1:2018. Socket outlet and plug rated at 5A or 15A for general application shall comply with BS 546:1950. Weatherproof socket outlet shall have cover with ingress protection of at least IP55 to IEC 60529:1989/AMD2:2013/COR1:2019. For socket outlet installed at outdoor or exposed to sunlight, the cover of the socket shall be UV stabilised, chemically and impact resistant with ingress protection at least IP66.

USB circuits incorporated in a socket-outlet shall conform to the requirements of BS EN 60950-1:2006+A2:2013; or BS EN 62368-1:2014; or BS EN 61558-2-16:2009+A1:2013 and BS EN 61558-2-6:2009; and BS EN 62680-1-1:2015.

Socket outlet used for supplying appliance mounted at high level shall be unswitched, otherwise it shall be fitted with an integral switch. The integral switch shall be of double pole, forming part of the same front plate as the socket outlet, and with clear indication of the ON/OFF switching position.

Industrial type socket outlet shall comply with IEC 60309-2:2012 and be provided with a push-on cap and cap retaining ring or a screw-on cap with rubber gasket. The socket outlet shall have ingress protection of at least IPX4 to IEC 60529:1989/AMD2:2013/COR1:2019.

7.2.4.3.2 Shaver Supply Unit

Electric shaver supply unit shall comply with IEC 61558-1:2017 and shall be all insulated, suitable for both flush and surface mounting. Each unit shall comprise two outlets, one for 110 V and the other for 220 V, obtained from tappings of a double wound transformer to IEC 61558-2-5:2010 and with unearthed secondary windings.

7.2.4.3.3 Plug

Unless otherwise specified, plug for 13 A socket outlet shall be fitted with a fuse to BS 1363-2:2016+A1:2018, rated at 13 A.

Each plug shall be fitted with a cord grip so that no stress will be exerted on the conductors of the flexible cable connected to it at the terminals.

7.2.4.4 CONNECTION UNITS

7.2.4.4.1 (NOT USED)

7.2.4.4.2 Switched or Unswitched Fused Connection Unit

The connection unit is intended for final connection to a fixed equipment or appliance which has a full load current not exceeding 13A. It shall be of double pole type with neon/LED indicator meeting the requirements of BS 1363-4:2016+A1:2018. It shall incorporate a fuse link to BS 1363-2:2016+A1:2018 rated to suit the appliance to be connected in the pole connecting to the phase conductor. An earth terminal shall also be provided for the connection of the circuit protective conductor to the appliance.

7.2.4.5 INSULATED TERMINAL BLOCK

The rated voltage of a terminal block shall not be less than 435 V between terminals and 250 V to earth.

Terminal block shall comprise copper connectors with screw connections, all contained within a moulded block suitable for working temperature up to 100°C.

7.2.4.6 LIGHTING SYSTEM ACCESSORIES

7.2.4.6.1 Luminaire Track System

Luminaire track system shall comply with IEC 60570:2003/AMD2:2019. It shall be for ordinary interior use for mounting on, or suspended from wall or ceiling. The track shall be of two or four-pole with provision for earthing, with a rated voltage not exceeding 250 V AC to earth and a rated current not exceeding 32 A per conductor for distribution to luminaires.

7.2.4.6.2 Photocell Device

Photocell device shall comply with BS 667:2005 and shall have good tolerances in physical dimensions and with no moving parts. An additional circuitry shall be provided to achieve a delay of at least 30 seconds so as to eliminate switching due to lightning or other short period changes in illumination.

7.2.4.6.3 Ceiling Rose

Ceiling rose of maximum rating of 6 A at 250 V shall comply with BS 67:1987 and shall be ivory or white moulding with outside diameter not less than 63 mm and 50.8 mm fixing centres, 3-plate pillar type with earth terminal and with integral cord-grip.

7.2.4.6.4 Lampholder

Batten lampholder shall be of bayonet type complying with IEC 61184:2017 or Edison screw type complying with IEC 60238:2016. The lampholder shall be manufactured from moulded hard white or ivory colour plastic material which shall be unaffected by the heat from the lamp.

Lampholder for weatherproof luminaire shall be porcelain and comply with IEC 61184:2017.

Lampholder for use with tubular fluorescent lamp shall be of bi-pin type, complying with IEC 61184:2017, IEC 60061-1:2005/AMD59:2019 and IEC 60061-2:2005/AMD54:2018. It shall be made of moulded white plastic material to hold the tube in position without the need for additional clip.

7.2.4.7 MEASURING INSTRUMENT

7.2.4.7.1 Watt-hour Meter

Watt-hour meter shall comply with IEC 62053-11:2003 /AMD1:2016/COR1:2018. The register shall be of drum type and the principal unit in which the register records shall be in kilowatt-hours (kWh). The casing shall be of black phenolic moulding with an inspection glass window.

Watt-hour meter shall have Class 2 accuracy calibrated at the normal working voltage and frequency.

7.2.4.7.2 Ammeter and Voltmeter

Ammeter and voltmeter shall be of moving iron type, moving magnet type or moving coil with transducer type complying with the relevant parts of IEC 60051 series (including IEC60051-1:2016 to IEC 60051-9:2019). The accuracy class shall be "2.5" or better in accordance with the relevant parts of IEC 60051 series. The dial of ammeter and voltmeter shall have a nominal diameter of 100 mm and shall have a scale deflection not less than 90°. The operating voltage and running current of the connected circuit shall be clearly indicated on the voltmeter and ammeter respectively.

An ammeter for any circuit of rating up to 60 A may be connected directly in series with the circuit, so that the full circuit current passes through the instrument. For a circuit of rating exceeding 60 A, the ammeter shall be fed through the secondary winding of a current transformer, and shall give a full scale deflection with a secondary current of 5A.

7.2.4.7.3 Current Transformer

Current transformer for use with measuring instrument shall comply with IEC 61869-2:2012 having rated secondary current of 5 A and rated output suitably matched with the loading of the measuring instrument. The accuracy class shall be "1" in accordance with IEC 61869-2:2012.

7.2.4.7.4 Selector Switch for Ammeter

Where a single ammeter is used to measure the current in each phase or the neutral of a three phase circuit, the ammeter shall be connected to a selector switch which shall enable the ammeter to be inserted in series with each phase and the neutral in turn. When the ammeter is connected to the secondary windings of the measuring current transformers, the selector switch shall have facilities to prevent the current transformers from being open circuited during change-over and at "OFF" position.

7.2.4.7.5 Selector Switch for Voltmeter

In a three phase circuit in which a single voltmeter is used to measure the various voltages, the voltmeter shall be provided with a selector switch to enable the following voltages to be measured:

(a) voltage between each phase to neutral; and

(b) voltage between any two phases.

The selector switch shall also have an "OFF" position.

7.2.4.7.6 Meter Chamber

Meter chamber for housing watt-hour meter shall be made from galvanised steel of not less than 1.6 mm thick and shall be of ample size to accommodate the required number of watt-hour meters and meter cables. Provision shall be made to enable the watt-hour meters to be fixed inside the chamber without removing the chamber from the wall or other supports. Meter fixing screws shall not project through the back of the chamber.

When a meter chamber is installed indoor, it shall be fitted with a hinged metal front cover. Meter chamber installed outdoor shall be waterproof, with screw-on type front cover. The ingress protection for the outdoor type shall be at least IP54 in accordance with IEC 60529:1989 /AMD2:2013/COR1:2019.

A glass window of adequate size shall be provided on the front cover of the meter chamber to enable the registers and serial numbers of the watt-hour meters to be read easily.

7.2.4.8 OCCUPANCY AND DAYLIGHT SENSOR

7.2.4.8.1 General

The sensor shall be suitable to operate under the following conditions: -

Operating voltage	:	12 – 36 V D.C. or 220 V ± 6% A.C.
Operating temperature	:	0°C – 40°C indoor,
Operating relative humidity	:	less than 95% non- condensing

Where the intelligent lighting management system is specified, the sensor shall be capable of networking and integrating into the system. Where the control of air conditioning units by the sensors is specified, the sensors shall be capable to control the designated air conditioning units as required to meet the contract requirements. For standalone application, the occupancy sensor shall be capable of controlling the lighting circuit connected for direct on/off switching or dimming performance.

7.2.4.8.2 Passive Infrared (PIR) sensor

(a) PIR sensor shall detect occupancy in the control area by sensing the difference between heat emission from human body in motion and the background space.

(b) The PIR sensor shall be provided with built-in heat sensing detector resided behind an optical lens.

(c) The PIR sensor shall have 360^{o} field of view with provision of mounting external covering mask for fine adjustment of the detection zone to meet the various applications.

(d) When the sensor is mounted under the ceiling at 2.4 m above the finished floor level, the minimum detection coverage area shall not be less than 5 m in diameter.

(e) A built-in LED lamp shall be provided and illuminated once the sensor detects movement within the control area.

(f) Sensing sensitivity and extent of detection area shall be adjustable in field.

(g) The sensor shall be provided with its own delay timer for adjusting the delay of switching off the lights between 5 seconds to 20 minutes when no occupancy being sensed.

7.2.4.8.3 Ultrasonic sensor

(a) Ultrasonic sensor shall detect occupancy by sensing frequency shift between the emitted ultrasonic wave (normally in the range of 32 －40 kHz) and the reflected wave in the controlled space.

(b) The sensor shall comprise one or two pairs of ultrasonic transducers. For each pair of transducers, one transducer shall be used for emitting while the other one for receiving signal.

(c) The sensor shall have either 180° or 360° field of view to meet the application need.

(d) Sensing sensitivity and extent of detection area shall be adjustable in field.

(e) The sensor shall be provided with its own delay timer for adjusting the delay of switching off the lights between 5 seconds to 20 minutes when no occupancy being sensed.

(f) When the sensor is mounted under the ceiling at 2.4 m above the floor level, the minimum area of coverage shall not be less than 40 m^2 under the 360° field of view.

(g) LED shall be provided with the sensor to indicate motion being detected.

(h) Air current (airflow) compensation device shall be provided for sensitivity adjustment.

7.2.4.8.4 Dual Technology sensor

(a) The sensor shall use both passive infrared heat change and frequency shifts in ultrasonic wave to detect occupancy.

(b) The sensor shall comprise one or two pairs of ultrasonic transducers and one PIR sensing detector. For each pair of

ultrasonic transducers, one transducer shall be used for emitting while the other one for receiving signal.

(c) Ultrasonic detection and PIR detection shall be independently enabled/disabled to suit the application.

(d) Sensing sensitivity and extent of detection area shall be adjustable in field.

(e) Switching on the lighting associated with the occupancy sensor shall be triggered either by ultrasonic or PIR signal or both.

(f) The sensor shall be provided with its own delay timer for adjusting the delay of switching off the lights between 5 seconds to 20 minutes when no occupancy being sensed.

(g) The ultrasonic sensor shall have either 180° or 360° field of vision. The PIR sensor shall have 360° field of view with provision of mounting external covering mask for fine adjustment of the detection zone to meet the various applications.

(h) The minimum area coverage shall not be less than 40 m^2 when the sensor is mounted under the ceiling at 2.4 m above the floor level under the 360° field of view.

(i) Two LEDs shall be provided with the sensor, one to indicate the detection of movement by PIR and another for movement indication by ultrasonic.

(j) Air current (airflow) compensation device shall be provided for sensitivity adjustment.

7.2.4.8.5 Daylight sensor

(a) Daylight sensor is used to measure and monitor the ambient light level for switching on/off or dimming the interior lighting fittings to maintain the setting illuminance in a given area. The daylight sensor shall connect to the intelligent lighting management system to perform the dimming function.

(b) The daylight sensor shall has a dynamic light level measuring ranging from 50 to 1,000 lux.

(c) The preset light level and its deadband range of maintaining the preset light level of daylight sensor shall be able to be adjusted through the intelligent lighting management system. If the light level stays within the deadband, the light level at the controlled area shall remain at preset level.

(d) Device shall be incorporated to compensate rapid light intensity fluctuations.

SUB-SECTION 7.2.5

SWITCHGEAR AND ASSOCIATED EQUIPMENT

7.2.5.1 GENERAL

7.2.5.1.1 Scope

This Section specifies the general requirements of switchgear and associated equipment operating at low voltages, which may be assembled on site from individual items of components. The switchgear and associated equipment shall be manufactured to the relevant current International Electrotechnical Commission (IEC) Standards as indicated below: -

IEC 60947-1:2007 /AMD2:2014	:	Low-voltage switchgear and controlgear – Part 1: General rules
IEC 61439-1:2011	:	Low-voltage switchgear and controlgear assemblies – Part 1: General rules
IEC 61439-2:2011	:	Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies
IEC 61439-3:2012 /COR2:2019	:	Low-voltage switchgear and controlgear assemblies – Part 3: Distribution boards intended to be operated by ordinary persons (DBO)

Other requirements as specified in this section, shall also apply to all items of switchgear and associated equipment where applicable unless explicitly mentioned elsewhere.

Additional and specific requirements for verification test of low-voltage switchgear and controlgear assemblies as described in IEC 61439-1:2011 and IEC 61439-2:2011 shall be given in Sub-section 7.2.11 of this General Specification, the Particular Specifications, the Drawings and other documents issued by the Supervising Officer.

The component equipment covered in this Section shall include the following: -

(a) Switches, disconnectors (isolators), fuse-switches and switch-fuses;

(b) Circuit-breakers including air circuit-breakers (ACB), moulded case circuit-breakers (MCCB), miniature circuit-breakers (MCB), residual current-operated circuit breakers without integral overcurrent protection (RCCB) and residual current-operated circuit breakers with integral overcurrent protection (RCBO);

(c) Fuses;

(d) Busbar chambers and distribution boards; and

(e) Electromechanical contactors, motor starters and automatic changeover switches.

7.2.5.1.2 Service Condition

The following service conditions shall apply:

(a) Ambient temperature - peak from minus 5°C to plus 40°C for 4-hours continuously with an average from 0°C to plus 35°C over only 24 hours period;

(b) Altitude - up to 2,000 m above sea level;

(c) Relative humidity - up to 99% or non-condensing;

(d) Pollution Degree 3 - Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation; and

(e) Climatic condition – Tropical (Hong Kong).

7.2.5.1.3 Short-circuit Rating and Continuous Current Rating

Switchgear shall be suitably rated for the specified prospective short-circuit current which can occur at the point of its installation. It shall also be rated for uninterrupted duty when carrying continuously the specified full load current. For non-automatic switching devices, the rated short-time withstanding current shall be at least 12 times of the maximum rated operational current for 1 second.

Where equipment components are installed in enclosures, they shall be suitable for operation at the actual maximum temperatures which will be reached within the enclosures under normal loaded conditions when the ambient temperature is 40°C.

7.2.5.1.4 [Not Used]

7.2.5.1.5 Degree of Protection for Enclosure

Enclosures for switchgear and associated equipment shall be of totally enclosed type. For indoor applications, the enclosure shall have an ingress protection (IP), in accordance with IEC 60529:1989 /AMD2:2013/COR1:2019, of at least IP41 for the top surface and IP31 for the other surfaces of the enclosure. For outdoor applications, the enclosure shall be of at least IP54.

7.2.5.1.6 Material

Unless otherwise specified, switchgear and associated equipment except MCCB and MCB shall be of metalclad. All ferrous metal parts shall be galvanised or chrome plated unless the final finish has been painted or enamelled in the manufacturer's factory.

All extraneous conductive parts shall be electrically continuous.

7.2.5.1.7 ON and OFF Indication

The switching device shall incorporate positive means to indicate clearly and reliably the ON (or CLOSE) and the OFF (or OPEN) positions of the contacts. Indication of either position shall only occur when the ON or OFF position on every pole has been attained. Such indication shall be provided on the outside of the device and shall be prominently visible to an operator when the device is installed in the normal manner.

When the switching device is also used for isolation purpose, then an indication of the OFF position shall occur only when all contacts are also in the OFF position and the isolating distance between contacts in every pole has attained a clearance not less than those specified for disconnectors according to IEC 60947-3:2008+AMD1:2012+ AMD2:2015 CSV.

7.2.5.1.8 Identification of Circuit

Labels or other means of identification shall be provided for every item of switchgear and associated equipment to indicate the purpose of the item. The labels shall either be fixed at the front cover of the equipment or at the inside surface of the hinged front cover.

7.2.5.2 SWITCH, DISCONNECTOR, FUSE-SWITCH AND SWITCH-FUSE

7.2.5.2.1 Scope of Switch

All reference to switches in this and subsequent Clauses shall include also fuse-switches or switch-fuses.

7.2.5.2.2 General

Switches, disconnectors, fuse-switches and switch-fuses shall comply with and be tested to IEC 60947-3:2008+AMD1:2012+AMD2:2015 CSV and shall have air-break type contacts for uninterrupted duties. They shall be either three pole with switched neutral (four-pole), triple-pole with neutral link, double-pole, or single pole with neutral link as specified, and shall each be fitted with earthing facilities. All live parts shall be efficiently shrouded with insulating materials. Cam switches or disconnectors shall not be used for circuits of 50 A or above.

Each switch shall be supplied in complete unit consisting of a basic unit contained within an enclosure. Adequate space shall be provided in the enclosure for proper cable termination, otherwise cable boxes shall be provided. Fuse carriers, when required, shall be included.

7.2.5.2.3 Operating Mechanism

Switches and disconnectors shall be of the quick-make and quick break type. The switching mechanism shall be of independent manual operation with suitable means such as accelerating springs.

For switches and isolators with switched neutral, the neutral pole shall open after the phase pole contacts and shall close before or at the same time as the phase pole contacts.

7.2.5.2.4 Construction

The enclosure shall be of totally enclosed type, made up of heavy gauge sheet metal, adequately rust and dust protected, and finished in enamel. An earthing terminal shall be provided. The enclosure shall be suitable for conduit, trunking and armoured cable entries and also for connection to busbar chamber from top or bottom. Frame sizes for the range of switches shall be kept to a minimum.

Switches and isolators shall be constructed with an interlocked front cover to prevent access to the interior parts of the equipment when the contacts are in the CLOSE position, and to prevent the contacts from being switched to close when the front cover is opened. However, facilities shall be provided to allow the checking of the contact alignments. The fastening devices for the front cover shall be of captive type.

Insulation material used shall be of non-hygroscopic and non-ignitable type. The contacts shall be self-aligning so that contact pressure can be maintained at all times. All live parts shall be adequately shielded from the front of the unit but easily accessible for maintenance by using a tool.

7.2.5.2.5 Operating Performance

The operating performance of the switches and disconnectors shall be tested in accordance with IEC 60947-3:2008+AMD1:2012+AMD2:2015 CSV. The number of operating cycles corresponding to the rated operational current shall not be less than the values given in Table 5 of IEC 60947-3:2008+AMD1:2012+AMD2:2015 CSV.

7.2.5.2.6 Utilisation Category

Switches shall be to utilisation categories of AC-22A or AC-22B for general applications and AC-23A or AC-23B for electrical motor circuits unless otherwise specified.

7.2.5.2.7 Padlocking Facility

Switches and disconnectors shall be fitted with padlocking facilities so that they can be padlocked in either ON or OFF position.

7.2.5.3 CIRCUIT BREAKER - GENERAL

7.2.5.3.1 Scope of Circuit Breaker

This Clause covers the general requirements of ACB, MCCB, MCB, and RCCB and RCBO. Additional requirements relevant to a particular type of circuit breakers shall be given in Clauses 7.2.5.4 to 7.2.5.7, both inclusive.

7.2.5.3.2 Number of Poles

Circuit breakers shall be of triple-pole with switched neutral (four-pole), three-pole, double-pole or single-pole, as specified, and shall have air-break contacts. All poles, except the neutral poles, shall have their contacts open or close simultaneously.

7.2.5.3.3 Operating Mechanism

The operating mechanism of a circuit breaker shall be trip-free.

When a MCCB, MCB, RCCB or RCBO trips and opens its contacts, the operating toggle shall automatically resume the OFF or TRIPPED position.

7.2.5.3.4 Casing

The casing of an ACB shall be metalclad.

The casing of a MCCB, MCB, RCCB or RCBO shall be formed from insulating material. The construction shall be capable of withstanding the appropriate rated short circuit current and reasonably rough use without fracture or distortion.

7.2.5.3.5 Current Rating

The rated current of a circuit breaker shall be taken as that rated continuous current when the circuit breaker is installed in the enclosure together with other equipment if any under normal operating conditions as specified in the Particular Specification.

7.2.5.4 AIR CIRCUIT BREAKER (ACB)

7.2.5.4.1 General

All circuit breakers shall not be of moulded case type. The neutral pole shall have cross-sectional areas not less than that of respective phase pole.

ACB shall be of triple-pole with switched neutral (four pole) or triple-pole with bolted neutral, as specified, fully metalclad with earth terminals. It shall be of horizontally withdrawable type having spring assisted closing and, where specified, motorised spring charger and push-button electrical control.

ACB shall comply with and be type tested to IEC 60947-2:2016 +AMD1:2019.

Unless otherwise specified, ACB shall have built-in overload protection with Inverse Definite Minimum Time (IDMT) characteristics and instantaneous short circuit interruption. Where an ACB is used as the main incomer, the IDMT characteristics shall be compatible with those of the electricity supplier.

7.2.5.4.2 Performance Characteristic

ACB shall be certified, in accordance with IEC 60947-2:2016 +AMD1:2019, to have the following performance characteristics:

(a) Rated short-circuit breaking capacity - not less than 50 kA;

(b) Rated short-circuit making capacity - not less than 105 kA; and

(c) Rated short-time withstanding current - not less than 50 kA for 1 second.

7.2.5.4.3 Closing and Tripping Operation

Unless otherwise specified, ACB shall be suitable for independent manual operation utilising energy stored in a spring. For automatic closing ACB, the spring mechanism shall be wound by a universal motor fitted with limiting switches. In addition, the spring mechanism shall have manual charging facilities for emergency use.

Unless otherwise specified, trip coil of 24 V or 30 V D.C. shall be fitted for local, remote or relay tripping.

"Trip" push buttons shall be provided on the front plate of each ACB. These buttons shall be direct acting mechanically.

When automatic closing is specified, the control circuit of the ACB shall be fitted with suitable anti-pumping devices.

7.2.5.4.4 Racking Gear

The enclosure shall be fitted with a set of racking gear which shall lock the ACB to the runner rails in three distinct positions, i.e. CONNECTED, TEST and ISOLATED. The ACB can only be closed fully when it is in the CONNECTED position. In the TEST position, it shall be possible to operate the ACB to close and test the secondary and auxiliary contacts, but not the main isolating contacts.

The racking gear shall consist of rollers fitted to the ACB frame. All parts shall be accurately aligned and adjusted so that the ACB can be moved freely along the runner rails within the enclosure between the two extreme positions, i.e. CONNECTED and ISOLATED. Facilities shall be provided to padlock the ACB in its CONNECTED, TEST or ISOLATED position.

Position indicators and breaker-condition indicators shall be provided. These indicators shall be arranged so as to be prominently visible when the ACB is in its normally installed position.

7.2.5.4.5 Interlocking Facility

Suitable interlocking facilities shall be provided such that:

(a) the ACB cannot be plugged in or withdrawn when it has been closed;

(b) the ACB cannot be closed until it is fully engaged in either the CONNECTED or the TEST position;

(c) the ACB cannot be slowly closed except in the TEST or ISOLATED position;

(d) it shall not be possible to initiate the closing action of the energy stored spring mechanism until the spring has been fully charged; and

(e) Where key interlocking is employed, tripping of a closed ACB shall occur if an attempt is made to remove the trapped key from the mechanism.

7.2.5.4.6 Main Isolating Contacts and Safety Shutter

The main isolating contacts shall be self-aligning and shall be protected by insulated barriers forming the safety shutter.

2 sets of safety shutters shall be provided for every ACB, one for the incoming terminals of the main isolating contacts and the other for the outgoing terminals. Each set shall be capable of being operated individually.

When the ACB is not in the CONNECTED position, the safety shutters shall close automatically, screening off the main isolating contacts. When the ACB is being racked into the CONNECTED position, the safety shutters shall automatically open the insulating barrier, thereby allowing the entry of the movable isolating contacts but without lowering the degree of protection.

Safety shutters shall be fitted with warning labels. In addition, facilities shall be provided to padlock the safety shutters after the ACB has been withdrawn from the enclosure.

7.2.5.4.7 Contact

All contacts shall be self-aligning, provided with spring accelerated opening mechanism.

Main contacts shall be fitted with detachable arc chutes for each pole. Sufficient auxiliary contacts shall be provided for connection of secondary wiring. These auxiliary contacts shall remain engaged when the ACB is in the TEST or CONNECTED position and shall be disengaged when the ACB is in the ISOLATED position.

All ACB shall be fitted with the maximum number of auxiliary contacts as the manufacturer's standard provision. In any event, not less than two pairs of normally-closed auxiliary switches and two pairs of normally-open auxiliary switches shall be provided. All auxiliary contacts and switches shall be wired to an easily accessible terminal strip for external connection.

Terminals for external connections of the secondary/auxiliary contacts and switches shall be of clamping yoke type for wires of minimum CSA of 1.0 mm^2. All terminals shall be clearly labelled to identify the function of the circuits connected to the terminals.

Terminals for each ACB for secondary/auxiliary contacts shall be separated from all other terminals by means of a spacer of 20 mm width.

7.2.5.5 MOULDED CASE CIRCUIT BREAKER (MCCB)

7.2.5.5.1 General

MCCB shall be of four-pole, triple-pole or double-pole as specified. It shall comply with and be type-tested to IEC 60947-2:2016+AMD1:2019. It shall be totally enclosed in a moulded casing formed from an insulating material. The construction of the casing shall be capable of withstanding the appropriate rated short circuit current and reasonably rough use without fracture or distortion. The moulded casing shall have an ingress of protection not less than IP30. Utilisation category for those MCCB with built-in protection and rated at 400 A or above shall be class B, unless otherwise specified in the Particular Specification or on Drawings or to substantiate with calculations to the satisfaction of the Supervising

Officer that class A MCCBs are suitable for ensuring discrimination under overload and short circuit conditions for the circuits concerned.

MCCB shall incorporate overcurrent and earth fault protection as specified with shunt trip coil operated by protection relays, and shall be suitable for use as an isolator.

7.2.5.5.2 Operating Characteristic

MCCB with built-in protection shall have thermal-magnetic or solid state tripping device which features a fixed, stable, inverse time-current characteristic. The operating characteristic shall be such that:

(a) the time delay on overload tripping shall be inversely proportional to the overcurrents up to a threshold value of approximately 7 times the rated current; and

(b) there shall be no intentional time-delay on overcurrent tripping due to short-circuit or heavy overcurrent exceeding the threshold value (i.e. approximately 7 times the rated current).

The operating characteristics shall be calibrated at 40°C.

When MCCB is specified to be completed with earth leakage tripping device, the tripping current shall be as specified in the Particular Specification or on the Drawings. The earth leakage relay and the zero-sequence current transformer, if any, shall comply with the IEC 60255-1:2009, IEC 60755:2017 and IEC 61869-2:2012 respectively.

7.2.5.5.3 Performance Characteristic

MCCB shall be certified, according to IEC 60947-2:2016+AMD1:2019, to have the following performance characteristics:

Rated short circuit breaking capacity - not less than the values given in the Table 7.2.5.5.3.

Table 7.2.5.5.3 Rated Short Circuit Breaking Capacity of MCCB

Frame size	Tested short-circuit breaking capacity	Tested at power factor of:
100 A	23 kA	not exceeding 0.30 lagging
225 A	23 kA	not exceeding 0.25 lagging
400 A	23 kA	not exceeding 0.25 lagging
> 400 A	40 kA	not exceeding 0.25 lagging

7.2.5.5.4 Shunt Trip Release

Where shunt trip release is specified, this shall operate correctly at all values of supply voltage between 70% and 110% of the nominal supply voltage under all operating conditions of the MCCB up to the rated short-

circuit breaking capacity of this MCCB. MCCB incorporating shunt release shall be provided with block terminals and shunt release lead cables.

7.2.5.5.5 Locking Facility

MCCB shall be provided with facility for padlocking in either the "ON" or "OFF" position.

7.2.5.6 MINIATURE CIRCUIT BREAKER (MCB)

7.2.5.6.1 General

MCB shall be of four-pole, triple-pole, double-pole or single-pole as specified. It shall comply with and be type tested to IEC 60898-1: 2015/AMD1:2019. It shall be totally enclosed in a moulded insulating case and lockable for safe use. Overall dimensions and fixing centres for the same range of MCB shall be identical and suitable for fixing individually to a metal back plate or directly mounted inside a distribution metal box.

Cable terminals of the MCB shall be at top and bottom of the units with access from front, and suitable for terminating the size of solid or stranded conductor in accordance with Table 5 of IEC 60898-1:2015 /AMD1:2019.

MCB with current carrying contacts of plug-in type shall not be accepted.

Contacts of the MCB shall be of non-weld type.

7.2.5.6.2 Operating Characteristic

The operating mechanism of a MCB shall be thermal-magnetic to give a fixed, stable, inverse time-current characteristic in accordance with Table 7 of IEC 60898-1:2015/AMD1:2019. The calibration temperature shall be 30°C. The classification according to rated instantaneous tripping current shall be Type B, except for motor circuit application where Type C shall be provided and 6 A circuits in which either Type B or Type C may be acceptable.

7.2.5.6.3 Short Circuit Breaking Capacity

The rated short circuit breaking capacity shall be certified, in accordance with IEC 60898-1:2015/AMD1:2019, to have at least 6,000 A of rated short circuit capacity. In addition, energy limiting class of MCB shall be of class 3 in accordance with table ZA1 and ZA2 of BS EN 60898-1:2019. MCB shall be capable of being connected in cascade with fuse to IEC 60269-1:2006/AMD2:2014 or BS EN 88-1:2011+A1:2016 up to a rating of 160 A in situation where the prospective short circuit current at the supply side is up to 22 kA.

7.2.5.7 RESIDUAL CURRENT-OPERATED CIRCUIT BREAKER WITHOUT INTEGRAL OVERCURRENT PROTECTION (RCCB) AND RESIDUAL CURRENT-OPERATED CIRCUIT BREAKER WITH INTEGRAL OVERCURRENT PROTECTION (RCBO)

7.2.5.7.1 RCCB - General

Residual Current-operated Circuit Breaker without Integral Overcurrent Protection (RCCB) shall be double-pole or four-pole as specified, type tested to IEC 61008-1:2010/AMD1:2012/COR1:2016. The casing of RCCB shall be constructed of totally enclosed moulded-case insulating material to withstand the fault level as certified to IEC 61008-1:2010/AMD1:2012/COR1:2016.

The RCCB shall be suitable for use at ambient temperature between -5°C and +40°C.

7.2.5.7.2 RCCB - Electrical and Operating Characteristics

The nominal rated current of RCCB shall be 10 A, 13 A, 16 A, 20 A, 25 A, 32 A, 40 A, 63 A, 80 A and 100A as shown on the Particular Specification or Drawings. Unless otherwise specified, the rated residual operating current shall be 30 mA.

RCCB shall have minimum conditional short circuit making and breaking capacity of 3,000 A with rated residual making and breaking capacity to be ten (10) times the rated current of RCCB or 500 A, whichever is the greater.

Tripping operation of RCCB shall not involve amplification of operating residual current and shall be independent of the line voltage.

Operating characteristic of RCCB shall be of Type AC as specified in IEC 61008-1:2010/AMD1:2012/COR1:2016 for which tripping is ensured for residual sinusoidal alternating current, whether suddenly applied or slowly rising. Type A RCCB shall be provided as specified in case of residual currents with D.C. components.

RCCB shall be instantaneous tripping type without time delay function.

Multi-pole RCCB shall be interlocked internally such that an earth leakage current through any one phase shall trip all the poles of the RCCB simultaneously.

7.2.5.7.3 RCCB – Test Device

An integral test device shall be provided on the front of every RCCB to enable automatic tripping operation be tested. Operation of the test device shall create “out-of-balance” condition simulating an earth fault.

7.2.5.7.4 RCBO – General

Residual current operated circuit-breaker with integral overcurrent protection (RCBO) shall be single-pole, double-pole or four-pole current operated circuit breaker as specified and housed in a totally enclosed moulded-case type tested to IEC 61009-1:2010/AMD2:2013/COR1:2014. The RCBO shall be suitable for use at ambient temperature between -5ºC and +40ºC. It shall be manufactured to the rail mounting method inside the distribution board.

7.2.5.7.5 RCBO – Electrical and Operating Characteristics

Technical requirement of RCBO shall refer to Clause 7.2.5.7.2 "RCCB – Electrical and Operating Characteristic", in addition to the overcurrent requirement as detailed in this Clause.

RCBO shall have minimum short circuit making and breaking capacity of 6,000 A with rated residual making and breaking capacity to be ten (10) times the rated current of RCBO or 500 A, whichever is the greater. In addition, energy limiting class shall be of class 3 in accordance with table ZD1 and ZD2 of IEC 61009-1:2010/AMD2:2013/COR1:2014.

Unless otherwise specified, RCBO shall have instantaneous tripping characteristic of type B, except for application of motor circuit or high inrush current situation where type C shall be provided. The calibration temperature shall be 30°C.

Multi-pole RCBO shall be interlocked internally such that an earth leakage current through any one phase shall trip all the poles of the RCBO simultaneously.

7.2.5.7.6 RCBO - Test Device

An integral test device shall be provided on the front of every RCBO to enable automatic tripping operation be tested. Operation of the test device shall create "out-of-balance" condition simulating an earth fault.

7.2.5.8 FUSE

7.2.5.8.1 Scope of Fuse

All references to fuses shall include fuses forming part of a fuse-switch, or a switch-fuse.

7.2.5.8.2 General

Fuse shall comply with, and be type tested to IEC 60269-1:2006/AMD2:2014 - Low-voltage fuses.

7.2.5.8.3 Fuse Carrier and Holder

Fuse carrier and fuse holder shall be constructed of ceramic porcelain or thermoplastic. Plastic units shall be unaffected by heat generated by an overloaded fuse or by a blown fuse. Fuse carrier shall be so manufactured that there is no risk of touching live parts when the fuse is being withdrawn.

The maximum rating of a fuse inserted in a fuse holder shall not be greater than the rating for which the holder is manufactured.

7.2.5.8.4 (NOT USED)

7.2.5.8.5 Fuse Ratings and Dimensions

Cartridge fuses to IEC 60269-1:2006/AMD2:2014 shall have a rated breaking capacity of 50 kA at rated voltage and the Utilisation Category shall be of "gG" unless otherwise specified. All dimensions shall be standardised in accordance with Figure 101 of IEC 60269-2:2013/ AMD1:2016.

7.2.5.9 BUSBAR CHAMBER

7.2.5.9.1 General

Standalone busbar chambers shall comply with and be verification tested to IEC 61439-6:2012.

Busbar chambers with rated current above 400 A shall be verification tested to a short-time withstand current not less than that of the incoming switchgear.

7.2.5.9.2 Construction

A busbar chamber shall contain 4 sets of fully sized, hard drawn, high conductivity, solid electro-tinned copper busbars to BS EN 13601:2013 and supported on epoxy resin or other approved insulators. The busbar chamber shall be totally enclosed and manufactured from sheet steel suitably rust-proofed and painted or hot-dip galvanised. The thickness of sheet steel shall not be less than 1.5 mm for current rating not exceeding 500 A, and not less than 2 mm for current rating of 500 A and above. The front cover and end plates shall be removable and normally held in position by non-ferrous metal screws.

7.2.5.9.3 Colour Identification of Busbar

Each busbar shall be coloured to indicate the phase to which it is connected. Colouring shall comprise a band of paint on the busbar at intervals of not more than 600 mm, but the busbar shall not be painted throughout its length.

7.2.5.9.4 Interconnection to Other Equipment

Items of switchgear or associated equipment shall be connected or jointed to a busbar chamber by means of connection flanges having similar material and finish of the busbar chamber, or by means of conduit couplers and bushes complying with Section 7.1.2.

Interconnection cables between a busbar chamber and other items of switchgear or associated equipment shall be of copper conductors and shall be sized in accordance with IEC 60364-5-52:2009.

7.2.5.10 DISTRIBUTION BOARD - GENERAL

7.2.5.10.1 Scope of Distribution Board

This Clause covers the general requirements of MCCB distribution boards and MCB distribution boards. Additional requirements relevant to a particular type of distribution board shall be given in Clauses 7.2.5.11 and 7.2.5.12 inclusive.

7.2.5.10.2 Construction of Enclosure

The enclosure of a distribution board shall be constructed from sheet steel, rust proofed and epoxy powder painted or baked enamelled finish to a colour approved by the Supervising Officer. Conduit knock-outs shall be provided on the top and bottom.

The construction shall capable of withstanding the mechanical, electrical and thermal stresses under all working conditions, including fault conditions.

7.2.5.10.3 Arrangement of Component Parts

Distribution board shall include all necessary components and accessories to form a complete assembly. Components and accessories shall be firmly fixed in position in the distribution board, and shall be assembled in such a way that it shall be possible to remove or replace any component parts and to carry out cable connection from the front. Ample space shall be allowed for cabling. MCCB, MCB, RCCB, RCBO or fuses shall be arranged neatly in a row or rows. All components shall be totally concealed. Only the toggles of the MCCB, MCB, RCCB or RCBO shall protrude through the cover plate of the distribution board.

7.2.5.10.4 Busbar

All busbar shall be of hard drawn high conductivity copper having ratings as specified and shall be electro-tinned. Busbar shall comply with BS EN 13601:2013 for rating exceeding 200A. Neutral busbars shall have CSA not smaller than that of the phase busbars, and shall have adequate number of terminals for all outgoing circuits including spare ways.

7.2.5.10.5 Earthing Terminal

Every distribution board shall be provided with an external earthing terminal. In addition, a multi-terminal connector shall be provided within the distribution board for connection of protective conductors of all outgoing circuits including spare ways.

Both the external earthing terminal and the multi-terminal connector for protective conductor shall be of hard drawn, electro-tinned copper and shall be labelled in accordance with the requirement of IEC 61439-2:2011 for MCCB distribution boards and IEC 61439-3:2012/COR2:2019 for MCB distribution boards.

7.2.5.10.6 Provision of Spare Ways

Each distribution board shall be provided with spare ways for future expansion. For new installations, unless otherwise specified, the number of spaces provided for spare ways in the distribution boards shall be as below: -

6 way SPN or less	:	At least 1 no. of space for 1-phase spare way
12 way SPN or less	:	At least 2 nos. of spaces for 1-phase spare way
More than 12 way SPN	:	At least 3 nos. of spaces for 1-phase spare way
4 way TPN or less	:	At least 1 no. of space for 3-phase spare way
8 way TPN or less	:	At least 2 nos. of spaces for 3-phase spare way
More than 8 way TPN	:	At least 3 nos. of spaces for 3-phase spare way
6 way SPN or less	:	At least 1 no. of space for 1-phase spare way

Each spare way shall be blanked off with a suitable blanking plate having a finish comparable to that of the distribution board.

7.2.5.10.7 Shrouding of Live Part

All conductive parts shall be properly shrouded against accidental contact by means of rigid barriers, partitions of insulating materials such that accidental contact can be prevented during operation of component replacement or cable connection.

All conductive structural parts of the distribution boards shall comply with the protective circuit requirements of IEC 61439-2:2011 for MCCB distribution boards and IEC 61439-3:2012/COR2:2019 for MCB distribution boards.

7.2.5.10.8 Certification and Verification Test

Verification testing of typical MCCB and MCB distribution board to IEC 61439-1:2011 shall be carried out by a competent and independent short circuit testing organisation internationally recognised as having equal standing as The Association of Short Circuit Testing Authorities (ASTA). The verification report issued by the testing organisation shall be submitted to the Supervising Officer for record. Appropriate technical information and literature in English and copies of the verification test certificate and drawings must be made available for examination.

Temperature rise limits test of typical distribution board shall be verified to IEC 61439-1:2011.

MCCB and MCB boards shall be verification tested to a short-time withstand current in accordance with Table 7.2.5.10.8.

Table 7.2.5.10.8 Busbar Short-time Withstand Current for MCCB and MCB Distribution Boards

Type of distribution board	Busbar rated current	Busbar rated short time withstand current
MCCB distribution board	250A	23kA for 0.2s (See Note 1) or 40kA for 0.2s
	400A	23kA for 0.2s (See Note 1) or 40kA for 0.2s
	630A	40kA for 0.2s
MCB distribution board	100A or 200A	10 kA for 0.2s

Note 1: Refer clause 7.2.5.11.1 for the condition of accepting the lower short-time withstand current.

If modifications are made to a verified distribution board, clause 10 of IEC 61439-1:2011 shall be used to check if these modifications will affect the performance of the distribution board. New verifications shall be carried out by a competent and independent short-circuit testing organisation if an adverse effect is likely to occur and the method of 'verification testing' shall be used. The other method(s) in clause 10 of IEC 61439-1:2011 may be acceptable subject to the approval of the Supervising Officer.

A functional unit in the verified distribution board may be substituted with a similar unit of the same manufacturer used in the original verification provided the following conditions are satisfied and subject to the approval of the Supervising Officer:-

(a) Power loss and terminal temperature rise of the functional unit when tested in accordance with its product standard, is the same or lower;

(b) The physical arrangement within the distribution board shall be maintained;

(c) The rating of the distribution board shall be maintained; and

(d) In addition to the temperature rise limits test, other requirements as listed in Annex D of IEC 61439-1:2011 including the short-circuit requirements shall be taken into consideration.

7.2.5.11 MCCB DISTRIBUTION BOARD

7.2.5.11.1 General

The MCCB distribution board shall be wall-mounted factory built assembly housing MCCBs & busbars. The enclosure of the MCCB distribution board shall be constructed from sheet steel having a thickness of not less than 1.5 mm, and shall be manufactured for general commercial and light industrial applications. The internal separation shall be of Form 2b as defined in IEC 61439-2:2011 and the ingress protection shall not be less than IP41.

The configuration, construction and testing specifications of the distribution board shall comply with IEC 61439-2:2011.

MCCB distribution board shall each be provided with a moulded-case isolating switch having a current rating not less than that of the supply side protective device. Moulded-case isolating switch shall meet the relevant requirements of Clauses 7.2.5.1 and 7.2.5.2.

MCCB shall have the breaking capacity to withstand the prospective fault level at the MCCB board. In general, the MCCB board with the short-time withstand current of 40kA for 1 second shall be installed. MCCB board with lower short-time withstand current in clause 7.2.5.10.8 may be offered provided that the short-circuit current at the MCCB board is assessed to be lower than 23kA. Calculation shall be submitted to the Supervising Officer for approval for using the lower short-time withstand current MCCB board.

7.2.5.11.2 Busbar

MCCB distribution board shall be provided with vertical triple-pole and neutral copper busbars of rating not less than that of the supply side protective device subject to a minimum of 250 A. The configuration of the busbars, busbar supports and busbar mounting arrangement shall meet the short-time withstand current in clause 7.2.5.10.8.

Outgoing MCCB shall be mounted horizontally on both sides of the vertical busbars. The connection between the MCCB and the phase busbars shall be by means of copper tapes and bolted joints.

7.2.5.12 MCB DISTRIBUTION BOARD

7.2.5.12.1 General

The enclosure of a MCB distribution board shall be constructed from sheet steel having a thickness of not less than 1.2 mm, and shall be manufactured for general commercial and light industrial applications. The ingress protection for the enclosure with the functional units and blanking plates fitted shall be at least IP41. The configuration and construction of MCB distribution boards shall comply with and be type tested to IEC 61439-3:2012/COR2:2019.

7.2.5.12.2 Construction

The moulded back plate assembly shall be of substantial thickness and attached to the back of the enclosure for mounting of MCB.

RCCB, RCBO and double pole or triple pole all insulated switch as specified.

MCB distribution board shall be provided with a moulded-case, all-insulated, double-pole or three-pole incoming switch-disconnector (isolating switch) having a current rating of not less than that of the supply side protective device. This incoming switch-disconnector shall meet the relevant requirements of Clauses 7.2.5.1 and 7.2.5.2 with a Utilisation Category of AC-22A. However, switch-disconnector of Category AC-23A shall be provided in event of any one of the outgoing circuits being fed for motor circuit.

Ferrules shall be provided for wires, including earthing, phase and neutral conductors, throughout the distribution board internally for circuit identification.

The metal front plate shall be screwed onto the metal box, making the assembly suitable for surface or flush mounting, and shall be supplied with a hinged cover to conceal all operating handles of the circuit breakers and isolating switch. The front plate shall be affixed with phase colour labels and circuit identification chart, and shall be supplied with moulded single way blanking plates.

MCB distribution board shall be provided with phase, neutral and earthing terminals for the incoming cables. There shall be one neutral and one earthing terminal for each outgoing MCB circuit and spare ways.

7.2.5.12.3 Method of Mounting

MCB distribution board shall be suitable for flush or surface mounting as specified. Flush mounting shall be so arranged that the assembly is flush with the surface of the wall and shall not cause any adverse effect to the heat dissipation of internal devices.

7.2.5.13 VOLTAGE DIP RIDE-THROUGH DEVICE

Where specified in the Particular Specification, appropriate voltage dip ride-through device for the equipment/ installation specified so as to assure operation of the equipment/installation be free of interruption as a result of voltage dip occurrence shall be supplied and installed. The voltage dip ride-through device shall comply with the ride-through duration and voltage dip magnitude as specified in the Particular Specification and in accordance with the testing method stipulated in IEC 61000-4-11:2004+AMD1:2017 CSV and IEC 61000-4-34:2005+AMD1:2009.

7.2.5.13.1 Constant Voltage Transformer (CVT)

(a) Constant voltage transformer (CVT), also known as ferroresonant transformer or regulating transformer, shall contain capacitor at the secondary winding in form of parallel resonant connection circuit.

(b) CVT shall perform in an operating principle that when the secondary magnetic circuit is operating in the saturation region under a resonant effect, the secondary electric circuit shall be decoupled from the primary circuit and thus insensitive to the voltage variation in the primary circuit.

(c) CVT shall be featured with galvanic isolation to ensure there is no electrical connection between the primary circuit and connected load at secondary windings.

(d) CVT shall provide a stabilised output voltage of ±3% under full load condition when the input voltage varies between +10% to -50%.

(e) CVT shall be capable of generating sinusoidal wave voltage at the output even when its primary winding input voltage is distorted to non-sinusoidal waveform, such as square or quasi-square waveforms.

(f) In case of CVT is operated continuously out of the specified voltage dip ride-through range, the output voltage shall dip as the input voltage dips.

(g) CVT shall have minimum efficiency of 90% at an operating range of full load to 70% of rated load.

(h) CVT shall be provided with built-in over current protection against short circuits at the output terminals.

(i) CVT shall be UL certified or tested to other equivalent certification.

7.2.5.13.2 Static Tap Switcher Voltage Regulator (STSVR)

(a) Static tap switcher voltage regulator (STSVR) shall comprise multi-tapped autotransformer, static tap switchers and control circuit.

(b) STSVR shall be constructed of battery free, maintenance free, robust, highly reliable and durable.

(c) The control circuit of STSVR shall monitor the variation of input supply voltage and regulate the static tap switcher on the autotransformer for maintaining the required output voltage, The tap changing process initiated by the control circuit shall occur at zero crossing of the supply voltage in order to avoid interference or switching transient.

(d) STSVR shall provide a stabilised output voltage of ±10% when the input voltage varies between +10% and -50%.

(e) For control circuit voltage ride-through application, STSVR shall be provided with a built-in timer circuit to control the ride-through duration. Upon expiry of the timed delay, the connected load of STSVR shall be automatically disconnected in case the voltage dip at input supply persists.

(f) For mains power circuit voltage ride-through application, STSVR shall deliver continuous output under voltage dip situation with current limiting protection so as to prevent from overloading.

(g) STSVR shall be provided with built-in over current protection against short circuits at the output terminals.

(h) Indicators shall be provided for incoming power supply healthy and fault alarm.

(i) STSVR shall be UL certified or tested to other equivalent certification.

7.2.5.13.3 Voltage Dip Ride-through Inverter (VDRI)

(a) Voltage dip ride-through inverter (VDRI) shall comprise static bypass switch, energy storage capacitor, inverter and microprocessor based control circuits.

(b) VDRI shall be constructed of battery free, maintenance free, robust, highly reliable and durable.

(c) The static bypass switch of VDRI shall let utility input voltage to the connected load under normal operation mode. Upon detection of under voltage at mains input, the static bypass switch shall shut off the supply line and trigger the operation of inverter spontaneously allowing discharge of energy storage at the capacitor for maintaining continuous supply to the connected load.

(d) VDRI shall synchronise with the input voltage, convert and regulate it into a stepped 50 Hz output voltage of square wave by Pulse Width Modulation technique or other equivalent technology.

(e) For control circuit voltage ride-through application, VDRI shall be provided with a built-in timer circuit to control the ride-through duration. Upon expiry of the timed delay, the connected load of VDRI shall be automatically disconnected in case the voltage dip at input supply persists or the input being loss of supply.

(f) VDRI shall perform in compliance with Semiconductor Equipment and Materials International, SEMI-F47, IEC 61000-4-11, IEC 61000-4-34 or other equivalent standards. Where specified, VDRI shall be capable of performing satisfactory ride-through of voltage dip at any one of the supply phases for 200 ms duration under the remaining supply voltage at 50% of nominal voltage.

(g) VDRI shall be provided with built-in over current protection against short circuits at the output terminals.

(h) VDRI shall be “Fail-safe” type so that under all circumstances the failure of VDRI shall not interrupt the system operation, but with the VDRI unit being inoperative in the ride-through function.

(i) VDRI shall be high efficiency with at least 97% under full load operation.

(j) Indicators shall be provided for incoming power supply healthy, energy discharge for ride-through operation and fault alarm.

(k) VDRI shall be UL certified or tested to other equivalent certification.

7.2.5.14 ELECTROMECHANICAL CONTACTORS

7.2.5.14.1 General

Electromechanical contactor shall comply with and be type tested to IEC 60947-4-1:2018. Each shall be of double air-break type with four pole, triple-pole, double-pole or single pole contacts as specified.

Both the main and auxiliary contacts shall be rated for uninterrupted and intermittent duty. The main contact of a contactor shall be silver or silver-faced.

Contactor shall have utilisation category suitable for the particular application as shown in Table 1 of IEC 60947-4-1:2018.

7.2.5.14.2 Performance Requirements

Contactor shall each be capable of making and breaking currents without failure under the conditions stated in Table 7 and 8 of IEC 60947-4-1:2018 for the required Utilisation Categories and the number of operation cycle indicated.

7.2.5.14.3 Co-ordination with Short-circuit Protective Devices

Contactor shall comply with the requirements for performance under short-circuit conditions stipulated in IEC 60947-4-1:2018. Type of co-ordination shall be Type "1" unless otherwise specified.

7.2.5.14.4 Control Circuit

Rated control circuit voltage of a contactor shall be the same as that of the main circuit; otherwise, it shall be 24 V, 30 V or 110 V D.C. as specified.

7.2.5.15 CHANGEOVER SWITCH

Changeover switch shall be either manually or automatically controlled at mains voltage, double air-break, four-pole type and tested to IEC 60947-6-1:2005/AMD1:2013 CSV.

Changeover switch shall be rated in Utilisation Categories AC-33A or AC-33B and capable of making, breaking and carrying continuously the rated current and making on fault without overheating, damage or deterioration.

Changeover switch shall be electrically and mechanically interlocked in operation. For automatic changeover switch the changeover action shall be automatic in response to the failure or resumption of supply mains.

The control circuit of changeover switch shall incorporate a true power off delay timer to overcome the momentarily mains alternating current power supply interruption.

Illuminated indicator for "Mains On" and "Essential Supply On" shall be provided at the cover of the compartment housing a changeover switch.

7.2.5.16 ACTIVE HARMONIC FILTER

7.2.5.16.1 General Requirements

(a) Active harmonic filter (hereinafter referred to as "AHF") shall be used to eliminate harmonic currents circulating across the installation so that the Total Harmonic Distortion (THD) shall be limited to a given percentage as specified in the Building Energy Code or Particular Specification.

(b) AHF shall be installed in parallel with the distribution system, i.e. shunt connected, wherever attenuation of harmonic current is needed. AHF shall be installed at the point just before the first lateral tee-off and close to those loads generating harmonic currents in order to avoid circulation of the harmonic currents along the cables.

(c) AHF shall conform to IEC 61000-4-2:2008, IEC 61000-4-3: 2006+AMD1:2007+AMD2:2010 CSV, IEC 61000-4-4:2012, IEC 61000-4-5:2014+AMD1:2017, IEC 61000-6-2:2016, IEC 61000-6-4:2018 or other similar recognised international standards on Electromagnetic Compatibility (EMC) compliance for industrial or commercial applications and shall be manufactured to ISO 9001:2015. Certificate of compliance shall be issued for each standard rating of AHF after being fully tested at the manufacturing facility.

(d) AHF shall be manufactured by a reputable manufacturer which has continuously manufactured AHF for at least 5 years and their manufacturing facility shall have a local agent to provide full technical support which includes adequate spares holding and technical expertise in testing, commissioning and trouble-shooting. Training shall be provided by the manufacturer's representatives for government staff on operation and maintenance aspects including essential trouble-shooting techniques.

(e) Full technical details of the AHF as submitted by the manufacturer shall be provided for the Supervising Officer's approval and shall cover the following:

(i) technical guide on its applications;

(ii) schematic and wiring drawings down to circuit board level released by the manufacturer;

(iii) shop drawings and as-fitted drawings;

(iv) operation manuals with commissioning guide;

(v) maintenance manuals with trouble-shooting guide; and

(vi) parts list and recommended spare parts with price.

(f) Unless otherwise specified, the rated operational voltage and services condition shall be as specified in Clause 1.1.3.18 and Clause 1.1.3.17. The following technical requirements shall also apply: -

No. of phases	:	3-phase without / with neutral, 3/4 wires as specified in the Particular Specification;
Unit capacity	:	as specified in the Particular Specification;
Harmonic orders	:	2^{nd} order to 25^{th} order or more compensation;
Filtering efficiency	:	85% or more;
Power factor correction	:	up to 0.98 lagging or more;
Steady state response	:	40 ms or less;
Ventilation	:	Forced air cooled;
Noise level	:	65 dBA or less;
Heat losses	:	8% of rated capacity or less;
THD settings	:	Selectable %THDi setpoint and %THDv setpoint;
Resonance avoidance	:	Output at specific harmonic order turned off if resonance detected; or manually turned off; and
Communication	:	Modbus

7.2.5.16.2 Performance Requirements

(a) The operating principle of AHF shall be based upon the injection of a harmonic current with appropriate phase shift corresponding to the harmonic current drawn by the load which shall be analysed by the AHF continuously. Consequently, the current supplied by the source shall remain sinusoidal under the effective operating range of the AHF.

(b) AHF shall be compatible with any type of load, and shall guarantee efficient compensation, even when changes are made to the installation. The AHF shall also be capable of delivering its

rated output harmonic current to the point of connection irrespective of load condition.

(c) If the compensation of neutral harmonic current is required, in the neutral conductor, the AHF shall be capable of compensating the harmonic current three times greater than the phase current, particularly to compensate harmonic current of order 3 and its multiples.

(d) Start-up and shut down of AHF shall be initiated by control push buttons or other means as specified in the Particular Specification. After a main power break-down, start-up of AHF shall be automatic.

(e) Should the AHF be overloaded during transient operation of certain loads or permanently, this shall not affect the reliability of its operation. Under such circumstance, the AHF shall operate in a current limiting mode and still deliver to the network its rated harmonic current.

(f) For better adaptation to any installation, AHF shall be capable of operating in association with other harmonic reduction systems. For ease of expansion, it shall be modular type or be possible to associate 2 or more AHF's in parallel to increase the compensation capacity and to enhance dependability, i.e. redundant operation.

(g) To compensate the harmonics at different levels in the distribution network, it shall be possible to connect the AHF at any point in the distribution network, or to connect several AHF's at different points in the installation for maximum effectiveness.

7.2.5.16.3 Construction

(a) AHF shall use an isolated gate bipolar transistor (IGBT) bridge or other similar technique to inject the proper harmonic current on the network, and will be controlled by a microprocessor based system.

(b) AHF shall be housed in an industrial grade cabinet constructed from high quality steel sheet of minimum 1.2 mm thick side and back plate and 1.5 mm thick hinged front door with key lock. Protection class of the cabinet shall be not less than IP21 for indoor and IP55 for outdoor application. The entire surface shall be applied with chemical rust inhibitor, rust resisting primer coat and topcoat to give maximum corrosion protection.

(c) The dimension of AHF shall be as small as possible. Particularly, it will be preferable to have the AHF fitted in low voltage cubicle switchboard or in motor control centre.

(d) AHF shall at least include the following kinds of protection:

(i) thermal overload protection;

(ii) internal short circuit protection; and

(iii) invertor bridge abnormal operation protection.

A three or four poles circuit breaker shall be installed close to the point of the connection to the system to protect the connection cables. It shall be selected according to general selection practice for circuit breakers and the manufacturer recommendation.

(e) As a minimum the AHF shall include the following read-out information at display panel:

(i) an indicator for each phase of the incoming power supply;

(ii) an indicator for normal operating condition;

(iii) an indicator for AHF shut down; and

(iv) an indicator for fault condition.

Also a diagnostics panel shall be accessible from the front of the unit to help the operator to identify the origin of abnormal situation and control push buttons will be provided for ON/OFF operation and alarm reset. The front display unit shall be capable of working independently or powered up by separate tool through a service port featured at each AHF without energising the AHF for diagnostics in case of AHF breakdown. The display shall provide past performance and display of all parameter set points and the event log at the juncture before the breakdown of AHF.

(f) AHF shall be equipped with built-in ethernet or RS485/232 serial communication ports for control, programming and monitoring of the AHF by PC / PQM / BEM or other user interface.

7.2.5.17 SURGE PROTECTION DEVICE

7.2.5.17.1 General Requirements

(a) Unless otherwise specified, surge protection device shall be suitable for the rated operational voltage as specified in Clause 1.1.3.18.

(b) The operation of surge protection device shall base on the use of metal oxide varistor or other similar technique to effectively limit over-voltage under surge conditions and to safely divert the excessive surge energy to ground.

(c) Surge protection device shall be manufactured by a reputable manufacturer which has been continuously manufacturing surge protection products preferably for at least 5 years and the manufacturer shall have a local agent to provide full technical support and after sales services.

(d) Type test certificate for the surge protection device shall be submitted for approval by the Supervising Officer. The certificate shall, unless otherwise specified, demonstrate that the equipment can fulfill the requirements stipulated in IEC 61643-11:2011 with the following performance: -

(i) Surge protection device at the main L.V. switchboard shall be able to perform under a standard test wave of 20 kV 1.2/50 μs voltage impulse and 10kA 8/20 μs current impulse;

(ii) Surge protection device at the electrical distribution system shall be able to perform under a standard test wave of 6 kV 1.2/50 μs voltage impulse and 3 kA 8/20 μs current impulse. It shall limit the transient voltage to below equipment susceptibility levels; and

(iii) Surge protection device at sub-main distribution board shall be able to perform under a standard test wave of 6 kV 1.2/50 μs voltage impulse and 0.5 kA 8/20 μs current impulse.

(e) Surge protection device shall be shunt or series connected to the concerned electrical installation to achieve maximum protection as recommended by the manufacturer. It shall be installed in strict compliance with manufacturer's installation instructions and relevant safety standards and regulations.

(f) Except for the panel mounted surge protection device, all components and circuits of the surge protection device shall be contained in a metal enclosure suitable for wall mounting. The enclosure shall be electrically earthed. In case of floor mounting is required because of its size and weight, the device shall be installed and mounted on concrete plinth provided for this purpose.

(g) Detailed installation instructions and manuals from the surge protection device manufacturer shall be submitted to the Supervising Officer for approval.

7.2.5.17.2 Performance Requirements

(a) The device shall be able to give protective performance in all modes, including Phase and Neutral, Phase and Earth, and Neutral and Earth.

(b) The device shall be manufactured in such a way that its performance shall not be easily affected by field wiring practice.

(c) The let-through voltage, i.e. the transient overvoltage which is allowed through a surge protection device, shall be clearly specified for the acceptance by the Supervising Officer. Unless otherwise specified, the let through voltage shall not exceed the impulse withstand voltage of the equipment to be protected specified in IEC 60364-4-44:2007+AMD1:2015+AMD2:2018. The reaction time between the start of the surge and the time the surge protection device initiates the protective action shall be less than 1 nanosecond.

(d) Surge protection device shall be able to withstand repeated electrical surges appeared in the electrical system without undue degradation of its surge protection performance under healthy condition.

7.2.5.17.3 Construction

(a) Surge protection device shall incorporate both high energy clamping devices and special filtering circuitry to reduce any electrical surge appearing in the connected electrical system to an acceptable level without causing any damage to the connected electrical and electronic equipment.

(b) For panel mounting, the installation method and construction of the surge protection device shall refer to the manufacturer's instruction and recommendation. For wall mounting and floor mounting, surge protection device shall be housed in an industrial grade cabinet with hinged and lockable front door made of high quality 1.5mm thick steel sheet. The device and the enclosure shall be electrically earthed. The entire cabinet shall also conform to the requirement of the manufacturer of the surge protection device.

(c) Surge protection device shall be equipped with monitoring facilities so that whenever its surge protection performance is reduced to a pre-determined level below its original rating after a number of incident surges it has been subjected to, an audible and visual alarm shall be given off to indicate that the device requires servicing or replacement. The audible and visual alarm may be given through a build-in facility inside the device or by activating an electrical dry contact to which an indicator and an alarm bell are connected. As an option, a surge counter shall be required if specified in the Particular Specification.

7.2.5.18 SOLID STATE SOFT MOTOR STARTER

7.2.5.18.1 General Requirements

(a) The solid state soft motor starter (hereinafter referred to as "softstarter") shall be of the power electronic type motor starting device. It shall control the voltage applied to the motor smoothly by varying the conduction angle of the solid stage AC switches which can be triacs, reverse parallel connected SCR-diode circuit or reverse parallel connected SCR-SCR circuit, etc. or using other similar technique.

(b) Softstarter shall be manufactured to conform to the following relevant standards or other similar recognised international standards: -

IEC 60068-2-6:2007	:	for vibration resistance where softstarter is affected by vibration;
IEC 60068-2-27:2008	:	for shock resistance where softstarter is affected by shock;
IEC 61000-4-2:2008	:	for electrostatic discharge immunity test;
IEC 61000-4-3:2006 +AMD1:2007+AMD2:2 010 CSV	:	for radiated, radio-frequency, electromagnetic field immunity test;
IEC 61000-4-4:2012	:	for electrical fast transient/burst immunity test; and
IEC 61000-4-5:2014 +AMD1:2017	:	for surge immunity test.

(c) The soft starter shall be manufactured by a reputable manufacturer which has continuously manufactured softstarter for at least 5 years and their manufacturing facility shall have a local agent to provide full technical support, including adequate spares holding and technical expertise in testing, commissioning and trouble-shooting. Training shall be provided by the manufacturer's representatives for government staff on operational and maintenance aspects including essential trouble-shooting techniques.

(d) Full technical details of the softstarter provided by the manufacturer shall be submitted and shall cover at least the following:

(i) technical guide on its applications;

(ii) schematic and wiring drawings down to circuit board level;

(iii) shop drawings and as-fitted drawings;

(iv) operation manuals with commissioning guide;

(v) maintenance manuals with trouble-shooting guide; and

(vi) parts list and recommended spare parts with price.

(e) Degree of Protection of Enclosure

The softstarter shall be protected to at least IP44 for indoor and IP55 for outdoor application by a single front-access enclosure and shall be suitable for operation without derating under ambient temperature of up to 40°C and relative humidity of up to 99%.

(f) Unless other specified, the rated operational voltage shall be as specified in Clause1.1.3.18. The rated power and quantities of the softstarters shall be as specified in the Particular Specification or the Drawings.

7.2.5.18.2 Performance Requirements

(a) Mode of Operation

Softstarter shall provide the following modes of operation and shall be transitionless without causing any current inrush and torque surges during operation: -

(i) Voltage ramp - The motor voltage shall begin initially at a preset 'start voltage' and increase to line voltage at a preset 'ramp rate'. The acceleration ramp time shall be adjustable up to 30 seconds;

(ii) Current limitation - It shall be capable of limiting the maximum starting current which shall be adjustable to at least 4 times of rated current;

(iii) Soft stop - A deceleration voltage ramp shall be applied to the motor for applications which require an extended coast to rest. The voltage ramp down time shall be adjustable to 30 seconds or above;

(iv) Kickstart - A current pulse shall be provided in the softstarter to develop additional torque when started for loads which may need a boost to get started;

(v) Energy saving – If specified in the Particular Specification, when the motor is lightly loaded or unloaded for long periods of time, it shall automatically

decrease motor power losses by controlling the motor terminal voltage; and

(vi) Apart from the above, other modes of operation such as voltage pedestal starting, full voltage starting, D.C. injection braking, etc. shall also be required when specified in the Particular Specification.

(b) Protection

Softstarter shall have internal protection to the motor and softstarter and LED diagnostics to aid in set-up and troubleshooting. The protection shall include: -

(i) thermal overload protection of the motor and softstarter;

(ii) mains supply protection for phase failure and phase unbalance;

(iii) internal fault protection; and

(iv) stalled motor protection.

(c) Auxiliary Contact

The softstarter shall provide auxiliary contacts for end of starting (by-pass) and fault condition. The output relay contact shall be suitable for 220 V A.C. operation in category AC11 and D.C. operation in category DC11.

7.2.5.18.3 Selection of Softstarter and Operating Precautions

(a) The starting current-speed transition curve of the selected softstarter shall closely match with the starting torque-speed characteristics of the motor and loading. The ratings of the softstarter shall base on 'hot start' operation i.e. the motor is re-started immediately after operating at maximum rating for a period of time.

(b) The motor associated with the softstarter shall be capable of starting the driven load when is supplied at reduced voltage and current. In case of severe duty, checking with the motor manufacturer shall be carried out that its derating is compatible with the operating cycle and the starting times.

(c) The heat sink of the softstarter shall be of good quality aluminium construction and shall provide sufficient thermal inertia to permit successful starting of the motor without exceeding the permitted junction temperature of the solid state AC switches.

(d) The softstarter shall be capable of continuously delivering rated output voltage (or reduced output voltage under energy saving mode) at any load. When using a by-pass contactor, the order to close and open the contactor shall be controlled by the built-in signal of the softstarter.

(e) The softstarter shall have the possibility to accept D.C. input from external device such as Programmable Logic Controller (PLC) for controlling the start and stop of the unit.

(f) Semiconductor fuses shall be available as an option and have the characteristics suitable to protect the softstarter.

(g) The solid stage AC switches shall have a blocking voltage of at least 1,400 V for 415 V system with a rate of rise of reapplied voltage tolerance of at least 1,000 V per microsecond. However, an isolation contactor or isolator shall be available as an option to isolate the supply in the 'Off' stage to the softstarter for the safety of the operator.

(h) UNDER NO CIRCUMSTANCES shall the power factor correction equipment be connected between the softstarter and the motor. If power factor correction equipment is employed, it shall be connected to the supply side of the softstarter.

7.2.5.19 VARIABLE SPEED DRIVES FOR CENTRIFUGAL FANS AND PUMPS

7.2.5.19.1 General Requirements

(a) Variable speed drive (hereinafter referred to as "VSD") shall be a solid-state converter to convert three phase mains supply of 380 V$\pm$6% and 50 Hz$\pm$2% to an adjustable voltage and frequency output at its rated throughout power. VSD shall conform to the following standards or other similar recognised international standards on Electromagnetic Compatibility (EMC) compliance for industrial or commercial applications: -

IEC 60068-2-6:2007	:	for vibration resistance
IEC 60068-2-27:2008	:	for shock resistance where
IEC 61000-4-2:2008	:	for electrostatic discharge immunity test;
IEC 61000-4-3:2006+AMD1:2007+AMD2:2010 CSV	:	for radiated, radio-frequency, electromagnetic field immunity test;
IEC 61000-4-4:2012	:	for electrical fast transient/burst immunity test; and

IEC 61000-4-5:2014 +AMD1:2017 : for surge immunity test.

VSD shall be manufactured to ISO 9001:2015. Certificate of compliance shall be issued for each standard rating of VSD used in the Contract after being fully tested at the manufacturing facility.

(b) VSD shall be manufactured by a reputable manufacturer which has continuously manufactured VSD's for at least 5 years and their manufacturing facility shall have a local agent to provide full technical support which includes adequate spares holding and technical expertise in testing, commissioning and trouble-shooting. Training shall be provided by the manufacturer's representatives for the Employer's representatives on operational and maintenance aspects including essential trouble-shooting techniques.

(c) Full technical details of the VSD shall be submitted and shall cover the following: -

(i) technical guide on its applications;

(ii) schematic and wiring drawings down to circuit board level;

(iii) shop drawings and as-fitted drawings;

(iv) operation manuals with commissioning guide;

(v) maintenance manuals with trouble-shooting guide; and

(vi) parts list and recommended spare parts with price.

(d) VSD shall be capable of continuously delivering rated output voltage even when the mains supply voltage is down by 6% of its nominal value and shall be able to control 3-phase squirrel cage induction motor of class B insulation over a speed range of 20% to 100% continuously and smoothly without the need to derate the motor kW rating and to provide total power factor of not less than 0.9 lagging, without external chokes or power factor correction capacitors, at full load within the speed range. The inrush current shall be zero and during starting, the current shall start from zero and rises as the load accelerates with no danger of exceeding full load current.

(e) VSD shall allow up to 100 metres of cables to be used between the VSD and the motor.

(f) VSD shall allow unlimited switching of the motor circuit, at any load and within the controlled speed range without damage and without the need of auxiliary control switching. The VSD shall be

capable of automatically reconnecting to a spinning fan and run without tripping, following mains interruption and on transfer from backup source. The VSD shall be capable of running with no motor connected during functional testing. The VSD shall have voltage/frequency (V/f) ratio suitable for centrifugal pumps and fans control. Selectable V/f ratios shall be provided and it shall not be possible to set a constant V/f ratio, to prevent damage to connected equipment and to optimise energy usage.

7.2.5.19.2 Performance Requirements

(a) VSD shall be fully rated to provide the performance as follows:

(i) minimum efficiency of 95% at 100% load and not less than 90% at any other operating loads;

(ii) output torque shall be limited to 105% of full load torque;

(iii) no facility for reversing the motor rotation shall be incorporated;

(iv) the limiting harmonics produced by the equipment shall comply with the following requirements:-

IEC 61000-3-2:2018 Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase);

IEC TS 61000-3-4:1998 Limits - Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16A;

IEC 61000-3-12:2011/ISH1:2012 - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16A and ≤ 75A per phase; and

IEC 61800-3:2017 Adjustable speed electrical power drive systems - EMC requirements and specific test methods.

(v) comply with the Building Energy Code; and

(vi) VSD shall have a maximum capacity as specified in the Particular Specification.

(b) The following minimum features shall be incorporated in the VSD unit complete with an integral control panel:

(i) it shall accept digital and analogue 0-10 V, 4-20 mA control signals;

(ii) integral measurement and selectable alpha-numeric or graphical display of:
- output current;
- output voltage;
- output frequency;
- output speed; and
- output power;

(iii) alpha-numeric or graphical display in English for warning / fault / alarm status;

(iv) information can be transmitted on the ethernet or RS485/232 output for remote interrogating and reprogramming;

(v) it shall have 1 programmable relay output (250 V 2 A) and 1 programmable analogue output of 4-20 mA or 0-10 V D.C.;

(vi) 10 programmable preset speeds (including at least 2 skip frequencies of adjustable bandwidth to overcome mechanical or air system resonance);

(vii) selectable local or remote control;

(viii) hardware lock to prevent unauthorised parameter adjustment;

(ix) it shall have the following integral protection against:

- loss of mains and motor phase;
- motor short circuit;
- motor circuit earth fault;
- motor overheat (without the use of motor winding thermistors);
- overvoltage;
- VSD overheat;
- under voltage;
- input transients;
- VSD and motor overload; and
- mains input accidentally couples to motor output terminals;

(x) it shall have a digital electronic equivalent of a motor operated potentiometer control or similar device for open loop operation;

(xi) it shall have an integral full 3-term PID control to provide close loop control direct from a signal transmitter without need for external signal conditioning; and

(xii) it shall have a facility for controlling motor anti-condensation heater for heater operation when the motor is idle.

7.2.5.19.3 Construction

(a) VSD shall incorporate a minimum 6-pulse full-wave uncontrolled diode bridge, fixed voltage-fed D.C. link with inductors and capacitors to form a filter, a mains filter for EMC compliance, a pulse width modulation (PWM) inverter bridge utilising insulated gate bipolar transistors (IGBTs) and output inductors in the motor lines. The inverter bridge shall be controlled by a microprocessor to produce a pulse width modulation (PWM) waveform or similar technique which would result in full motor voltage and sinusoidal current mains supply in the motor circuit. The VSD shall be equipped with built-in ethernet or RS485/232 serial communication ports.

(b) The complete VSD unit shall be housed in a single front-access enclosure as an integral part of the VSD. The enclosure shall be of degree of protection minimum IP20 for indoor application and minimum IP54 for outdoor application. Unless otherwise specified, it shall be suitable for continuous operation without derating under ambient temperature of up to 40oC and relative humidity of up to 95%. The equipment shall be fully tested including motor loading at manufacturer's facility or by an approved testing authority to certify that the equipment conforms to the aforesaid standard. Certificate of compliance shall be issued for each standard rating of VSD used after being fully tested at the manufacturing facility or by the testing authority.

7.2.5.20 DIGITAL MULTIFUNCTION POWER METER

7.2.5.20.1 General Requirements

(a) The microprocessor based Digital Multifunction Power Meter shall measure the electrical parameters as specified in this General Specification by means of microprocessor technology. The meter shall be able to communicate with PC-based PQM System, BEM System and Building Management System via a common network protocol by means of plugging in communication module and without further modification of the basic unit. The Digital Multifunction Power Meter shall also be able to communicate by BACnet or Modbus Communication or open protocol with iBMS at remote site simultaneously via internet. The detailed requirements of the iBMS enabling works including but not limited to the demonstration of compatibility, software, data interfacing requirements, testing and commissioning shall refer to relevant sections of this General Specification and Particular Specification.

(b) The Digital Multifunction Power Meter shall continuously monitor the power system for power monitoring and analysis. The stored and instantaneous measurement data shall be recalled and displayed on the front panel upon pressing of keypad on the Digital Multifunction Power Meter and alternatively monitored by PC-based application software supplied together with the Digital Multifunction Power Meter.

(c) Digital Multifunction Power Meter shall be housed in a single front access industrial grade enclosure as an integral part of the meter by the original manufacturer. The meter shall be panel mounted in the L.V. switchboard cubicles or local motor control panels. Alternatively, the meter can be configured for DIN rail mounting. The display shall either be LED or LCD with backlight, with auto blinking function for prolonging the life of the display.

(d) The meter shall be so arranged that the replacement of meter shall not require the switching off of the respective switchgear. All wiring shall be routed via terminal block to allow easy removal of the cable connectors in the event that the meter requires replacement. Current transformers shorting block shall be provided such that current inputs can be disconnected without open circuiting the current transformers. The shorting block shall be wired so as not to affect the operation of protective relays.

(e) The Digital Multifunction Power Meter shall comply with the requirements specified in IEC 61557-12:2018.

(f) The Digital Multifunction Power Meter shall comply with Electromagnetic Compatibility (EMC) requirements in accordance with the following international standards: -

IEC 61000-4-2:2008	:	Electrostatic discharge immunity test;
IEC 61000-4-3: 2006+AMD1:2007+AMD2:2010 CSV	:	Radiated, radio-frequency, electromagnetic field immunity test;
IEC 61000-4-4:2012	:	Electrical fast transient/burst immunity test;
IEC 61000-4-5:2014 +AMD1:2017	:	Surge immunity test; and
IEC 61000-3-2: 2018	:	Limits for harmonic current emissions.
IEC 61010-1:2010 +AMD1:2016	:	Safety requirements for electrical equipment for measurement, control, and laboratory use - General requirements

IEC 61000-6-2:2016 : Electromagnetic compatibility (EMC) – Immunity standard

IEC 61000-6-4:2018 : Electromagnetic compatibility (EMC) – Emission standard

(g) The Digital Multifunction Power Meter shall be fully compatible with the digital power analyser and PQM / BEM system.

7.2.5.20.2 Technical Requirements

(a) Digital Multifunction Power Meter shall comply with the following technical requirements: -

Voltage input : 380 V AC between phase;

Current input (In) : On current transformers, In / 5 A (secondary);

Measurement :
- True RMS value of line current for each phase and neutral current
- True RMS value of phase-neutral voltage for each phase
- True RMS value of line voltage for each phase
- Active power, kW for each phase and three-phase total
- Reactive power, kVAr for each phase and three-phase total
- Apparent power, kVA for each phase and three-phase total
- Frequency, Hz
- Total power factor for each phase and three-phase total
- Active energy, kWh
- Harmonic distortion for each phase voltage and current, up to 31st harmonic orders
- Total harmonic distortion for each phase voltage and current, up to 31st harmonic orders;

Accuracy
Voltage : $\pm$0.5%

Current	:	±0.5%
Power	:	±0.5%
Power factor	:	±1.0%
Frequency	:	±0.5%
Active energy	:	Class 0.5 S of IEC 62053-22
Harmonic distortion	:	±1.0%
Service condition		
Temperature	:	0° to 50°C
Relative humidity	:	Up to 80%; and
Communication		
Interface	:	Ethernet or Series link RS485/232
Protocol	:	Modbus / BACnet

(b) Digital Multifunction Power Meter shall store in non volatile flash memory the maximum and minimum values of the each parameter measured by the unit. The values in memory shall be recalled and displayed upon pressing of a switch on the meter. All measurement parameters shall be trended every 15 minutes and include hourly, daily, monthly and annual data. The digital multifunction power meter shall be capable of maintaining all data collected for a minimum of 36 months.

(c) Digital Multifunction Power Meter shall have a minimum overcurrent withstand rating of 100A for 1 second.

(d) Digital Multifunction Power Meter shall be equipped with a communication port at front panel, using either ethernet, RS232, RS485, RJ45 or similar socket and plug as approved by the Supervising Officer, for communication with portable personal computer for energy control and audit purpose. The connection cable with the appropriate plug and a copy of the proprietary-made software for data retrieval shall be provided.

(e) The manufacturer shall operate a quality management system conforming to ISO 9001 or other equivalent national/international quality system. The manufacturer shall issue a calibration certificate for every meter at time of production. Such calibration shall be conducted by the manufacturer within one year prior to delivery of the meter on site or prior to the date of factory acceptance test if the meter is installed in a switchboard that factory acceptance test is required. The manufacturer shall also declare in writing that the meter shall require no re-calibration for a minimum of 10 years from the time of issue of calibration certificate. A label marking the manufacturer's calibration date shall be fixed adjacent to the meter.

7.2.5.21 CHARGER AND BATTERY SET

7.2.5.21.1 General Requirements

(a) Battery charger set shall be a solid state secondary D.C. power supply unit operating in parallel with a battery bank. The maximum rated capacity referred to herein this General Specification shall be 3 kVA. Battery charger shall be supplied and installed with rated capacity that can supply a constant voltage current for the combined standing load and alarm / switch tripping load, if applicable, or not less than 15 Amperes or as specified in the Particular Specification, as well as recharging and restoring the battery bank back to its constant potential voltage setting within the specified time limit after fully discharge.

(b) The charger unit shall consist of a rectifier bridge which has the AC mains input supplied via the isolation transformer and has the ripples of its D.C. output smoothed by a D.C. filter before supplying connected load under normal operation or the battery after discharging in AC mains failure. The rectifier shall be equipped with two voltage levels output, trickle charge and high rate charge (hereinafter called boost charge) which shall be fully automatically controlled and switched by a control logic unit comprising the printed circuit boards (hereinafter called PCB).

(c) Battery charger set shall be manufactured to conform to the currently-in-forced editions of the relevant standards as indicated below: -

BS EN 61204:1995	:	Specification for Performance Characteristics and Safety Requirements of Low-voltage Power Supply Devices, D.C. Output;
IEC 61204:1993 +AMD1:2001	:	Rating and Performance;
BS 7430:2011+A1:2015	:	Code of Practice for Protective Earthing of Electrical Installations; and
IEC 60950-1:2005 +AMD1:2009 +AMD2:2013	:	Information Technology Equipment – Safety – General Requirements

(d) the unit shall be able to recharge and restoring the battery bank back to its constant potential voltage setting in not more than twenty-four (24) hours unless otherwise specified after fully discharged.

(e) The battery bank shall have sufficient voltage and rated capacity in ampere-hour rating to maintain the connected load at the rated

output capacity for the duration specified below. Calculation shall be submitted to demonstrate that the offered capacity of the battery and charger unit is able to cope with the power demand of the whole system. In any case, the ampere-hour rating shall be not less than 10 ampere-hour if it is not specified in the Particular Specification. The battery shall be sealed, high rate maintenance free nickel-metal hydride type, or a type of better functions and performance and approved by the Supervising Officer and shall have a proven life expectancy of at least 4 years. It shall not have any memory effect to affect its usable life or performance. The nickel-metal hydride battery shall comply with IEC 61951-2:2017 where applicable.

(f) Battery charger set shall be manufactured by a reputable manufacturer which has continuously manufactured battery set to work in conjunction with a wide range of applications for at least 5 years and their manufacturing facility shall have a local agent to provide full technical support which includes adequate spare holding and technical expertise in testing, commissioning and trouble-shooting.

(g) The following technical information shall be submitted to the Supervising Officer for approval prior to ordering of equipment:

(i) Technical catalogues and specification, calculation sheet for charger and battery capacity;

(ii) Power supply unit circuit diagram;

(iii) Circuit diagram of control and battery disconnected;

(iv) Printed circuit board diagram;

(v) Power supply unit front plate layout; and

(vi) Power supply unit console detail.

7.2.5.21.2 Technical Requirements

The following technical requirements shall apply: -

Input voltage	:	220 V A.C. $\pm$10%;
Frequency	:	50 Hz $\pm$5%;
Output ripple voltage	:	$\pm$5% of D.C. output;
Output voltage	:	12 V/24 V/30 V/48 V ($\pm$1%) or to suit application;
Overcurrent protection	:	Mains fuse, charger fuse, battery fuse against overload and short circuit conditions;
Control	:	Manual boost charge, automatic trickle charge and boost charge;
Indication	:	- Mains and charger healthy;

- Charger short-circuit;
- Battery connected;
- Battery low-volt; and
- Boost charge;

Voltage-free contact : Voltage-free contacts for "load on battery" and "battery low voltage" shall be provided if specified in Particular Specification for remote monitoring; and

Input connection : 13 A fused AC supply.

7.2.5.21.3 Construction

(a) The charger and battery set shall be housed in an industrial grade cabinet constructed from high quality steel sheet of minimum 1.2 mm thick side and back plate and 1.5 mm thick hinged front door with key lock. Protection class of the cabinet shall be not less than IP31 for indoor and IP55 for outdoor application as specified in IEC 60529:1989/AMD2:2013/COR1:2019. The entire enclosure surface shall be applied with chemical rust inhibitor, rust resisting primer coat and top coat to give maximum corrosion protection.

(b) The logic PCB, together with the isolation transformer and fused mains input terminals, shall be factory assembled on a plate located at the rear of the case. The power transistors are mounted on heatsinks, separately from the PCB, on the back plate. The instruments and LED indicators are mounted on the front door of the cabinet. A lower ventilated compartment inside the cabinet provides adequate space for accommodation of the storage battery bank and ventilation

(c) The cabinet shall be suitable for wall-mount or installation inside a switch cubicle where appropriate.

7.2.5.21.4 Selection Criteria

(a) The rated kVA capacity, voltage, current of the rectifier charger and the storage capacity, terminal voltage, ampere-hour rating of the battery bank shall be suitable to work in conjunction with a range of application in switch tripping / fire alarm and protection system / gas detection system / security system / PA and audio system.

(b) For the switch tripping of cubicle switchboards, the selected charger and battery set shall satisfy the following criteria: -

Output voltage : 24 V, 30 V, 48 V or operating voltage of tripping coil as specified in the Particular Specification;

Output current and re-charge time	:	15 A or 20 times operating current of tripping coil for air circuit breaker and upon mains restoration, adequate to re-charge the battery from fully discharge to fully charge within 24 hours as specified in the Particular Specification; and
Ampere-hour rating	:	10 Amp-hour or Upon mains failure, adequate to discharge the tripping current of the associated air circuit breaker(s) consecutively at least 20 times up to twenty air circuit breaker(s) simultaneously or as specified in the Particular Specification.

(c) When used in conjunction with in fire alarm and protection system / gas detection system, the selected charger and battery set shall satisfy the following criteria: -

Output voltage	:	24 V;
Output current and re-charge time	:	15 A or output current for combined standing load at normal condition and alarm load at maximum alarm condition and upon mains restoration, adequate to re-charge the battery from discharge to fully charge within 24 hours or as specified in the Particular Specification; and
Ampere-hour rating	:	10 Amp-hour or upon mains failure, adequate to discharge the operating current for connected load at normal condition for 24 hours and then the connected alarm load at maximum alarm condition for at least 60 minutes or as specified in the Particular Specification. If the fire alarm control system is connected by an alternative standby supply such as automatically started emergency generator approved by the FSD, the capacity of the battery and charger unit may be reduced to maintain normal operation for eighteen (18) hours and thereafter capable of operating in maximum alarm condition for at least thirty (30) minutes and/or capable of actuating the fire service installation as required.

(d) When used in conjunction with in security system / PA and audio system, the selected charger and battery set shall satisfy the following criteria: -

Output voltage	:	12 V or 24 V or as specified in the Particular Specification;
Output current and re-charge time	:	15 A or output current for combined standing load at normal condition and alarm load at maximum alarm condition and upon mains restoration, adequate to re-charge the battery from discharge to fully charge within 24 hours or as specified in the Particular Specification; and
Ampere-hour rating	:	10 Amp-hour or Upon mains failure, adequate to discharge the operating current for the connected standing load at normal condition for 24 hours and then the connected alarm load at maximum alarm condition for at least 60 minutes or as specified in the Particular Specification.

7.2.5.22 POWER FACTOR CORRECTION EQUIPMENT

7.2.5.22.1 General Requirements

The power factor correction equipment (hereafter referred to as "the equipment" in this section) shall include capacitors, protective devices, contactors, control relays, current transformers, cabinet, cables, cable glands, trunkings, control wirings, necessary accessories, etc. For capacitors to be installed in system where the 5th, 7th, 11th harmonics are anticipated, the normal de-tuning factor is around 7% which will tune the resonance frequency f_{LC} to 189 Hz. For capacitors to be installed in system where 3rd harmonic is also present, the normal de-tuning factor is around 12.5% which will tune the resonance frequency f_{LC} to 141 Hz. The de-tuning reactor shall be rated to handle 110% of the capacitor fundamental current continuously to compensate for capacitor tolerance and aging. The overall power factor at the main switchboard and motor control switchboard shall be improved to not less than 0.95. The equipment shall be installed at the point just before the first lateral tee-off.

Additional and specific requirements for the equipment shall be given in the Particular Specifications, the Drawings or other documents issued by the Supervising Officer.

7.2.5.22.2 Requirements of the Components

(a) Capacitor Units

The capacitors shall be of low loss dry-type, metallised polypropylene (MPP) film type with self-healing properties and fitted in a sheet steel plate enclosure filled with non-inflammable medium. The capacitor units shall be hermetically sealed and manufactured from continuous metal foil and low loss high quality dielectric material. The total capacitor losses shall not exceed 0.5 Watt per kVAr. The capacitors shall comply with the requirement of IEC 60831-1:2014 and IEC 60831-2:2014. Oil type capacitors shall be rejected.

The capacitors shall be provided with directly connected discharge resistors which shall reduce the residual voltage from the rated peak alternating voltage to 75 V or less measured at the capacitor bank terminals within 3 minutes after disconnection from the source of supply. The discharge resistors shall be protected by an insulating cover.

The capacitor shall have the following characteristics: -

Rated voltage	:	380 V or 440V;
Frequency	:	50 Hz;
Insulation level	:	3 kV rms/15 kV crest;
Dielectric	:	Polypropylene;
Discharge resistors	:	Fitted;
Total capacitor losses	:	< 0.5 W/kVAr;
Maximum voltage Overload	:	1.1 times rate voltage;
Maximum current Overload	:	1.3 times rated current;
Power tolerance	:	- 5/+10%; and
Residual voltage at Energisation	:	< 10% of rated voltage.

(b) Protection Units

The capacitor units shall be fed by fuse-switch or MCCB for protection against high fault currents. Besides, an overpressure disconnection device for protection against low fault currents shall be provided.

(c) Control Relays

The capacitors in each bank shall be controlled by an automatic multi-step capacitor control relay capable of switching the appropriate amount of capacitors “IN” or “OUT” so as to achieve the best average power factor. A no-volt resetting feature shall be incorporated to ensure that, in the event of power interruption lasting for a period over 50 ms, all capacitors involved shall be disconnected from the L.V. installation and re-connected in accordance with the aforementioned arrangement upon supply resumption.

The relay shall be commanded by a microprocessor which measures the reactive power of an installation and gives the necessary instructions to the relay for connecting or disconnecting the capacitors in order to maintain the desired power factor. The microprocessor shall be capable to ensure an uniform aging of contactors and capacitors by using a circular connection sequence which takes into account the time that each capacitor has been switched on (First-In-First-Out (FIFO) System). The control relay shall include a fully operational alarm system which shall operate in case the equipment cannot reach the required power factor. LED/LCD indicator shall be provided to show which step the capacitors are connected.

The control relay shall have the following characteristics: -

Dual voltage	:	220 or 380 V;
Control current	:	Can be connected without any additional adaptor to C.T. 2,500/5 A burden 5 VA min. Class 1;
Contacts for contactor switching	:	Control relay capable of withstanding 2500 V AC, 5A and 1,200 VA;
Test voltage	:	Supply connecting cable and contactor connecting cable: 1,500 V, 50Hz; C.T. Contactor: 500 V 50 Hz;
Harmonics filtering	:	A filter shall be incorporated to avoid falsified measuring results. Not to be confused with the filter circuits for the equipment;
Response current (C/K setting range)	:	Adjustable from 0.05 to 1 A;
C/K setting	:	Manual or Automatic;
Power factor reversal point	:	Adjustable from 0.85 lagging to 1 and prevent leading P.F. during light load condition;
Power factor setting	:	0.85 inductance to 0.95 capacitance;
Switching time from one step to another	:	Adjustable from 10s to 3 minutes according to reactive load;
Indicator for operating and steps	:	LED/LCD;

No-voltage release	:	If voltage fails, the no-voltage release operates automatically due to drop-out of control relay;
Alarm relay	:	Yes;
Manual switching	:	Two push-buttons for manual operation, suitable to check functioning of relay;
Connection	:	Plug-in connector; and
Mounting	:	With angle brackets and threaded bolts.

(d) Contactors

The equipment shall be equipped with special contactors for limiting over-current on itself from high inrush current at capacitor switching. The contactors are characterised for having auxiliary contacts equipped with pre-charge resistors. These auxiliary contacts shall be closed before the power contacts such that the connection peak is strongly limited by the effect of the resistors.

Contactors shall be adequately rated to make and break the capacitive current at low power factor. This current limitation increases the life of all the components of the equipment, in particular that of the protective devices and capacitors. The contactors shall comply with the requirement of IEC 60947-4-1:2018.

The contactor shall have the following characteristics: -

Prospective peak current at Switch-on	:	100 times rated current;
Maximum operating rate	:	150 operations/hour;
Electrical life at rated load	:	100,000 – 200,000 operations; and
Utilisation category	:	AC6b.

(e) Cabinet

The equipment shall be of cabinet type of at least IP31 (Indoor) and contained in a separate cubicle with control switchgear and all other necessary accessories and shall comprise multiple identical capacitor units connected and easily dismountable for its replacement. Integrated cubicle with the L.V. Switchboard installation is not acceptable. The equipment shall be installed in separate compartment segregated from the rest of the L.V.

Switchboard such that failure of the equipment will not affect the operation of the L.V. Switchboard. The equipment shall be housed in a front-access industrial grade enclosure with epoxy powder coating.

All exposed ferrous metal surfaces of the capacitor bank where applicable shall be treated with rust-inhibiting primer paint, undercoat and finished to a colour approved by the Supervising Officer.

(f) Blocking Filter or De-tuning Reactor

Each power factor correction capacitor bank/step shall be equipped with series connected blocking filter or de-tuning reactors if specified in the Particular Specification to suppress harmonic and inrush currents for the protection of capacitors and components of the installation, as well as to avoid or attentuate the harmonic amplification present in the power distribution network. The equipment here refers to the power factor correction equipment. The reactors shall be constructed to IEC 60076-6:2007 and shall be rated to handle 110% of the capacitor fundamental current continuously to compensate for capacitor tolerance and aging. The reactor shall be rated to handle 5th harmonic current of a magnitude equal to 15% of the capacitor current rating. The nameplate on the de-tuning capacitor bank shall indicate the rated fundamental and harmonic currents and frequencies. The reactors shall be copper wounded with class H (180°C) insulation system and shall be suitable for an ambient temperature of 40°C and a maximum temperature rise of 100°C. Power loss of the reactor shall be less than 1% of the capacitor kVAr rating. Reactors shall be manufactured in flat or round copper wire technology. They shall be dried and impregnated in a vacuum, which ensures they can withstand high voltages and maintain a long operating life.

7.2.5.23 DIGITAL PROTECTION RELAY

7.2.5.23.1 General Requirements

(a) This digital protection relay is used as standalone type. The microprocessor-based digital protection relay shall accept three-phase inputs from industrial standard current transformers with nominal secondary current of 1 or 5 Amperes and shall sense the true RMS current values.

(b) The digital protection relay shall provide time delayed three-phase overcurrent protection and earth fault protection and shall allow a variety of selectable time-current IDMT characteristic curves according to IEC 60255-26:2013 and associated requirements.

(c) The digital protection relay shall have remote operation feature and shall be able to communicate with PC-based PQM system, BEM system and Building Management System via multiple operating communication ports and common network protocol such as Modbus/Lonworks via RS232/RS485/Ethernet communication link by means of plugging in communication module and without further modification of the basic unit. The digital protection relay shall also be able to communicate by BACnet or Modbus Communication or open protocol with iBMS at remote site simultaneously via internet. The detailed requirements of the iBMS enabling works including but not limited to the demonstration of compatibility, software, data interfacing requirements, testing and commissioning shall refer to relevant sections of this General Specification and Particular Specification.

(d) The digital protection relay shall be suitable for protection at main incoming circuit breaker in low voltage electrical system and the tripping characteristics of the relay shall match with the power supply companies' breaker/fuse tripping characteristics for discrimination. The protection scheme and tripping characteristics of the digital relay shall be approved by the power supply companies in Hong Kong.

(e) The digital protection relay shall have continuous self-supervision feature to monitor the control circuit. Fault recording function shall be triggered upon fault detection or tripping operation for diagnostic use. The monitoring information and relay setting shall be recallable and programmable by means of front panel keypad or remote access by software. The digital relay shall have security password feature to protect access to relay parameter settings and remote tripping.

(f) The digital protection relay shall be type tested for Electromagnetic Compatibility (EMC) and other relevant requirements in accordance with the following international standards: -

IEC 60255-26:2013	:	Electrostatic discharge tests
IEC 60255-26:2013	:	Radiated electromagnetic field disturbance test
IEC 60255-26:2013	:	Electrical fast transient/burst immunity test
IEC 60255-26:2013	:	Surge immunity test
IEC 60255-26:2013	:	Electromagnetic emission tests
IEC 60255-21-1:1988	:	Vibration tests

IEC 60255-21-2:1988	:	Shock and bump test

The digital protection relay shall be fully compatible with the PQM system.

7.2.5.23.2 Technical Requirements

(a) The digital protection relay shall comply with the following technical requirements: -

Current input	:	1 A or 5 A via standard protection current transformer
Overcurrent setting	:	50% to 200% in step of 5% of nominal current In
Earth fault setting	:	10% to 40% in step of 5% of In
Time multiple setting	:	0.1 to 1.0 in step of 0.05
A.C. burden (maximum)	:	0.25 VA at In = 1 A 0.50 VA at In = 5 A
Service condition	:	Temperature range: 0° to 40°C Relative humidity: Up to 95%

(b) The monitoring and fault records of the digital relay shall be stored in nonvolatile memory and retained in the event of control power interruption. Either using lithium battery or non-volatile flash memory for data storage shall be adopted on condition that the memory shall be backup not less than 36 months. Each fault/event record shall include at least the type of faults/alarms, current values, date & time of tripping, etc. The memory shall be capable of storing minimum 5 fault records.

(c) The digital relay shall be accommodated in a dust-proof case to IP51 and shall be draw-out type flush mounted on the front panel of switchboard cubicle. Facility shall be provided for automatic short-circuiting the associated current transformers upon withdrawal of the module. Each digital relay shall be connected to the circuit test block for the conduction of secondary injection test and functional tests.

(d) The digital relay shall be able to receive auxiliary D.C. power supply at 30 V or 48 V for control operation. A battery set and charger shall be provided for digital relay operation.

(e) The digital relay shall provide at least 4 auxiliary contacts for the input/output of other functions such as remote tripping, alarms, blocking logic, watchdog, etc.

(f) Trip indicators shall be provided for identification of the type of fault condition.

(g) The digital protection relay shall be equipped with a communication port at front panel, using either USB, ethernet, RS232, RS485, RJ45 or similar socket and plug as approved by the Supervising Officer, for communication with portable personal computer. The connection cable with the appropriate plug and a copy of the proprietary-made software for data retrieval shall be provided.

(h) The manufacturer shall operate a quality management system conforming to ISO 9001 or other equivalent national/international quality system. The manufacturer shall issue a calibration certificate for every meter at time of production. Such calibration shall be conducted by the manufacturer within one year prior to delivery of the meter on site or prior to the date of factory acceptance test if the meter is installed in a switchboard that factory acceptance test is required. The manufacturer shall also declare in writing that the meter shall require no re-calibration for a minimum of 10 years from the time of issue of calibration certificate. A label marking the manufacturer's calibration date shall be fixed adjacent to the meter.

7.2.5.24 DIGITAL POWER ANALYSER

7.2.5.24.1 General Requirements

(a) The microprocessor based digital power analyser shall measure and monitor the electrical parameters as specified in this General Specification by means of microprocessor technology. The digital power analyser shall be able to communicate with PC-based PQM system, BEM system and Building Management System via multiple operating communication ports and common network protocols by means of plugging in communication module and without further modification of the basic unit. The digital power analyser shall also be able to communicate by BACnet or Modbus Communication or open protocol with iBMS at remote site simultaneously via internet. The detailed requirements of the iBMS enabling works including but not limited to the demonstration of compatibility, software, data interfacing requirements, testing and commissioning shall refer to relevant sections of this General Specification and Particular Specification.

(b) The digital power analyser shall continuously monitor the power system and trigger alarm/event logging for power monitoring and analysis. The stored and instantaneous measurement data shall be recalled and displayed on the front panel upon pressing of keypad on the digital power analyser and alternatively monitored by PC-based application software supplied together with the analyser.

(c) The digital power analyser shall have waveform capture capability which shall be either initiated from the software or by the power analyser as a user defined response to an alarm condition. The captured waveform samples shall be able to transmit over the network to PC-based workstation for display, archival and analysis.

(d) The digital power analyser shall comply with the requirements specified in IEC 61557-12:2018.

(e) The digital power analyser shall comply with the Electromagnetic Compatibility (EMC) requirements in accordance with the following international standards: -

IEC 61000-4-2:2008	:	Electrostatic discharge immunity test;
IEC 61000-4-3: 2006+AMD1:2007+AMD2:2010 CSV	:	Radiated, radio-frequency, electromagnetic field immunity test;
IEC 61000-4-4:2012	:	Electrical fast transient/ burst immunity test;
IEC 61000-4-5:2014 +AMD1:2017	:	Surge immunity test;
IEC 61000-3-2:2018	:	Limits for harmonic current emissions;
IEC 61000-4-6:2013	:	Immunity to conducted disturbances, induced by radio-frequency fields;
IEC 61000-4-8:2009	:	Power frequency magnetic field immunity test;
IEC 61010-1:2010 +AMD1:2016	:	Safety requirements for electrical equipment for measurement, control, and laboratory use - General requirements;
IEC 61000-6-2:2016	:	Electromagnetic compatibility (EMC) – Immunity standard; and
IEC 61000-6-4:2018	:	Electromagnetic compatibility (EMC) – Emission standard

(f) The digital power analyser shall be fully compatible with the digital multifunction power meter and PQM system.

7.2.5.24.2 Technical Requirements

(a) The digital power analyser shall comply with the following technical requirements: -

Voltage input:

Maximum direct voltage	:	600 V AC between phase
Other voltages	:	Through potential transformers;

Current input (In) : On current transformer, In / 5 A (secondary); and

Measurement :
- True RMS value of line current for each phase
- Neutral current
- % current unbalance
- True RMS value of phase-neutral voltage for each phase
- True RMS value of line voltage for each phase
- % voltage unbalance
- Active power, kW for each phase and three-phase total
- Reactive power, kVAr for each phase and three-phase total
- Apparent power, kVA for each phase and three-phase total with instantaneous and average over configurable time periods
- Frequency, Hz
- Total power factor for each phase and three-phase total
- Active energy, kWh for three-phase total with instantaneous and accumulated values
- Maximum demand current, Id for each phase and three-phase average
- Demand active power, kWd for three-phase total, present & peak
- Demand apparent power, kVAd for three-phase total, present & peak
- Harmonic distortion of each phase for voltage and current, up to 31st harmonic orders
- Total harmonic distortion for each phase voltage and current, up to 31st harmonic orders;

Accuracy:

Voltage	:	± 0.5%
Current	:	± 0.5%
Power	:	± 0.5%
Power factor	:	± 0.5%
Frequency	:	± 0.5%
Active energy	:	Class 0.2 S of IEC 62053-22
Harmonic distortion	:	± 1.0%;

Services Condition:

Temperature	:	0° to 50°C
Relative humidity	:	Up to 95%; and

Communication

Interfaces	:	Ethernet
Protocols	:	Modbus / BACnet

(b) The digital power analyser shall provide date and time stamped event log. The type of alarm events and size of the event log shall be user definable. The following classes of events shall be available as alarm events:

- Over /under voltage;
- Over /under current;
- Current or voltage unbalance;
- Phase loss, voltage or current;
- Over /under frequency;
- Overall/total kVA, kW or kVAr into /out of load;
- Under power factor, true or displacement;
- Over THD;
- Over demand, current or power;
- Phase reversal; and
- Voltage or current sag /swell.

(c) All setup parameters required by the digital power analyser shall be stored in non volatile flash memory and retained in the event of control power interruption. The memory shall maintain the maximum and minimum values of each parameter measured by the unit. All measurement parameters shall be trended every 15 minutes and include hourly, daily, monthly and annual data. The digital power analyser shall be capable of maintaining all data collected for a minimum of 36 months.

(d) The digital power analyser shall have a minimum overcurrent withstand rating of 100A for 1 second.

(e) The digital power analyser shall be equipped with a communication port at front panel, using either ethernet, RS232, RS485, RJ45 or similar socket and plug as approved by the Supervising Officer, for communication with portable personal computer for energy control and audit purpose. The connection cable with the appropriate plug and a copy of the proprietary-made software for data retrieval shall be provided.

(f) The manufacturer shall operate a quality management system conforming to ISO 9001 or other equivalent national/international quality system. The manufacturer shall issue a calibration certificate for every meter at time of production. Such calibration shall be conducted by the manufacturer within one year prior to delivery of the meter on site or prior to the date of factory acceptance test if the meter is installed in a switchboard that factory acceptance test is required. The manufacturer shall also declare in writing that the meter shall require no re-calibration for a minimum of 10 years from the time of issue of calibration certificate. A label marking the manufacturer's calibration date shall be fixed adjacent to the meter.

7.2.5.25 ELECTRIC MOTORS

7.2.5.25.1 General

All electric motors shall be of the high efficiency totally enclosed fan-cooled type and comply with IEC 60034-1:2017 and other associated Parts of the Standard.

The motors shall be insulated to IEC 60085:2007 with Class F as the minimum insulation, unless otherwise specified.

Motor enclosures shall be in accordance with IEC 60034-5:2000+AMD1:2006 CSV and the degree of protection shall be appropriate to the location in which the motors are operating and the environment indicated. Unless otherwise specified, motors shall be protected with enclosures to at least IP44 for indoor and IP55 for outdoor application.

Motors of 2.2 kW output or above shall be suitable for operation from three-phase supply.

The synchronous speed of the motor shall not exceed 25 rev/s unless otherwise approved.

Synchronous motors for applications requiring high starting torque shall be equipped with suitable converter drives to provide the high torque required at all starting conditions.

Synchronous motors shall be equipped with damper winding, or suitable converter drives to prevent hunting and halt.

7.2.5.25.2 Insulation Test

All low voltage motors shall have a minimum insulation resistance of 1 megaohm between phases and to earth when tested with an approved 500 V D.C. insulation tester.

7.2.5.25.3 Starting Torque and Current

Motors shall have starting torque characteristics to suit the connected load and the type of starting.

Starting current conditions shall conform to the requirements as stipulated in the latest edition of the Supply Rules of the power utility companies. Unless otherwise approved in writing by the power utility company, maximum starting current shall be in accordance with Table 7.2.5.25.3 below:

Table 7.2.5.25.3 Maximum Starting Current

Supply Arrangement	Motor Size (M) in Kilowatts	No. of Phases	Maximum Starting Current (in Multiple of Full Load Current)
From Power Utility Company's Overhead Line System	$M \leq 1.5$	1-phase	6
	$1.5 < M < 3.8$	3-phase	6
	$3.8 \leq M \leq 11$	3-phase	2.5
From Power Utility Company's Non-overhead Line System	$M < 2.2$	1-phase	6
	$2.2 < M < 11$	3-phase	6
	$11 \leq M < 55$	3-phase	2.5

7.2.5.25.4 Maintenance Access and Safety

The electrical and mechanical arrangements of all motors shall be such that the necessary periodical testing, cleaning and maintenance can be carried out in a minimum of time with economy of labour.

7.2.5.25.5 Noise and Vibration

All motor rotors shall be dynamically balanced. The vibration and noise level generated by the motors shall not exceed the recommended limits as stipulated in IEC 60034-9:2007 and IEC 60034-14:2018 respectively. The Supervising Officer will reject motors that operate with unacceptable noise and vibration.

7.2.5.25.6 Minimum Motor Efficiency

Except for motor integrated into machine that the motor efficiency cannot be tested separately from the machine or domestic appliances as specified in Section 7.2.10 or otherwise specified in this General Specification or the Particular Specification, the efficiency at rated output of the single-speed, three-phase, cage-induction motors shall in general comply with or better than the nominal efficiency limits for 'Premium Efficiency' (IE3) class in IEC 60034-2-1:2014. Motors between 75kW and 200kW shall comply with the nominal efficiency limits for 'Super Premium Efficiency' (IE4) class in IEC 60034-30-1:2014. The efficiency levels

shall be measured based on the test methods defined in IEC 60034-2-1:2014.

7.2.5.25.7 Continuous Rating

The motors shall be continuously rated to IEC 60034-1:2017. They shall be adequately rated to meet the service demands of driven units connected thereto under normal conditions without overload. The continuous rating of the motors shall cover the full specified range of duty plus a further 5% margin for compressors, 15% margin for fans and 10% for pumps.

7.2.5.25.8 Tachometers

In all cases of direct drive (except hermetic), an application point shall be provided for speed checking by a tachometer.

7.2.5.25.9 Terminals

One large terminal box shall be provided, mounted on the stator casing only. Each end of each stator phase must be brought out to a terminal in the box. For motors rated 10 kW and above, adequate clearance between terminations shall be allowed for the use of cable lugs.

7.2.5.25.10 Anti-condensation Heater

Anti-condensation heater shall be provided in damp environment such as sea water pump motors located inside water-front pump chambers, or motors above 30kW.

7.2.5.25.11 Belt Drives and Pulleys

Belt drives shall comply with BS 3790:2006 and be capable of transmitting at least the rated power output of the driving motor with one belt removed. A minimum of two belts per drive shall be used and all multi-belt drives shall use matched sets.

Slide rails shall be provided for all motors driving through belts. Purpose-made adjusting devices shall be provided to enable belt tension to be altered and motors to be secured.

Belt driven machinery such as fans shall be fitted with pulleys suitable for the belt drive used. Pulleys may use split taper bushings for drives up to 30kW. Alternatively, and in any case for output above 30kW, pulleys shall be secured to the fan and motor shafts by keys fitted into machined keyways. Keys shall be easily accessible so that they can be withdrawn or tightened. Where gib head keys are used they shall not protrude beyond the end of the shaft. For keys without gib heads, they shall be drilled and tapped to accept an extractor bolt.

7.2.5.25.12 Protective Guards

Protective fixed guards shall be provided at all forms of open power transmission systems including belt drives and drive couplings, and to dangerous parts of machinery to prevent inadvertent access or contact. The guards shall comply with the safety requirements stipulated by the Labour Department.

For belt drives, the guards shall be of galvanised steel wire of not less than 2.5mm diameter attached to a rigid galvanised steel rod or angle framework. The mesh size and the location of the guard shall prevent finger contact with any enclosed danger point. Alternatively guards may be constructed from galvanised sheet steel of not less than 0.8mm thick stiffened to ensure a rigid enclosure. Removable access panels shall be provided in guards to allow tachometer readings to be taken on both driving and driven shafts and also belt tension to be tested. The sizes of guards including the dimensions and locations of access panels shall also allow the size and position of the motor.

7.2.5.25.13 Motor Fed by Converter

As converter drive can generate repetitive voltage overshoots at the terminals of a motor connected by cables, which can reduce the life of a motor winding insulation system if these repetitive voltage overshoots exceed the repetitive voltage stress withstand capability of the motor winding insulation system, the motor winding insulation shall have the pulse withstand capability at least equal that depicted by Curve A (for motors up to 500 V AC) of Figure 17 of IEC TS 60034-25:2014.

In order to avoid damage by bearing currents in converter fed operation, motor of frame size 225 or larger shall be fitted with isolated bearing at the non-drive end.

7.2.5.26 MOTOR SWITCHGEAR, STARTERS AND CONTROL PANEL

7.2.5.26.1 General

Motor switchgear, starters and controls shall be supplied and installed to perform the operation and control of the equipment to be provided. The control panels or switchboards shall incorporate all control devices, timers, accessories and wiring necessary for proper operation.

7.2.5.26.2 Local Motor Control Panels

The local motor control panel shall be of wall-mounted factory built assemblies of low voltage switchboard or distribution board housing the motor starter and switchgear.

The panel shall be configured and fabricated to conform with IEC 61439-2:2011 with ingress protection not less than IP41. For the panel housing busbars, the internal separation shall be constructed to Form 2b. The certification and verification test of typical local motor control panel shall comply with the requirements in clause 7.2.5.10.8 of this General Specification. Apart from this General Specification hereunder, the panel shall comply where applicable with the requirements laid down in clause 7.2.5.10, 7.2.5.11 and 7.2.5.12 of this General Specification.

The panel shall be of steel construction, self-supporting, with modular top, side and back panels and doors of sheet steel built up on substantial framing with all necessary stiffeners, supports and return edges to provide a rigid construction and clear accessibility to all internal components within the panel. The thickness of the sheet steel shall be at least 1.6 mm.

All panels shall, but not be limited to, include the following operational features: -

(a) Local Auto/On/Off switch for each equipment;

(b) Starter or variable speed drive as shown on the Drawings or as specified in the Particular Specification;

(c) Fuse switch or circuit breaker for each equipment;

(d) Isolating switch for each main incoming supply and for each motor starter;

(e) Protective, control and auxiliary relays;

(f) Current transformer;

(g) Digital multifunction power meter for each outgoing circuit and incoming power supply of 60A 3-phase or above;

(h) Hour run meter;

(i) LED Indicating lamps, push buttons, selectors and control switches;

(j) Emergency stop push buttons; and

(k) Labelling.

Unless otherwise specified, the components above shall comply with the requirements stipulated in the respective sections of this General Specification.

7.2.5.26.3 Motor Control Switchboard

The motor control switchboard (hereafter called the "MC Switchboard") shall be a free-standing floor-mounted low voltage switchboard to group centrally the motor starters, controls and switchgear for the air-conditioning and ventilation equipment etc.

The MC Switchboard shall be configured and fabricated to comply with IEC 61439-2:2011. The certification and verification test of typical MC Switchboard shall comply with the requirements in clause 7.2.11.15 of this General Specification. Apart from the Specification hereunder, the MC Switchboard shall comply where applicable with the requirements laid down in Sub-section 7.2.11 of this General Specification.

If modifications are made to a verified MC Switchboard, clause 10 of IEC 61439-1:2011 shall be used to check if these modifications will affect the performance of the MC Switchboard. If it can be verified the heat dissipation from the starters in the proposed MC Switchboard is not more than those starters installed in the same compartment of the verified MC Switchboard, the temperature rise limit of the proposed MC Switchboard is deemed to be in compliance with IEC 61439-1:2011 according to the method – 'verification comparison with a tested reference design'. However, new verifications shall be carried out by a competent and independent short circuit testing organisation if an adverse effect is likely to occur and the method of 'verification testing' shall be used. The other method(s) in clause 10 of IEC 61439-1:2011 may be acceptable subject to the approval of the Supervising Officer.

The MC Switchboard shall, but not be limited to, include the following provisions: -

(a) Local Auto/On/Off switch for each equipment;

(b) Air circuit breaker, fuse switch and/or moulded case circuit breaker;

(c) Busbars;

(d) Isolating switch for each main incoming supply and for each motor starter;

(e) Starter or variable speed drive as shown on the Drawings or as specified in the Particular Specification;

(f) Protective, control and auxiliary relays;

(g) Current transformer;

(h) Digital multifunction power meter for each outgoing circuit and incoming power supply of 60A 3-phase or above;

(i) Hour run meter;

(j) LED Indicating lamps, push buttons, selector and control switches;

(k) Emergency stop push buttons; and

(l) Labelling.

Unless otherwise specified, the MC Switchboard and associated components above shall comply with the requirements stipulated in the respective sections of this General Specification.

7.2.5.26.4 Motor Starters

(a) General Requirements

(i) Motor starters shall generally comply with the following requirements.

- IEC 60947-4-1:2018 Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters

- IEC 62271-106:2011/COR1:2014 High-voltage switchgear and controlgear – Part 106: Alternating current contactors, contactor-based controllers and motor-starters

(ii) The duty of the starters shall be suitable for the mechanical and electrical duties imposed by the motors being switched and in particular, the starting torque, current, starting time and frequency of operation.

(iii) Motor of more than 0.5 kW rating shall be provided with a starter to perform the following functions efficiently and safely: -

- To start the motor without damage to the drive or driven equipment whilst regulating the starting current to the satisfaction of the power supply company and ensuring that at all stages of starting, the motor will develop sufficient torque to accelerate the load;

- To stop the motor;

- To prevent damage to the motor due to overload, under voltage, disconnection of one phase;

- To prevent damage to reduced voltage started motors and danger to personnel due to resumption of the electricity supply following a failure;

- To limit the damage to the motor due to stalling or internal electrical or mechanical faults by quickly disconnecting the supply; and

- To prevent damage to the motor or the starter itself due to improper unskilled or hesitant operation or failure to complete a starting sequence once it is connected.

(iv) Motor starters shall comply with the Supply Rules of the power utility companies.

(v) Each motor starter assembly shall comprise fused switchgear, contactors, protection relays, main and auxiliary contacts, and associated accessories. For starter to be installed in motor control switchboard, the whole unit shall be enclosed in the switchboard from which no access can be gained to adjoining sections of the switchboard. Both the main and auxiliary contacts shall be rated for uninterrupted and intermittent duty.

(vi) All starters shall be of the electrically held-on pattern and shall not release until the voltage falls below 75% of nominal value.

(vii) All starters shall be of the air-break triple-pole electro-magnetic type and shall comply with IEC 60947-4-1:2018 or IEC 62271-106:2011/COR1:2014, with utilisation category suitable for the particular application as shown in Table 1 of IEC 60947-4-1:2018. The starter shall be capable of making and breaking currents without failure under the conditions stated in Table 7 and Table 8 of IEC 60947-4-1:2018 for the required utilisation categories and the number of operation cycle indicated. The duty rating of the contactors shall not be less than intermittent duty class 12 60% on-load factor. Where specified in the Contract, the solid state soft motor starter can be used to start motors over 2 kW.

(viii) The starter shall comply with the requirements for performance under short-circuit conditions stipulated in IEC 60947-4-1:2018, and type of coordination shall be Type “1” unless otherwise specified.

(ix) Overload relay for a starter shall be of thermal type unless otherwise specified. The trip class of starters shall be according to the classification of Table 2 of IEC 60947-4-1:2018. Overload relay shall be able to operate at an ambient air temperature of 40ºC and have a setting range of 50% to 150% rated operational current.

(x) For an assisted start starter, timer shall be of solid state plug-in type with 0 to 15 seconds setting. For star/delta and reversing starter, mechanical and electrical interlocks shall be fitted with the contactor.

(xi) Control circuits shall be operated on main supply derived from the control panel or switchboard, and protected by fuse to IEC 60269-1:2006+AMD1:2009+AMD2:2014.

(xii) Where duplicate equipment is provided, the starter for each equipment shall be housed in a separate panel. Unless otherwise indicated, where an equipment is provided with duplicate motors, two starters shall be supplied; a single starter with a local changeover switch will not be accepted.

(b) Direct-on-line (DOL) Starters

(i) Unless otherwise specified in the General Specification or Particular Specification for the specific type of installations, motors rated below 11 kW shall be direct-on-line provided that the maximum starting current does not exceed six times the rated motor full load current, otherwise star-delta starters shall be provided.

(ii) The starters shall, but not be limited to, include the following: -

- Fused switchgear;
- Triple pole air break contactor;
- A triple pole motor protection unit incorporating over-current and single-phasing protection with manual reset facilities;
- Under-volt release protection device. Unless otherwise specified, it shall be arranged to provide automatic restart on restoration of mains voltage;
- Current transformers with suitable ratio, output and accuracy for motor protection;
- Local/off/remote control selector switch lockable in each position;
- Start and stop push buttons;
- Indicating lamps for motor running, off and tripped on fault;

- Dry contacts wired to terminals for remote indication of motor running, off, tripped on fault and summary alarm to supervisory control panels;

- Terminals wired to provide for connection to emergency stop push button and remote start/stop of the motor;

- Hour run meter; and

- Lamp test button.

(c) Star-delta Starters

(i) Unless otherwise specified in the General Specification or Particular Specification for the specific type of installations, motors rated at and above 11 kW and up to 55 kW shall be star-delta started to limit the maximum starting current to within 2.5 times the rated motor full load current.

(ii) Star-delta starters shall be equipped as per DOL starters specified above, with the following additional provisions: -

- Triple pole air break contactors with electrical and mechanical interlock arranged for automatic star-delta transition;

- Calibrated and adjustable solid state timer for automatic star-delta transition; and

- A triple pole motor protection unit incorporating over-current, single-phasing and earth leakage protection with manual reset facilities. The earth leakage protection unit shall be selected to isolate the motor circuit with a maximum fault disconnection time of 5 seconds in case of earth leakage without causing nuisance tripping of the motor circuit due to motor starting and transient current transformer saturation.

(d) Auto-transformer Starters

(i) Unless otherwise specified in the General Specification or Particular Specification for the specific type of installations, motors rated above 55 kW shall be reduced voltage started by means of auto-transformer to limit the maximum starting current to within 2.5 times the rated motor full load current.

(ii) Reduced voltage starters shall be equipped as per star-delta starters specified above, with the following additional provisions: -

- Triple pole air break contactor with electrical and mechanical interlock arranged for automatic reduced voltage transition;

- Air-cooled copper winding auto-transformer with Class F insulation enclosed in an earthed metal casing suitably ventilated by splash proof louvres. Suitable tappings shall be arranged for closed transition reduced voltage motor starting; and

- Calibrated and adjustable solid state timers for switching over from reduced voltage to full voltage connection.

7.2.5.27 METERING AND MONITORING FACILITIES

7.2.5.27.1 General

The requirements of metering shall comply with the current Code of Practice for Energy Efficiency of Building Services Installation, including but not limited to the following: -

(a) Main Circuit - A main incoming circuit at or above 400A current rating, single or three phase (based on circuit protective device rating) shall be incorporated with metering devices for measuring voltages (all phase-to-phase and phase-to-neutral), currents (three phases and neutral), total power factor, total energy consumption (kWh), maximum demand (kVA) and total harmonic distortion.

(b) Feeder and Sub-main Circuit - A feeder or sub-main circuit exceeding 200A and below 400A current rating, single or three phase (based on circuit protective device), except for correction of reactive or distortion power purpose, shall be incorporated with metering devices, for measuring currents (three phases and neutral) and total energy consumption (kWh). A feeder or sub-main circuit at or above 400A current rating, single or three phase (based on circuit protective device rating), except for correction of reactive and distortion power purpose, shall be incorporated with metering devices for measuring voltages (all phase-to-phase and phase-to-neutral), currents (three phases and neutral), total power factor, total energy consumption (kWh), maximum demand (kVA) and total harmonic distortion.

(c) Circuits for central building services installations serving each of the following installation shall be incorporated with metering devices separately: -

(i) entire chilled water plant / heated water plant

(ii) all lifts

(iii) all escalators or passenger conveyors

The metering devices shall be able to provide the measurement parameters as stated in 7.2.5.27.1(b) above. For the circuit at or below 200A, the metering devices shall be able to provide the measurement for currents (three phases and neutral) and total energy consumption (kWh).

(d) Lift / Escalator Installations - Metering devices shall be provided for the electrical supply circuit for the motor drive of each lift, escalator or passenger conveyor, for measurement of voltages (all phase-to-phase and phase-to-neutral), currents (three phases and neutral), total power factor, total harmonic distortion, energy consumption (kWh), power (kW) and maximum demand (kVA). A metering device or a set of metering device shall be provided for each lift, escalator or passenger conveyor.

In respect of total harmonic distortion measurement, the metering device shall be capable of measuring at least up to 31st harmonic order.

All measurement parameters shall be trended every 15 minutes and include hourly, daily, monthly and annual data. The metering devices and the associated monitoring facilities shall be capable of maintaining all data collected for a minimum of 36 months.

Metering devices shall also be provided for the electrical supply circuit of the following systems / equipment, for measurement of energy consumption (kWh) and power (kW).

(a) Each equipment in ACMV water-side system (including but not limited to chiller plant, heating plant & heat rejection plant);

(b) Each equipment in ACMV air-side system (including but not limited to Primary air / air handling units / fans, ventilation fans);

(c) Variable refrigerant volume and unitary systems;

(d) Exhaust Systems (including but not limited to car park ventilation, toilet exhaust ventilation (>2.5kW each));

(e) Each equipment in plumbing and drainage system;

(f) Each equipment with electrical power rating 50kW or above and every floor or area with sub-main distribution exceeding 100A; and

(g) Lighting and power system (including but not limited to interior lighting, exterior lighting, small power).

SUB-SECTION 7.2.6

BUSBAR TRUNKING SYSTEM

7.2.6.1 GENERAL

Busbar trunking system shall be manufactured t0 operate on 220/380 V 3 phase 4 busbar at 50 Hz system and shall be manufactured and tested by organistaions accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS to verify to comply with IEC 61439-6:2012. Busbar trunking systems manufactured to other standards (such as National Electrical Manufacturers Association (NEMA) of USA and UL listed) with insulation voltage of 415 V may be considered as acceptable provided that the standard of manufacture is not inferior to the relevant IEC standard and that the busbar trunking system meets all the requirements of this Section. All material, components and accessories (such as bends, joints, tees, feeder units, tap-off units, etc.) used for the busbar trunking shall be of the same origin of manufacture.

In case where busbar trunkings are manufactured under license from the Principal Company, a letter shall be produced by the Principal Company to guarantee that the products manufactured by the licensee will be equivalent to every respect to the verified standard products.

Busbar trunking installed within switchroom shall comply with the requirements stipulated in Clause 7.2.11.7 of this General Specification.

7.2.6.2 BUSBAR TRUNKING CONSTRUCTION

The busbar trunking system shall be of the totally enclosed type with ingress of protection not less than IP54 of IEC 60529:1989/AMD2:2013/COR1:2019 for indoor erection in non-sprinklered areas, IP55 of IEC 60529:1989/AMD2:2013/COR1:2019 for indoor erection in sprinklered areas and mechanical plant rooms and IP66 of IEC 60529:1989/AMD2:2013/COR1:2019 for outdoor erection. It shall be constructed to withstand heavy mechanical loads as stated in IEC 61439-6:2012. The casing shall be finished in enamel paint to a grey colour or the nearest manufacturer's colour of standard production.

Adjacent lengths of the busbar casing shall be butt-jointed and the joint shall be mechanically and electrically continuous. The mechanical strength of the joint shall not be less than that of the busbar casing.

Colour circles indicating the phase arrangement of the busbars shall be painted on the casing of the terminal units and at any physical compartment. Removal of the cover for access facility shall necessitate the use of tools.

For long busbar run, phase transposition of busbar shall be incorporated in accordance with manufacturer's recommendation.

7.2.6.3 BUSBAR INSULATION

The insulation material shall be of halogen free, heat resistant, self-extinguishing, non-hygroscopic, high electrical and mechanical strength to withstand the stresses under all normal and short-circuit conditions.

7.2.6.4 BUSBAR

Busbars shall be three phase and full rated neutral made of hard drawn, high conductivity solid copper bars to BS EN 13601:2013.

The busbar including all electrical contact surfaces shall be silver or tin plated. The busbars shall be of adequate size to carry the rated current continuously at mean ambient temperature of 35 ºC and shall not exceed the temperature rise limits in accordance with Clause 7.2 of IEC 61439-6:2012.

Each bar shall be painted to indicate the phase to which it is connected. Painting shall comprise a band of colour at each accessible position to the busbars.

7.2.6.5 FEEDER UNIT

Feeder unit shall be of manufacturer's proprietary product. The rated current and rated short-time withstand current of the feeder unit shall not be less than that of the busbar trunking system to which it is connected.

7.2.6.6 TAP-OFF UNITS

Tap-off units shall be used for branch circuits taken off from the busbars. MCCB to IEC 60947-2:2016+AMD1:2019 or H.R.C. fuses to IEC 60269-1:2006+AMD1:2009+AMD2:2014 and other associated Parts of the Standard of appropriate current ratings and short-circuit breaking capacities shall be provided as near as practically possible to the tapping position for protection of the branch circuits.

Plug-in tap-off units shall be attached on the busbar casing and held in position by means of wing nuts or other quick fastening and quick releasing device.

Tap-off units shall make positive earth connection and shall be equipped with internal barriers to prevent direct contact.

Mechanical interlock shall be incorporated such that the tap-off unit cannot be inserted or removed from the busbar trunking unless it is in the switch OFF position.

7.2.6.7 BUSBAR EXPANSION UNIT

The busbar expansion unit shall be of a single pole laminated copper strip type of appropriate current rating and shall be arranged to take up the axial expansion or contraction of the busbar trunking system under normal service conditions. The

expansion unit shall be prevented from short-circuit from adjacent bar either by ample space between phases or alternatively by segregation between phases.

7.2.6.8 FIRE BARRIER IN BUSBAR TRUNKING SYSTEM

Fire barrier shall be made of non-hygroscopic material having a fire-resistant period of not less than that of the corresponding compartmentation wall or slab at where it is installed. Factory fabricated internal barrier shall be used.

7.2.6.9 BUSBAR TRUNKING ACCESSORIES

Bends, tees and intersection units shall be specifically manufactured for the particular type of busbar system with which it is to be used. The casing of the accessories shall be of same material and finish as the busbar casing and shall have a cross-sectional area not less than that of the busbar casing. No loss in mechanical strength, electrical continuity, rated current and rated short-circuit capacity shall be incurred due to insertion of bends or tees.

7.2.6.10 CERTIFICATION AND VERIFICATION TEST

Verification testing of typical busbar trunking system to IEC 61439-6:2012 shall be carried out by competent and independent short circuit testing organisations accredited by HOKLAS or HKAS, or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS and internationally recognised as having equal standing as The Association of Short Circuit Testing Authorities (ASTA). The verification report issued by the testing organisation shall be submitted to the Supervising Officer for record. Appropriate technical information and literature in English and copies of the verification test certificate and drawings must be made available for examination.

Temperature rise limits test of typical busbar trunking system shall be verified to IEC 61439-1:2011.

The configuration of the busbar trunking system shall be verification tested to a short-time withstand current in accordance with Table 7.2.6.10 at a voltage of not less than 380V.

Table 7.2.6.10 Short-time Withstand Current for Busbar Trunking System

Busbar rated current	Rated short-time withstand current
Under 800A	Fused short-time withstand current of 40 kA minimum
800A to 1,600A inclusive	40 kA minimum for one second
Above 1,600A	50 kA for one second

If modifications are made to a verified busbar trunking system, clause 10 of IEC 61439-1:2011 shall be used to check if these modifications will affect the performance of the busbar trunking system. New verifications shall be carried out by a competent and independent short circuit testing organisation if an adverse effect is likely to occur and

the method of 'verification testing' shall be used. The other methods in clause 10 of IEC 61439-1:2011 may be acceptable subject to the approval of the Supervising Officer.

A functional unit in the verified busbar trunking system may be substituted with a similar unit of the same manufacturer used in the original verification provided the following conditions are satisfied and subject to the approval of the Supervising Officer: -

(a) Power loss and terminal temperature rise of the functional unit when tested in accordance with its product standard, is the same or lower;

(b) The physical arrangement within the busbar trunking unit shall be maintained;

(c) The rating of the busbar trunking system shall be maintained; and

(d) In addition to the temperature rise limits test, other requirements as listed in Annex D of IEC 61439-1:2011 including the short-circuit requirements shall be taken into consideration.

7.2.6.11 REQUIREMENT FOR AIR-INSULATED BUSBAR TRUNKING SYSTEM

7.2.6.11.1 Busbar Enclosure

Enclosure of the busbar trunking shall be of steel construction, made of sheet steel of not less than l.2 mm thick for busbar trunking's width or height of casing not exceeding 100 mm and not less than 1.5 mm thick for a width or height exceeding 100 mm, formed in such a way as to give a rigid structure of sufficient strength. Both the main portion of the enclosure and cover shall be flanged at the side edges.

The cover shall be fixed onto the body of the busbar trunking at the front by means of heavily electroplated hexagonal head screws and nuts, one of which shall be firmly fixed onto the trunking assembly. The cover shall be removable except where the busbar trunking passes through the floor slab.

Steel work shall be treated to prohibit corrosion by hot-dip galvanising or electrolytically coated with zinc. The inside and outside surfaces of the enclosure shall then be coated with two layers of stoved enamel finish paint with contrasting colours or one layer of stoved epoxy powder paint.

7.2.6.11.2 Busbar Supports

Busbars shall be supported on insulated racks or blocks to IEC 60667-1:1980 and other associated Parts of the Standard:

(a) At each location of the busbar support insulator, the busbar shall be insulated with self-extinguishing heat shrinkable insulating sleeve of suitable operating temperature extended to 50 mm on each side of the busbar support insulator; and

(b) The busbar supports shall be mechanically strong enough to withstand the force between busbars produced by a short circuit of negligible impedance between two or more busbars.

7.2.6.11.3 Busbar Jointing

Jointing of sections of busbars shall be made by clamps tightened by bolts and nuts. Soldered, welded or riveted joints shall not be used.

Bolts for jointing busbars shall be of steel either hot dip galvanised or heavily electroplated with zinc or cadmium to guard against corrosion.

7.2.6.11.4 Suspension Unit, Flexible Joint and Stop-end Unit

Suspension unit and flexible joint shall be capable of taking up the busbar movements due to axial expansion and contraction. The flexible joint shall be insulated with self-extinguishing heat shrinkable insulating sleeves of suitable operation temperature.

Stop-end unit and built-in thrust block shall be of the same material and finish as the busbar casing. The unit shall contain an insulated support to enable the ends of the busbars to be properly supported.

7.2.6.11.5 Tap-off Unit

Proper tap off devices in the form of tap-off clamps and cable lugs where necessary shall be provided for tap-off cables and such devices shall not reduce the effective size or rating of the busbars. Slots through enclosures for tap-off cables shall be sealed with phenolic resin bonded paper laminated sheet.

7.2.6.12 REQUIREMENT FOR ALL INSULATED BUSBAR TRUNKING SYSTEM

7.2.6.12.1 Busbar Enclosure

The enclosure of the busbar trunking shall be rigidly constructed from galvanised sheet steel of not less than 1.5 mm thick or aluminium of minimum 2.5 mm thick clamped on rigid casing side steel channels. Where a combination of sheets of these two materials is used as the assembly, no apparent visible stress shall be observed during operation when the busbar trunking are properly supported. However, the thickness of the metal sheets employed shall, in no cases, be less than 1.5 mm each.

Steel work shall be treated to prohibit from rusting and corrosion by hot-dip galvanising or electrolytically coated with zinc. The inside and outside surfaces of the enclosure shall then be coated with two layers of stoved enamel finish paint, or one layer of stoved epoxy powder paint.

Sheet metal shield or appropriate protective cover with neoprene gasket shall be provided to prevent contamination of busbar trunking if it is for outdoor use or it is running near any services water pipe.

7.2.6.12.2 Busbar Insulation

Busbar shall be insulated over their entire length except at joints and plug-in contact surfaces and the insulation material shall be of at least Class B (130°C) rating.

The temperature rise at any point in the busbar trunking shall not exceed 55°C rise above ambient temperature when operating at rated load current.

7.2.6.12.3 Tap-off Units

Tap-off unit shall be equipped with internal barriers to prevent accidental contact of draw wire and conductors with the live parts at the terminals of the outgoing protective device during the time of conductor fixing.

Bolt-in tap-off unit enclosure shall be provided with sufficient spacing for cable connection to other sub-circuit devices.

Plug-in tap-off unit shall be polarised to prevent incorrect insertion and be mechanically interlocked with the busbar trunking housing to prevent insertion or removal of the plug-in unit while the protective device is in the ON position and shall be equipped with an operating handle which always remains in control of the switching mechanism. The protective device shall be fusible switch type with visible blade quick-make and break mechanism unless otherwise specified. Plug-in unit enclosures shall make positive ground connection with the earthing conductors before the jaws make contact with the phase busbars.

7.2.6.12.4 Joint in Busbar Trunking System

Joints shall be of removable type with through-bolts that can be checked for tightness without de-energising the system. It shall be possible to make up a joint from one side in the event the busbar trunking is installed against a wall or ceiling. The joint shall allow removal of any length without disturbing adjacent lengths. All bolts shall be tightened up either by means of a torque wrench to a strength figure as recommended by the manufacturer, or in accordance with the manufacturer's provision of special torque-indicating tightening device.

SUB-SECTON 7.2.7

FLUORESCENT LUMINAIRE AND LAMP

7.2.7.1 GENERAL

7.2.7.1.1 The luminaires, including the control gear, shall be suitable for operation at 220 V ±6%, 50 Hz ±2%, single phase, A.C. supply.

7.2.7.1.2 The luminaires shall comply both in manufacturing and testing with the following international standards and their manufacturing process shall conform to the relevant quality standard of ISO 9000:2008: -

Luminaires	:	IEC 60598-1:2014+AMD1:2017 CSV for general requirements and tests; IEC 60598-2-1:1979/AMD1:1987 for general purpose luminaires or IEC 60598-2-2:2011 for recessed luminaires; and IEC 62722-1:2016 for Luminaires Performance
Ballast	:	IEC 61347-2-11:2001 and/or IEC 61347-2-8:2000 and/or IEC 60921:2004+AMD1:2006 as applicable;
Miscellaneous electronic circuits	:	IEC 61347-2-11:2001+AMD1:2017;
Electronic ballast	:	IEC 61347-2-3:2011+AMD1:2016 and/or IEC 60929:2011+AMD1: 2015 as applicable;
Capacitor	:	IEC 61048:2006+AMD1:2015 and/or IEC 61049:1991/COR1:1992 as applicable;
Starter, glow type	:	IEC 60155:1993/AMD2:2006;
Starter, electronic type	:	IEC 61347-1:2015+AMD1:2017, IEC 61347-2-1:2000+AMD1:2005 +AMD2:2013 and/or IEC 60927:2007+AMD1:2013 as applicable;
Lampholder	:	IEC 60400:2017;
Lamp	:	IEC 60081:1997/AMD6:2017 and/or IEC 60901:1996/AMD6: 2014 as applicable; and
Internal cable	:	Internal wiring shall be made with conductors of a suitable size and type to handle the power

occurring during normal use. The insulation of the wiring shall be made of a material capable of withstanding the voltage and the maximum temperature to which it is subjected, without affecting the safety when properly installed and connected to the mains.

7.2.7.1.3 The luminaires excluding the fluorescent lamp shall be supplied in complete set comprising control gear, lampholders, cable terminal block, etc.

7.2.7.1.4 The lamp circuit power factor for luminaire employing electromagnetic ballast shall not be less than 0.85, whilst that for luminaire employing electronic ballast shall be higher than 0.95.

7.2.7.1.5 Type test certificate shall be provided and the luminaires shall be marked in accordance with the requirements of IEC 60598-2-1:1979/AMD1:1987 for general purpose luminaires or IEC 60598-2-2:2011 for recessed luminaires.

In exceptional cases like tailor-made luminaires having been specified where type test certificate for the luminaire is not available, compliance of individual components to the respective international standards as stipulated in this Section to ensure safety in use shall be demonstrated to the approval of the Supervising Officer.

7.2.7.2 TYPE OF LUMINAIRES

Group 1
This group includes all recessed modular luminaires and surface mounted batten luminaires.

Group 2
This group covers special luminaires including glass fibre, garage pit and flame-proof luminaires.

Group 3
This group covers self-contained emergency fluorescent luminaire.

7.2.7.3 GROUP 1 – RECESSED MODULAR LUMINAIRES AND SURFACE MOUNTED BATTEN LUMINAIRES

7.2.7.3.1 Unless otherwise specified, the starting arrangement for these luminaires shall be electronic start, and the position of the starter shall be readily accessible. Starter is not required if electronic ballast is used.

7.2.7.3.2 Unless otherwise specified, the basic batten shall be made of sheet steel of minimum 0.5mm thickness and finished in white stove enamel/stove miracryl enamel/stove miracoat enameld or alternative finishes approved by the Supervising Officer to IEC 60598-1:2014+AMD1:2017 CSV

protection against electric shock Class I. The ingress protection shall be at least IP2X to IEC60598: 2014+AMD1: 2017 general requirement.

7.2.7.3.3 The basic batten shall be suitable for 20 mm diameter conduit suspension and/or direct-on-ceiling mounting. Two 20 mm diameter clearance holes shall be provided at 610 mm fixing centres on 1,200 and 1,500 mm long luminaires, but only one clearance hole at central position on 600 mm long luminaire. All clearance holes shall be surrounded by four number 50.8 mm Pitch Circle Diameter (P.C.D.) holes for circular conduit box fixing.

7.2.7.3.4 The basic batten shall have a 20 mm diameter knockout at the centre (except for 600 mm long luminaire) and in each end face for back or end cable entry. Where the end face of the basic batten is made of non-metallic material, additional means shall be provided to ensure the continuity of earthing when the luminaire is used for surface conduit installation.

7.2.7.3.5 For back entry installation, if the basic batten cannot fully cover the circular conduit box, a pattress block cover made of 0.5 mm thick mild steel, finished in white stoved enamel shall be supplied with each basic batten to shield the conduit box outlet.

7.2.7.3.6 The basic batten shall be capable to accept the metal cover plate and different reflectors or diffusers.

7.2.7.3.7 The metal cover plate, open-end metal angle reflector, and open-end metal trough reflector shall be manufactured and finished to the same specification as the basic batten, and shall be suitable for direct fixing to a basic batten of the appropriate length. The luminaires of this group include: -

(a) Batten luminaire with metal cover plate

Luminaire composed of basic batten and metal cover plate;

(b) Batten luminaire with metal angle reflector

Luminaire composed of basic batten and open-end metal angle reflector;

(c) Batten luminaire with metal trough reflector

Luminaire composed of basic batten and open-end metal trough reflector; and

(d) Batten luminaire with plastic diffuser

Luminaire composed of basic batten, metal cover plate and plastic prismatic diffuser.

7.2.7.3.8 The plastic prismatic diffuser with clip-on-end-plates shall be manufactured from extruded plastics with external reed suitable for fixing to a basic batten with metal cover plate. The plastic clip-on-end-plate shall be simply fitted to the basic batten thus enabling the diffuser to be quickly and easily removed for cleaning and general maintenance.

7.2.7.4 GROUP 2 - SPECIAL LUMINAIRES

7.2.7.4.1 Luminaires of this group are categorised as follows: -

Cat.A : Glass-fibre luminaires;

Cat.B : Garage pit luminaires; and

Cat.C : Flameproof luminaires.

7.2.7.4.2 Cat. A: Glass-fibre luminaires

(a) Unless otherwise specified, the starting arrangement shall be of electronic start, and the control gear components shall be fixed in a removable tray. The construction of the luminaire shall be suitable for chemically corrosive atmosphere and complying with IEC 60598-1:2014+AMD1:2017 CSV Class II. The ingress protection shall be at least IP55 to IEC 60529:1989/AMD2:2013/COR1:2019.

(b) The luminaire shall comprise glass fibre reinforced polyester base canopy and high impact resistant polycarbonate diffuser with internal prisms held together by corrosion resistant clips. Wide seamless polyurethane gasket shall be fitted between diffuser and canopy.

(c) The luminaire shall be suitable for 20 mm diameter conduit suspension and direct-on-ceiling mounting. Two 20 mm diameter clearance holes shall be provided at 610 mm centres, surrounded by four number 50.8 mm Pitch Circle Diameter (P.C.D.) holes for circular conduit box fixing. One number 20 mm diameter knockout shall also be provided in one end face of the fitting.

7.2.7.4.3 Cat. B: Garage pit luminaires

(a) Unless otherwise specified, the starting arrangement shall be of electronic start. The construction of the luminaire shall comply with IEC 60598-1:2014+AMD1:2017 CSV, Class II and suitable for use in Zone 2 hazardous area as defined by IEC 60079-10-1:2015/COR1:2015. The ingress protection shall be at least IP65 to IEC 60529:1989/AMD2:2013/COR1:2019.

(b) The luminaire shall be made of sheet steel and finished in white stove enamel internally and grey externally. The luminaire shall have a removable opal polycarbonate front cover which shall be

clamped securely into a soft rubber gasket by means of quick release fasteners. Fixing holes shall be provided in the front flange together with 20 mm diameter knockout at each end.

7.2.7.4.4 Cat. C: Flameproof luminaires

(a) The luminaires shall be constructed in accordance with IEC 60079-1:2014/COR1:2018, flameproof enclosure Ex'd' and certified flameproof by an approved independent testing authorities, such as the British Approval Services for Electrical Equipment in Flammable Atmospheres (BASEEFA). The luminaire shall be suitable for installation in Zone 1 hazardous area as classified in IEC 60079-10-1:2015/COR1:2015. The enclosure of the luminaire shall comply with the requirements for temperature classification T6, i.e. maximum surface temperature does not exceed 85°C, as stated in IEC 60079-0:2017/ISH2:2019 and Gas Group IIB as stated in ISO/IEC 80079-20-1:2017/COR1:2018 The ingress protection shall be at least IP66 to 60529:1989/AMD2:2013/COR1:2019.

(b) The body casting, control gear housing and end covers shall be constructed with cast aluminium at least to ISO 3522:2007 or BS EN 1706:2010 Al-Si5Cu3 and with suitable coating for increased protection against corrosion. The fluorescent lamp shall be housed in a cylinder of borosilicate glass and flamesealed at the end of the casing.

(c) Unless otherwise specified, the starting arrangement shall be electronic start and the control gear components shall be installed on a removable metal tray enclosed in a separate housing which shall be provided with at least 20 mm conduit entries for through connections.

(d) The luminaire shall be suitable for either 20 mm diameter conduit suspension or direct-on-ceiling mounting by hook brackets with locking screw which mates with catch bracket. The luminaire shall also be suitable for wall mounting without diminution of performance.

(e) The incoming terminal chamber shall be an integral part of the body casting complete with phase, neutral and earth terminal blocks. The cover of chamber shall be provided with weatherproof gasket and with at least 20 mm conduit entries fitted with hexagonal headed flameproof plug.

7.2.7.5 GROUP 3 - SELF-CONTAINED EMERGENCY FLUORESCENT LUMINAIRES

7.2.7.5.1 General

The specified type of self-contained emergency fluorescent luminaires shall be of the following types: -

Type I : 14 W T5 550 mm or 18 W T8 600 mm long, single fluorescent lamp;

Type II : 28 W T5 1,150 mm or 36 W T8 1,200 mm long, single fluorescent lamp; and

Type III : 35 W T5 1,450 mm or 58 W T8 1,500 mm long, single fluorescent lamp.

7.2.7.5.2 Standards

In addition to Clause 7.2.7.1.2, the luminaire shall comply with the following standards: -

Luminaire : IEC 60598-2-22:2014/AMD1:2017 CSV; and

Control gear : IEC 61347-2-7:2011+AMD1:2017.

7.2.7.5.3 Functional Requirements

(a) Emergency luminaire shall be of maintained type. Under normal supply, a sealed nickel-metal hydride battery unit complying to IEC 61951-2:2017 where applicable shall be charged to maintain in a fully charged state ready to supply power as required and lamp shall be operated by the mains supply through a separate circuit. When a failure of mains supply occurs, the unit shall automatically switch to battery-powered operation. Upon restoration of the mains supply, the lamp shall be switched back to mains supply operation and the batteries shall be re-charged again. The whole operation shall be performed automatically.

(b) Battery cells shall be capable of continuous operation at cell wall temperature up to 60°C. The battery shall have ample capacity to maintain the output of the fluorescent lamp upon mains supply failure as specified below for up to a period complying with FSD CoP and for at least 2 hours. The life time of the battery cells shall be not less than 4 years.

(c) Charging system shall be capable of recharging the battery to full capacity in 24 hours after a total discharge of the battery. Facilities shall be provided to prevent the battery from over-charging.

(d) Circuit of the fitting shall be so configured such that a lighting switch can be installed to control the lamp in the ON or OFF position under the mains-powered operation. Upon mains supply

failure, the lamp shall be switched on under battery power irrespective of whether the lighting switch is in the ON or OFF position.

(e) Light output throughout the average mid-tube life when using 4,000K fluorescent tube shall be not less than:

(i) When in normal operation mode

Type I: 1,200 lumen (T5) or 1,350 lumen (T8);
Type II: 2,600 lumen (T5) or 3,350 lumen (T8); and
Type III: 3,300 lumen (T5) or 5,200 lumen (T8);

(ii) Throughout the 2-hour discharging period when mains fails

Light output shall not be less than 50% of the nominal light output under the maintained mode.

7.2.7.5.4 Construction

(a) The luminaire shall be supplied complete with the following component parts integrated in the interior of the fitting:

(i) A battery charger/inverter unit complete with a main power failure detector, an automatic change-over switch, capable of changing over within 8 ms from mains supply to battery supply, a low voltage "cut-out" battery protective device and a battery over-charging protective device;

(ii) A sealed, rechargeable, maintenance free, nickel-metal hydride battery;

(iii) Electronic ballast;

(iv) Capacitors and radio interference suppressors;

(v) Indications that the mains supply is normal or that the battery is discharging;

(vi) A test button for checking battery condition; and

(vii) Fluorescent tube.

(b) The basic spine of the fitting shall be manufactured from sheet steel to form a complete enclosure, and finished in white stoved enamel.

(c) The luminaire shall be suitable for conduit, rod chain or conduit box mounting at normal suspension centres. Alternative mains entry shall also be provided in the centre back of the spines or by a knock-out in each end plate.

(d) A fused terminal block fitted with cartridge fuses of appropriate rating shall be provided separately for both the charger and the maintained circuit.

7.2.7.6 (NOT USED)

7.2.7.7 FLUORESCENT LAMPS

7.2.7.7.1 Lamp Features

Lamps shall have, but not limited to, the following features:

(a) Superb Colour Rendering Index (CRI) with values not less than 80 except for hospitals or other clinical functional areas where the CRI values shall not be less than 90.

(b) Energy saving;

(c) Compatible to the type of lamp circuit; and

(d) Tubular shape with preheated cathode and suitable for operation in ambient temperature up to 40°C and 100% relative humidity.

The integrated compact fluorescent lamp up to 60W shall have obtained a Grade 3 or better Energy Label under the Energy Efficiency Labelling Scheme of Electrical and Mechanical Services Department

The non-integrated compact fluorescent lamp shall have obtained a Recognition Type Energy Label under the Energy Efficiency Labelling Scheme of Electrical and Mechanical Services Department.

7.2.7.7.2 All fluorescent lamps shall have lumen output not less than those listed in Tables 7.2.7.7.2(1) to 7.2.7.7.2(7) at an ambient temperature of 25°C.

Table 7.2.7.7.2 (1) Lumen Output for 26 mm Diameter (T8) Tubular Fluorescent Lamps (LBS ref. (LM) T26)

Rated power of lamp(W) – Cap G13	Min. Lumen output		
	3,000K	4,000K	6,000K & Above
18	1,350	1,350	1,300
36	3,350	3,350	3,250
58	5,200	5,200	5,000

Table 7.2.7.7.2 (2) Lumen Output for 16 mm Diameter (T5) Tubular Fluorescent Lamps (LBS ref. (LM) T16)

Rated power of lamp(W) – Cap G13	Min. Lumen output (25°C/35°C)		
	3,000K	4,000K	6,000K & Above
14	1,200/1,350	1,200/1,350	1,100/1,250
21	1,900/2,100	1,900/2,100	1,750/1,950
28	2,600/2,900	2,600/2,900	2,400/2,700
35	3,300/3,650	3,300/3,650	3,050/3,400
24	1,750/2,000	1,750/2,000	1,600/1,900
39	3,100/3,500	3,100/3,500	2,850/3,325
49	4,300/4,900	4,300/4,900	4,100/4,650
54	4,450/5,000	4,450/5,000	4,050/4,750
80	6,150/7,000	6,150/7,000	5,700/6,650

Table 7.2.7.7.2 (3) Lumen Output for Compact Fluorescent, Single-ended , 4 Pin Base Lamps (LBS ref. (LM) TC-L)

Rated power of lamp (W)/ Cap type	Min. Lumen output			
	2,700K	3,000K	4,000K	5,400K
5 / 2G7	265	--	265	--
7/ 2G7	400	--	400	--
9 / 2G7	600	600	600	--
11/ 2G7	900	900	900	900
18 / 2G11	1,200	1,200	1,200	1,170
24 / 2G11	1,800	1,800	1,800	1,560
36 / 2G11	2,900	2,900	2,900	2,750
40 / 2G11	3,500	3,500	3,500	3,325
55 / 2G11	4,800	4,800	4,800	4,550

Table 7.2.7.7.2 (4) Lumen Output for Compact Fluorescent, Single-ended, 2 Pin Base Lamps (LBS ref. (LM) TC-SEL)

Rated power of lamp (W) - Cap G23	Min. Lumen output			
	2,700K	3,000K	4,000K	5,400K
5	250	250	250	--
7	400	400	400	375
9	600	600	600	565
11	900	900	900	850

Table 7.2.7.7.2 (5) Lumen Output for Compact Fluorescent, Twin Independent Single-ended, 2 Pin Base Lamps (LBS ref. (LM) TC-DEL)

Rated power of lamp (W) - Cap G24d	Min. Lumen output		
	2,700K	3,000K	4,000K
10	600	600	600
13	900	900	900
18	1,200	1,200	1,200
26	1,710	1,710	1,710

Table 7.2.7.7.2 (6) Lumen Output for Compact Fluorescent, Triple Independent Single-ended, 2 Pin Base Lamps (LBS ref. (LM) TC-T)

Rated power of lamp (W) - Cap GX24d	Min. Lumen output		
	2,700K	3,000K	4,000K
13	900	900	900
18	1,200	1,200	1,200
26	1,710	1,710	1,710

Table 7.2.7.7.2 (7) Lumen Output for Compact Fluorescent, Triple Independent Single-ended, 4 Pin Base Lamps (LBS ref. (LM) TC-TEL)

Rated power of lamp (W) - Cap GX24q	Min. Lumen output		
	2,700K	3,000K	4,000K
13	900	900	900
18	1,200	1,200	1,200
26	1,710	1,710	1,710
32	2,400	2,400	2,400
42	3,200	3,200	3,200

7.2.7.7.3 All fluorescent lamps shall have average rated life not less than those listed below at 50% failure:

Table 7.2.7.7.3 Average Rate Life for Fluorescent Lamp

Fluorescent Lamp Type	Average Rated Life (Hour)
T8 fluorescent lamp	15,000
T5 fluorescent lamp	20,000
Compact fluorescent lamp	8,000

7.2.7.8 ELECTRONIC BALLASTS

7.2.7.8.1 General

The electronic ballast for both fixed output and dimmable types shall be a solid-state converter to convert single phase mains supply of 220 V $\pm$ 6% and 50 Hz $\pm$1 Hz to a high frequency voltage output at its rated throughout power to suit the lamp(s) connected. The electronic ballast shall conform to the following international standards:

(a) BS EN IEC 61347-2-3:2011+AMD1:2016:
AC-supplied electronic ballasts for tubular fluorescent lamps - General & safety requirements;

(b) BS EN IEC 60929:2011+AMD1:2015:
AC-supplied electronic ballasts for tubular fluorescent lamps - Performance requirements;

(c) IEC 61000-3-2:2018:
Limits for harmonic current emission
(equipment input current < 16 A per phase);

(d) BS EN IEC 55015:2019:
Limit and method of measurement of radio disturbance characteristics of lighting and similar equipment; and

(e) IEC 61547:2009/ISH1:2013:
Equipment for general lighting purposes - EMC immunity requirements.

Certificates of compliance with the above standards shall be issued by organisations accredited by HOKLAS or HKAS, or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS for each standard rating of electronic ballast to be used in the Contract.

The electronic ballast shall have obtained a Recognition Type Energy Label under the Energy Efficiency Labelling Scheme of Electrical and Mechanical Services Department.

7.2.7.8.2 Construction

The electronic ballast shall incorporate a low-pass filter for limitation of harmonic distortion, radio interference, inrush current and high mains voltage peak, a full diode bridge rectifier, a power factor correction part, a high frequency oscillator and an internal control circuit.

7.2.7.8.3 Performance Requirements

The maximum power loss of the electronic ballast shall not be more than those listed in Table 7.2.7.8.3.

Table 7.2.7.8.3 Maximum Allowable Power Loss of Electronic Ballast

Lamp Type	Rated lamp rating operated at high frequency	Maximum allowable power loss in Wattage
T8 linear fluorescent lamp	16 W	3
	24 W	4
	32 W	4
	50 W	5
	60 W	8
T5 linear fluorescent lamp	14 W	3
	21 W	3
	24 W	3
	28 W	4
	35 W	4
	39 W	4
	49 W	6
	54 W	6
	80 W	8
Compact fluorescent lamp – 2 tubes	4.5 W	2.2
	6.5 W	2.5
	8 W	3
	10 W	4
	16 W	3
	22 W	3
	32 W	4
	40 W	5
	55 W	6

Table 7.2.7.8.3 Maximum Allowable Power Loss of Electronic Ballast (Cont'd)

Lamp Type	Rated lamp rating operated at high frequency	Maximum allowable power loss in Wattage
Compact fluorescent lamp – 4 tubes	9.5 W	1.5
	12.5 W	1.5
	16.5 W	2.5
	24 W	3
Compact fluorescent lamp – 6 tubes	16.5 W	2.5
	24 W	3
	32 W	4
	42 W	5
Circular fluorescent lamp	19 W	3
	22 W	4
	40 W	4
	55 W	5

For the fluorescent lamp(s) operated by electronic ballast, the regulated light output shall be less than +2% over a supply voltage range of 220 V ±10% to the electronic ballast.

The Ballast Lumen Factor of the electronic ballast shall not be lower than 0.95 or higher than 1.05 with reference to a standard conventional ballast.

The electronic ballast shall be rapid or preheat start and the lamp operating frequency shall be above 30 kHz.

The Total Power Factor (TPF) of the luminaire employing electronic ballast shall be higher than 0.95 and its maximum Total Harmonic Distortion (THD) shall be less than 15% when tested on a pure sinusoidal mains supply.

The complete electronic ballast shall be housed in a single front-access enclosure with appropriate terminal blocks for easy connection of wiring. The electronic ballast shall be suitable to operate at an ambient temperature range from 0ºC to 50ºC and at a maximum relative humidity of 95%. The maximum case temperature of the electronic ballast shall be 70°C.

The electronic ballast shall go into a shutdown or low power stand-by state when defective lamps are connected or when overload occurs in the lamp circuit.

The maximum inrush current of the electronic ballast shall not exceed 15 A peak at starting and shall not last longer than 0.5 ms.

The rated life of the electronic ballast shall not be less than 50,000 hours at the test point of 70°C.

The failure rate of the electronic ballast shall be less than 1% per 4,000 hours operation at the maximum case temperature.

7.2.7.8.4 Additional Requirements for Dimmable Electronic Ballasts

Electronic ballasts with dimmable function shall meet the following additional requirements:

(a) high energy efficient dimming system providing continuous dimming range of 5% - 100%;

(b) the electronic ballast shall be compatible with the dimming circuit provided;

(c) dimming performance shall follow logarithmic characteristics that is optimised according to the sensitivity of human eye; and

(d) provide flicker-free dimming operation throughout the complete operation temperature range.

SUB-SECTION 7.2.8

HIGH INTENSITY DISCHARGE LUMINAIRE AND LAMP

7.2.8.1 GENERAL

This Section covers the requirements for the following high intensity discharge (HID) lamps:

Tubular sodium vapour discharge lamps (SON-T or LBS : HST)

Elliptical sodium vapour discharge lamps (SON-E or LBS : HSE)

Elliptical mercury vapour discharge lamp (MBF or LBS : HME)

Linear metal halide (MBIL) or LBS: HIT-DE / linear high pressure sodium lamp (SON-TD) or LBS: HST-DE

The lamp, in connection with the control gear, shall be suitable for operation at 220 V ± 6%, 50 Hz ± 2%, single phase, A.C. supply.

The lamp shall be compatible with the luminaire and the control gear of the luminaire.

7.2.8.2 HIGH PRESSURE SODIUM VAPOUR DISCHARGE LAMP (SON-T AND SON-E OR LBS : HST AND HSE)

The lamp shall be manufactured and tested in accordance with IEC 60662:2011.

The lamp shall consist of a high pressure sodium discharge operating within a sintered alumina arc tube. The arc tube shall be mounted in a clear glass bulb completed with an E40 lamp cap.

The lamp shall have a universal operating position and shall be suitable for use with external ignitor.

The correlated colour temperature of the lamp shall be in the order of 2,000K. The light output of the lamp shall be constant and shall not be less than the following figures for the respective wattage type in the initial 2,000 hours: -

Nominal Lamp Wattage	Initial Light Output
150 W	16,500 lumens
250 W	28,000 lumens
400 W	48,000 lumens

The rated average life of the lamp shall not be less than 24,000 hours at 50% failure.

7.2.8.3 ELLIPTICAL HIGH PRESSURE MERCURY VAPOUR DISCHARGE LAMP (MBF OR LBS : HME)

The lamp shall be manufactured and tested in accordance with IEC 60188:2001.

The lamp shall consist of a high pressure mercury discharge operating within a quartz arc tube. The arc tube shall be mounted in an elliptical glass bulb coated with a fluorescent phosphor and complete with a cap of the type compatible with the respective lamp wattage type.

The correlated colour temperature of the lamp shall be in the range of 3,400K to 4,000K with respective to the selected nominal lamp wattage.

The lamp shall have a universal operation position.

The light output of the lamp shall be constant and shall not be less than the following figures for the respective wattage type in the initial 2,000 hours: -

Nominal Lamp Wattage	Initial Light Output
50 W	2,500 lumens
80 W	4,000 lumens
125 W	6,500 lumens
250 W	13,750 lumens
400 W	22,000 lumens

The rated average life of the lamp shall not be less than 16,000 hours or 24,000 hours with respective to the selected nominal lamp wattage at 50% failure.

7.2.8.4 LINEAR METAL HALIDE/LINEAR HIGH PRESSURE SODIUM LAMP

This Sub-section covers the following lamps:

750 W/1,500 W linear metal halide (MBIL or LBS : HIT-DE); and

400 W linear high pressure sodium (SON-TD or LBS : HST-DE)

MBIL (or LBS : HIT-DE) linear metal halide lamp shall be manufactured and tested according to IEC 61167:2018/COR1:2019. The lamp consists of an arc burning between tungsten electrodes in an atmosphere of mercury and additional metal halides enclosed in a double-ended quartz arc tube. The halides shall be chosen to have a high efficiency light output of good colour rendering and correlated colour temperature of 5,200K. The lamp shall be 750/1,500 W as specified. The rated average life of the lamp shall not be less than 6,000 hours at 50% failure.

The luminous efficacy of the MBIL lamp shall not be less than the following figures for the respective wattage type in the initial 2,000 hours: -

Nominal Lamp Wattage (L)	Initial Light Output
750 W	63,750 1umens
1,500 W	127,500 1umens

SON-TD (or LBS : HST-DE) linear high pressure sodium lamp shall be manufactured and tested according to IEC 60662:2011. The lamp shall be tubular, double ended in construction and shall consist of an arc tube made of sintered aluminium oxide and mounted in a clear tubular quartz outer bulb having a single contact ceramic cap at each end. The lamp shall be rated at 400 W and have a correlated colour temperature of 2,100K. The rated average life of the lamp shall not be less than 24,000 hours at 50% failure.

The luminous efficacy of the SON-TD lamp shall not be less than the following figures for the respective wattage type in the initial 2,000 hours: -

Nominal Lamp Wattage (L)	Initial Light Output
400 W	34,000 lumens

7.2.8.5 LUMINAIRE FOR FLOODLIGHTING

7.2.8.5.1 General

The floodlighting luminaires shall be manufactured and tested in accordance with IEC 60598-1:2014+AMD1:2017 CSV and IEC 60598-2-5:2015.

The floodlighting luminaires shall have a degree of protection of not less than IP54 to IEC 60529:1989/AMD2:2013/COR1:2019 and they shall be constructed from corrosion resistant materials.

The floodlighting luminaires shall be suitable of continuous outdoor operation at an ambient temperature of 35°C without unduly affecting the life and performance of the floodlighting luminaires, the control gear and the lamps.

The floodlighting luminaires shall be supplied in complete set including the main body, reflectors, front glass, lampholder assemblies, terminal box, internal wirings, control gear, control gear box and mounting facilities as specified and as required.

7.2.8.5.2 Construction

The main body shall be manufactured from die cast aluminium, which is fixed to two aluminium alloy end castings. The luminaire shall also incorporate removable drain plugs for use in humid conditions.

Internal reflectors consisting of the main body and two end cheeks and the two optional reflectors, baffled and faceted, are to be constructed from highly specular aluminium. The metal reflector shall be polished, anodised and give an asymmetrical light distribution of beam angle to 1/10 peak to approximately the following requirements:

(a) for 750/1,500 W MBIL (or LBS : HIT-DE) lamp
Horizontal 90°
Vertical 9° above peak, 41° below peak; and

(b) for 400 W SON-TD (or LBS : HST : DE) lamp
Horizontal 84°
Vertical 4° above peak, 19° below peak.

The heat resistant toughened glass shall be fitted to a non-ferrous metal front frame with corrosion resistant hinges and four swivel bolts (stainless steel) for securing to the main body and provided with weatherproofing silicon rubber gasket between the main body and toughened front glass.

The lampholder assembly shall be suitable for accepting the lamp as specified. They shall be incorporated with appropriate heat sinks if necessary to avoid overheating.

Weatherproof wiring terminal box shall be mounted at the rear side of the main body suitable for housing a two-way terminal block, each terminal suitable for 1x10 mm^2 cable. Cable entry is provided via a combined cable gland/cord grip. Earthing stud/terminal shall be provided. Internal wiring shall be of heat resistant type to the appropriate IEC Standard.

The control gear shall be suitable for operation of the lamp as specified, and shall consist of a ballast, ignitor, transformer and power factor correction capacitor(s) as appropriate, to enable the whole assembly to operate at the specified voltage with an overall power factor not less than 0.85.

Control gear shall be provided with facilities for easy and securely fixing to a metal back plate or gear box. Control gear shall be suitable for continuous operation under an ambient temperature of 35°C.

The floodlighting luminaires shall be complete with the stirrup arrangement which permits the floodlighting luminaires to be rotated in azimuth and adjusted in elevation. An aiming stop shall be provided on the floodlighting luminaires to ensure that the aiming angle remains undisturbed even if the floodlighting luminaires are removed from the stirrup for servicing.

7.2.8.5.3 Lamps

All types of lamps suitable for fixing to the specified luminaire shall have a high efficiency and a fairly constant output and be constructed with appropriate lamp caps.

SUB-SECTION 7.2.9

LIGHT EMITTING DIODE LUMINAIRE AND DRIVER

7.2.9.1 GENERAL

7.2.9.1.1 The 'Light Emitting Diode' (LED) luminaires, including the electronic driver and LED module shall be suitable for operation at 220 V ± 6%, 50 Hz ± 2%, single phase AC supply.

7.2.9.1.2 The LED luminaires shall be fully assembled and tested before shipment from factory. The LED luminaire shall comply with the following international standards and their manufacturing process shall conform to the relevant quality standard of ISO 9001:2015: -

IEC 60598-1:2014+AMD1:2017 CSV	:	Luminaires – Part 1: General requirements and tests; and
IEC 60598-2-1: 1979/AMD1:1987	:	Luminaires – Part 2: Particular requirements. Section 1: Fixed general purpose luminaires; or
IEC 60598-2-2:2011	:	Luminaires – Part 2 Particular requirements. Section 2: Recessed luminaries; or
IEC 60598-2-3:2002 +AMD1:2011	:	Luminaires – Part 2 Particular Requirements Section 3: Luminaries for road and street lighting; or
IEC 60598-2-5:2015	:	Luminaires – Part 2 Particular Requirements Section 5: Floodlights
IEC 60598-2-13: 2006+AMD1:2011+AMD2:2016	:	Luminaires – Part 2 Particular Requirements Section 13: Ground recessed luminaires
IEC 60598-2-22: 2014/AMD1:2017 CSV	:	Luminaires – Part 2 Particular Requirements Section 22: Luminaires for emergency lighting

Type test certificate shall be provided to demonstrate the compliance with the above standards issued by organisations accredited by HOKLAS or HKAS, or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS for the LED luminaries.

7.2.9.1.3 The LED luminaires shall be marked in accordance with the requirements of IEC 60598-2-1:1979/AMD1:1987 for general-purpose luminaires or IEC 60598-2-2:2011 for recessed luminaries. The ingress protection for indoor, outdoor and underwater LED luminaire shall be at least IP2X, IP54 and IP68 respectively to IEC 60529:1989/AMD2:2013/COR1:2019.

7.2.9.1.4 The irradiance and radiance emission limits of the LED luminaires, that are exposed to view directly, shall be tested to comply with the hazard 'Risk Group 1' (low risk) unlimited as stated in the requirements of the IEC 62471:2006 and IEC/TR 62778:2014.

7.2.9.1.5 The LED luminaires shall be rated for continuous service at an ambient temperature of 40°C without affecting the performance requirements as stated in Clause 7.2.9.4 of this General Specification. The Supervising Officer shall be advised if the performance of the LED luminaires will be affected by the installation conditions.

7.2.9.1.6 The LED luminaires components (circuit boards, electrical, electronic and plastic components) shall comply with RoHS.

7.2.9.1.7 The LED luminaires shall have a full set of photometric data prepared to CIBSE TM5 or IES format for general lighting purpose.

7.2.9.1.8 The type of LED Luminaires shall comply where applicable with the requirements as stipulated Clauses 7.2.7.2 to 7.2.7.5 of this General Specification.

7.2.9.2 ELECTRONIC DRIVER

7.2.9.2.1 The electronic driver (driver) for the LED luminaire shall include the components of power factor correction, radio interference suppression and also dimming facility if it is specified. The driver shall conform to the following international standards if applicable: -

BS EN IEC 55015: 2019	:	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment.
BS EN IEC 61000-3-2:2018	:	Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≦ 16 A per phase);
BS EN IEC 61000-3-3:2013		Electromagnetic Compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≦ 16A per phase and not subject to conditional connection

BS EN IEC 61347-1:2015 +AMD1:2017	:	Lamp controlgear – Part 1: General and safety requirements;
BS EN IEC 61347-2-13:2014 +AMD1:2016	:	Lamp controlgear – Part 2-13: Particular requirements for D.C. or A.C. supplied electronic controlgear for LED modules;
BS EN IEC 61547:2009 /ISH1:2013	:	Equipment for general lighting purposes – EMC immunity requirements; and
BS EN IEC 62384:2006 +AMD1:2009 CSV	:	D.C. or A.C. supplied electronic control gear for LED modules – Performance requirements;

7.2.9.2.2 Technical information of the drivers shall be provided to indicate the performance of the drivers. The data shall include, but not limited to, minimum and maximum input voltage, frequency, maximum operating temperature, rated output voltage, rated output current, rated output power, power factor and radio interference suppression.

7.2.9.2.3 The rated life of driver shall not be less than 35,000 hours operating at ambient temperature not lower than 40°C.

7.2.9.2.4 Electronic ballast shall be compatible with the dimming circuit provided. Unless other specified, the electronic ballast shall have at least continuous dimming range 40% - 100% without flickering.

7.2.9.3 LED MODULE

7.2.9.3.1 The LED module, self-ballasted LED module or self-ballasted LED lamp shall be manufactured and tested to comply with the following standards if applicable: -

LED module & Self-ballasted LED module	:	IEC 62031:2018 LED modules for general lighting – Safety specifications. IEC 62717:2014+AMD1:2015+AMD2: 2019: LED modules for general lighting – Performance requirements
Connector for LED modules	:	IEC 60838-2-2:2006+AMD1:2012 Miscellaneous lampholders – Part 2-2: Particular requirements – Connectors for LED modules

Certificate of compliance with the above standards shall be issued by organisations accredited by HOKLAS or HKAS, or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS or the manufacturer of LED module.

7.2.9.4 PERFORMANCE REQUIREMENTS

7.2.9.4.1 Each type of LED module, LED luminaire or self-ballasted LED lamp shall be fully assembled with all the associated components. The performance of the LED module, LED luminaire and self-ballasted LED lamp shall comply with the following requirements:

(a) Luminaire efficacy (lumen/watt):

The luminaire efficacy of different types of luminaires under different colour temperatures to be used in the Contract shall be provided to indicate its performance.

(b) Lumen maintenance (L_{70})

The lumen maintenance of LED module shall not be less than 90% of its initial value until an operating time of 25% rated life or 6,000 hours. The lumen output of LED luminaire shall deliver at least 70% of its initial lumen output after operating 35,000 hours and 25,000 hours for LED luminaire and self-ballasted LED lamp respectively. For compliance with the L_{70} threshold lumen maintenance requirements, the lumen maintenance data of each colour temperature LED luminaire using 6,000 hours is acceptable for projecting the L_{70}. The required lumen maintenance at 6,000 hours shall not be less than 94.1% and 91.8% for L_{70} = 35,000 hours and L_{70} = 25,000 hours respectively.

(c) Colour Rendering Index (CRI):

CRI shall be minimum 80 for colour temperature from 2,700 – 6,000K for indoor luminaires and self-ballasted LED lamp.

(d) Power factor:

The power factor of the LED luminaire circuit and self-ballasted LED lamp shall be minimum 0.9 and minimum 0.7 respectively.

(e) Correlated Colour Temperature (CCT) and its tolerance limit:

The colour temperature of a group of LED luminaires in the same space or room shall not be visually noticeable. The nominal CCT of the LED light source shall preferably be one of the following values. The tolerance limits shall be within the below ranges: -

2,700 K	2,725 ± 145 K
3,000 K	3,045 ± 175 K
3,500 K	3,465 ± 245 K
4,000 K	3,985 ± 275 K
4,500 K	4,503 ± 243 K
5,000 K	5,028 ± 283 K
5,700 K	5,665 ± 355 K
6,500 K	6,530 ± 510 K

7.2.9.4.2 Each model of LED module, LED luminaire or self-ballasted LED lamp shall be tested to comply with the above performance requirements. The test report from the organisations accredited by HOKLAS or HKAS, or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS shall be submitted to certify each model of LED module, LED luminaire or self-ballasted LED lamp complying with the standards or other recognised international/national standards or other standards proposed and agreed by the Supervising Officer.

7.2.9.4.3 Self-ballasted LED lamps for general lighting services shall comply with the following requirement;

(a) IEC 62560:2011/COR2:2015 - Self-ballasted LED lamps for general lighting services by voltage > 50V – Safety specifications; and

(b) IEC 62612:2013+AMD1:2015+AMD2:2018 – Self-ballasted LED lamps for general lighting services with supply voltages > 50 V - Performance Requirements.

7.2.9.4.4 For double-capped LED tubular lamp intends to retrofit tubular fluorescent lamp, the LED lamp shall comply with IEC62776:2014/ISH1:2018 “Double-capped LED Lamps Designed to Retrofit Linear Fluorescent Lamps – Safety Specifications”. Where LED tubular lamp with built-in sensors is specified, the LED lamp shall be integrated with motion sensors and/or daylight sensors. The sensors shall be capable to control the lumen output of LED lamp to maintain the setting illuminance in a given area. The sensors shall meet the relevant requirements of Clause 7.2.4.8.

7.2.9.4.5 The self-ballasted LED lamp up to 60W shall have obtained a Grade 1 Energy Label under the Voluntary Energy Efficiency Labelling Scheme of Electrical and Mechanical Services Department.

SUB-SECTION 7.2.10

DOMESTIC APPLIANCES

7.2.10.1 GENERAL

7.2.10.1.1 Compliance with Regulation

Domestic appliances together with their electric components and cabling shall comply with the currently-in-forced edition of

(a) Electrical Products (Safety) Regulation, (Cap.406G), Laws of Hong Kong;

(b) Code 26A of the Code of Practice for Electricity (Wiring) Regulations; and

(c) IEC 60335-1:2010/AMD2:2016/COR1:2016 Household and similar electrical appliances – Safety – Part 1: General requirements.

7.2.10.1.2 General Requirements

(a) Unless otherwise specified, the domestic appliances shall be manufactured for operation on 220 V ± 10%, 50 Hz ± 2%, single phase, AC supply.

(b) Unless otherwise specified, the domestic appliances shall be suitable in all respects for operation in ambient air condition of temperature range between 0°C and 40°C, and relative humidity range between 0% and 99% with condensation due to temperature changes.

(c) Unless otherwise classified, all accessible metal parts of the domestic appliances that may become live in the event of electric fault shall be effectively and suitably bonded to earth via to a common earthing terminal provided within the domestic appliances.

(d) Twin core cables without earth wire are only allowed for double insulated appliances classified as Class II appliances under the specified IEC or equivalent standards.

(e) Where specified, 3-core flexible cord connected to the domestic appliances shall conform to BS EN50525-2-11:2011. The size of the cable shall not be less than that specified and shall be compatible with the rating of the respective domestic appliance. Twin core cables without earth wire are only allowed for double insulated appliances.

(f) Where specified, 13 A plug connected to the flexible cord shall conform to BS 1363-1:2016+A1:2018. The fuse of the plug shall be of a rating compatible with the rating of the respective domestic appliance.

(g) Unless otherwise specified, domestic appliances and office equipment shall have been registered with the Energy Label Grade 1 under the Mandatory or Voluntary Energy Efficiency Labelling Scheme where applicable, or be of recognition types under the Voluntary Energy Efficiency Labelling Scheme from the Electrical and Mechanical Services Department if relevant schemes are available for the items concerned.

7.2.10.1.3 Technical Literature

The following technical literatures in Chinese and/or English shall be provided, where applicable: -

(a) Certificate of safety compliance;

(b) Product catalogue;

(c) Assembly drawings with dimensions;

(d) Electrical circuit diagram;

(e) Installation, operation and service manuals;

(f) Trouble-shooting guide; and

(g) Spare part list with itemised price.

7.2.10.2 900 MM, 1,200 MM and 1,400 MM CEILING FAN

7.2.10.2.1 General Requirements

(a) The fan shall be fully balanced after assembly to ensure that the fan shall not oscillate/vibrate due to out-of-balance forces or whatsoever during operation.

(b) The fan shall conform to the latest edition of the following standards:

(i) IEC 60879:2019 Comfort fans and regulators for household and similar purposes – Methods for measuring performance; and

(ii) IEC 60335-2-80:2015 Household and similar electrical appliances – Part 2-80: Particular requirements for fans.

7.2.10.2.2 Performance Requirements

(a) The sweep diameter of the fans shall be: -

Size of Fan	Sweep Diameter
900 mm	900 mm ± 5%
1,200 mm	1,200 mm ± 5%
1,400 mm	1,400 mm ± 5%

(b) The air delivery rate of the fans shall be: -

Size of Fan	Air Delivery Rate
900 mm	not less than 2.2 m^3/s
1,200 mm	not less than 4.0 m^3/s
1,400 mm	not less than 4.5 m^3/s

7.2.10.2.3 Construction

(a) Fan unit

(i) Fan motor

The motor shall be a totally enclosed, capacitor run induction motor with internal stator and external squirrel-cage rotor.

The rotor shall be mounted on sealed-for-life grease lubricated ball bearings.

(ii) Fan blades

The fan shall be fitted with two or more well balanced blades so as to be reasonably free from vibration.

The blade assemblies shall consist of blades manufactured from heavy gauge aluminium riveted to steel blade carriers.

The blade carriers shall be manufactured from mild steel plate of not less than 40 mm width at the narrowest point, pressed to shape.

Where the blade carriers are twisted to give the required angle of incidence to the blades, there shall be large radius bends to prevent stress concentrations in the blade carriers.

The blade carriers shall be securely fastened to the frame of the motor by machine screws and spring washers to ensure that there is no possibility of a blade becoming detached during operation.

(b) Connecting piece (capacitor housing)

The plastic terminal block and capacitor shall be mounted in a ferrous metal connecting piece located between the fan and the down-rod assembly. The leads from the stator windings shall be connected to the terminal block. An earthing terminal, consisting of a round head brass screw and washer, shall be provided on the connecting piece. All exposed metal parts of the fan shall be connected to this earthing terminal.

The bottom portion of the connecting piece shall be screwed on the shaft of the motor. The connecting piece shall be tightened on to a shoulder formed on the motor shaft. A 4 mm minimum thickness steel hexagonal lock-nut with lock bracket underneath shall then be fitted and tightened. The connecting piece shall be secured in the fully tightened position by two (2) hardened steel grub screws. These screws shall engage in shallow depressions drilled in the shaft after the connecting piece has been tightened in place to ensure positive locking.

(c) Down-rod assembly

(i) The down-rod assembly shall consist of a steel down-rod complete with shackle and hard rubber roller for suspension of the fan. The down-rod shall be supplied in lengths of 200 mm, 300 mm, 450 mm, 600 mm, 750 mm, 900 mm and 1,200 mm as specified in the Particular Specification.

(ii) Cable of such a length as to suit the down-rod shall be provided. The down-rod shall be manufactured from steel tube to BS EN 10255:2004, having an outside diameter of approximately 21 mm, with minimum wall thickness of not less than 3 mm as specified in Table 2 of BS EN 10255:2004. It shall be accurately threaded at one end and shall be screwed into the top portion of the fan connecting piece (capacitor housing) from which it shall protrude by a minimum of 2 mm. The minimum wall thickness of the threaded portion, measured from the minor diameter of the thread to the internal diameter of the tube, shall be not less than 1.8 mm.

(iii) The down-rod shall be locked in position by two (2) hexagonal steel lock nuts, having a minimum thickness of 6 mm, tightened on to the upper machined surface of the fan connecting piece.

(iv) The down-rod shall also be locked to the fan connecting piece by means of a steel split-pin, of not less than 5 mm diameter, passing through both the fan connecting piece and the down-rod.

(v) The split-pin holes in the fan connecting piece shall be of such diameter that the split-pin is a light push-fit there in. The matching split-pin holes in the down-rod shall be just sufficiently large so that the split-pin shall be a light push-fit, when the hole is in its worst position relative to the threading. All burrs and sharp edges shall be removed from the split-pin holes in both the fan connecting piece and the down-rod.

(vi) The steel suspension shackle shall be welded to the down-rod. Welding shall be of good quality. The rubber roller shall be mounted on an 8 mm diameter steel clevis pin secured by a split-pin.

(vii) The ends of the down-rod shall rounded off and free from burrs. There shall be no sharp edges which could cause damage to the insulation of the wiring.

(viii) Suspension joints and threaded parts:

Joints along the suspension rod must be of double-locking type, i.e. at least two independent positive locking devices must be employed to prevent a joint from loosening itself.

All factory-assembled threaded components which form part of a suspension joint must be bonded with glue as approved by the Supervising Officer.

The maximum clearance between threaded mating parts must not exceed 1% of their mean diameter.

The direction of rotation of the fan shall be such that all screwed joints tend to be tightened when the fan is in operation.

(ix) Two (2) canopies manufactured from plastic or pressed steel sheet and fitted over the upper and lower ends of the down-rod shall be provided. They shall be fixed to the down-rod by grub screws.

(d) Surface finish

The whole fan shall be finished in high quality stove enamel in white or ivory colour.

(e) Speed regulator

A speed regulator shall be supplied with each fan.

The speed regulator shall be of robust construction and built on a flame-retardant moulded plastic or insulated steel base and enclosed by a flame-retardant moulded plastic cover or metal cover. Plastic cover shall be in white or ivory colour to match the fan. Metal cover shall be of stainless steel or metalclad finish.

The speed regulator shall be equipped with at least three (3) speed controls and an "OFF" position.

The rotary switch of the speed regulator shall be manufactured for smooth and easy movement by hand between different speed positions.

For choke type regulator, an earth terminal shall be provided on the base with an earth wire permanently connected to the steel core of the choke unit.

7.2.10.3 400 MM SWEEP AUTO CYCLE/OSCILLATING FAN

7.2.10.3.1 General Requirements

The fan shall be provided with cable entries, conduit opening or glands for permanent connection to fixed wiring. Connection terminal shall be provided and secured by means of screws, nuts or equally effective devices.

The power factor of the fan shall not be less than 0.8.

The fan shall comply with the latest edition of safety standards for household electric fans and regulators as follows: -

(a) IEC 60335-2-80:2015; and

(b) JIS C 9601:2011 issued by Japan Standards Association.

7.2.10.3.2 Performance Requirements

The fan blades shall have a sweep diameter ranging from 385 to 415 mm.

The air delivery rate of the fan shall be not less than 1 m^3/s.

The noise level of the fan at all operating speeds shall not exceed 58 dBA measured at 1 m from the fan.

The fan shall be provided with double oscillating mounting of not less than 360° (i.e. the direction of the axis of the air flow is changed automatically and continuously in more than one plane).

7.2.10.3.3 Construction

The fan shall be manufactured for ceiling-mounted application.

The fan motor shall have sealed-for-life roller bearings or bushes.

The fan shall have adequate mechanical strength and be so constructed as to withstand such rough usage as may be expected in normal use.

The material of the fan shall be fire-resistant and non-flame propagating.

The fan shall be of domestic type with smooth, safe edges and 'easy-to-disassemble' for cleaning.

The fan blades shall be enclosed in a chromed and closely meshed metal guard. The gap of the guard slots shall not be greater than 13 mm.

The fan shall equip with a thermal cut-out device to protect the fan from abnormal operation.

The fan shall include a separate fan regulator which shall comprise of three speed settings and a switching-off function.

The fan shall equip with a control device for adjustment of its angle of oscillation.

The fan shall have shock-proof device for quiet operation.

The fan shall be finished to manufacturer's standard light colour to be approved by the Supervising Officer.

The construction of the fan shall be so manufactured that end-user does not need any tools to assemble/disassemble the fan guard and fan blade for cleaning.

7.2.10.4 400 MM SWEEP WALL FAN

7.2.10.4.1 General Requirements

The fan shall be fitted with a 0.75 mm^2 3-core PVC insulated and sheathed flexible cord of approximately 1.5 m in length; and a suitably fused 13 A plug.

The power factor of the fan shall be not less than 0.8.

The fan shall comply with the latest edition of safety standards for household electric fans and regulators as follows:

(a) IEC 60335-2-80:2015; and

(b) JIS C 9601:2011 issued by Japan Standards Association.

7.2.10.4.2 Performance Requirements

The fan blades of the fan shall have a sweep diameter ranging from 385 to 415 mm.

The air delivery rate of the fan shall not be less than 1 m^3/s.

The noise level of the fan at all operating speeds shall not exceed 58 dBA measured at 1 m from the fan.

7.2.10.4.3 Construction

The fan shall be manufactured for wall-mounted application. Fans converted from desk type fan will NOT be accepted.

The fan motor shall have sealed-for-life roller bearings or bushes.

The fan shall have adequate mechanical strength and be so constructed as to withstand such rough usage as may be expected in normal use.

The material of the fan shall be fire-resistant and non-flame propagating.

The fan shall be of domestic type with smooth, safe edges and 'easy-to-disassemble' for cleaning.

The fan blades shall be enclosed in a chromed and closely meshed metal guard. The gap of the guard slots shall be not greater than 13 mm.

The fan shall equip with a thermal cut-out device to protect the fan from abnormal operation.

The fan shall equip with an integral regulator comprising three speed settings and a switching-off function.

The fan regulator shall be of push-cord type.

The fan shall be provided with oscillating and tilting mechanism for horizontal swing and vertical adjustment respectively.

The fan head shall be capable of being clamped or locked at any desired position within a range of tilting angle.

The tilting mechanism shall be of robust and durable construction. If plastic stand is used, a U-shape sheet steel of suitable thickness shall be inserted into the pivot spring chamber as a reinforcement of supporting strength of the tilting mechanism, otherwise the tilting mechanism shall be approved by the Supervising Officer.

The oscillating mechanism shall have a reinforced and reliable clutch that will slip or disengage the steering-gear of the oscillating mechanism if the

fan meets an obstruction as it swings. The oscillating mechanism shall be easily disengaged when not required.

An oscillation switch for controlling of 'oscillation' and 'not oscillating', must be provided in a hand-touch position and easily accessible by the operator at floor level.

The fan shall be finished to manufacturer's standard light colour approved by the Supervising Officer.

The construction of the fan shall be manufactured that end-user does not need any tools to assemble/disassemble the fan guard and fan blade for cleaning.

7.2.10.5 DOMESTIC EXHAUST FAN

7.2.10.5.1 General Requirements

The construction, and testing of the fan shall be in compliance with the requirements of IEC 60335-2-80:2015.

All electrical components, parts and accessories shall be manufactured conforming to the relevant IEC standards.

The fan shall be fitted with a 0.75 mm^2 3-core PVC insulated and sheathed flexible cord of approximately 2 m in length. 2-core cord is allowed only for double insulated appliances classified as Class II.

The power factor of the fan shall not be less than 0.85.

7.2.10.5.2 Performance Requirements

(a) The fan diameters of the respectively exhaust fans shall be: -

Fan Size (mm)	Fan Diameters (mm)
150	150 ± 5%
230	230 ± 5%
300	300 ± 5%

(b) The exhaust fans shall be capable of providing the following air extraction rate: -

Fan Size (mm)	Air Extraction Rate (m^3/s)
150	0.06
230	0.15
300	0.3

(c) The noise level of the fan during operation shall not exceed 65 dBA measured at 1 m from the fan.

(d) Maximum overall height and width: -

Fan Size (mm)	Maximum Height (mm)	Maximum Width (mm)
150	232	230
230	323	305
300	413	391

7.2.10.5.3 Construction

The exhaust fan shall be of robust construction. The exhaust fan shall be suitable for mounting on windows and partitions which shall have an opening of the following diameter: -

Fan Size (mm)	Diameter of Opening (mm)
150	175 to 185
230	250 to 260
300	315 to 325

The impeller, fan duct, outlet grille and shutter assembly shall be constructed of high quality flame retardant plastic material.

The motor winding shall have Class B insulation and protected by a thermal cut-out. The fan motor shall be totally enclosed in an aluminium alloy casing.

Motor bearings shall be of self-aligning, oil impregnated porous bronze brushes.

The exhaust fan shall comprise an electrically operated back draught shutter assembly.

The inner and outer clamp plate/grille assembly shall have rubber gasket.

The exhaust fan impeller shall be fully balanced to avoid vibration during operation.

The exhaust fan shall be manufactured for easy assembling/dismantling to facilitate servicing and maintenance work.

7.2.10.6 PROPELLER FAN – RING MOUNTED TYPE

7.2.10.6.1 General Requirements

The fan shall be rated for continuous operation under ambient temperature up to 50°C.

The motor shall have Class E insulation to IEC 60085:2007. The power factor of the fan motor shall not be less than 0.85 under any operating condition.

The fan shall be fitted with a 0.75 mm² 3-core PVC insulated and sheathed flexible cord of approximately 2 m in length. 2-core cord is allowed only for double insulated appliances classified as Class II.

7.2.10.6.2 Performance Requirements

(a) The fan diameters of the respectively propeller fans shall be: -

Fan Size (mm)	Fan Diameters (mm)
241	241 ± 5%
305	305 ± 5%
381	381 ± 5%
457	457 ± 5%
610	610 ± 5%

(b) The air flow rate of the propeller fan of respective sizes shall be not less than the following: -

Fan Diameter	Fan Speed	Air Flow Rate	
(mm)	(rpm)	(m³/min)	(cfm)
241	1,300	12	241
305	900	19	305
381	900	39	381
457	900	70	457
610	700	129	4,600

(c) The sound pressure level emitted by the fan shall not exceed 65 dBA measured at 1 m from the fan outlet.

7.2.10.6.3 Construction

The fan impeller shall be mounted on the same shaft as the driving motor and constructed of heavy gauge pressed steel blades fitted to cast aluminium alloy hubs, fully balanced after assembly.

The motor shall be of squirrel cage induction type, with capacitor start and run, and of totally enclosed construction with dust seals.

Ball or roller bearings shall be provided and shall be filled with lithium based grease suitable for operating temperature between -30°C and 120°C.

The fan and motor assembly shall have heavy duty and robust steel mounting arms.

The mounting arms shall be fixed to the mounting ring through a rubber or neoprene resilient cushion to reduce the transmission of vibration to the fixing surface.

The mounting rings shall be constructed of steel pressing and have sufficient flexibility to prevent fracture when fixed to slightly uneven surfaces.

The fan shall be suitable for both vertical and horizontal mounting.

The fan shall be supplied for air discharge away from the motor.

The fan assembly shall be protected with corrosion resistant resin based paints. All bolts and nuts and washers shall be hot dip galvanised. The finishing coat shall be in grey colour unless otherwise specified.

All exposed metal parts shall be effectively bonded together and connected to a common earthing terminal.

If screws and nuts are fitted onto the fan blades for balancing purpose, spring washer shall be provided to avoid loosening. Other securing mechanism such as welding shall be subject to the approval of the Supervising Officer.

7.2.10.7 FUME CUPBOARD EXHAUST FAN

7.2.10.7.1 General Requirements

The equipment shall be of axial flow type composed of durable materials and quiet in operation.

Duct connector, cupboard adaptor, clamp ring, Jubilee clips shall be provided. All of them shall be highly resistant to corrosive gases and chemical fumes emitted during chemical reactions as resulted from laboratory experiments and shall be capable of handling gases and fumes of from 0°C to 40°C.

7.2.10.7.2 Performance Requirements

The fan shall cover the range from 240 to 300 mm in nominal diameter.

The revolution speed of the fan shall be not less than 2,700 rpm.

The air volume flow rate shall be not less than 0.35 m^3/s in static pressure of 100 N/m^2.

The noise level of the fan at all operating speeds shall not exceed 58 dBA measured at 1 m from the fan.

7.2.10.7.3 Construction

(a) Motor

The fan shall be driven by a totally enclosed but externally cooled single phase induction motor to the latest edition of IEC 60034-1:2017.

Insulation shall be not lower than Class E as defined in IEC 60085:2007.

The motor shall be rated for continuous running at ambient temperature of up to 40°C.

The motor shall be protected by a sealing coat of polyurethane compound or equivalent material.

(b) The impellers shall be moulded in phenolic resin or equivalent material.

(c) Circular fan casing shall be made from rigid PVC or galvanised steel coated with epoxy resin or equivalent material. Ends of the casing shall be spigotted for attachment of duct and fume cupboard connectors respectively.

(d) Terminal box

Terminal box shall be made of the same material as the casing and shall be located outside air stream and affixed to the casing.

Terminal box shall be suitable for reception of a 2 m long, 3-core 1.25 mm² flexible cable to BS EN50525-2-11:2011. The cable shall be fitted with the fan. 2-core cord is allowed only for double insulated appliances classified as Class II.

Duct/cupboard connectors and accessories shall be made from corrosion resistant material such as neoprene, epoxy resin or other approved material.

The fan shall be suitable for mounting vertically, horizontally or at an inclined angle. Normally, the duct/cupboard connectors will support the fan when fitted to the duct work. Extra supporting facilities in the form of two extended ribs shall be provided on the casing and shall be drilled for fixing supporting brackets.

7.2.10.8 10-Litre OPEN-OUTLET TYPE, ELECTRIC SINK WATER HEATER

7.2.10.8.1 General Requirements

The hot water capacity shall not be less than 10 litres.

The sink water heater shall be suitable for installing above the water sink.

The sink water heater shall be of wall-mounted type.

The sink water heater shall comply with IEC 60335-2-21:2012+AMD1:2018.

7.2.10.8.2 Performance Requirements

The sink water heater shall be capable of maintaining water temperature in the container between 55°C and 78°C irrespective of the water inlet temperature and ambient air conditions.

The water container shall be suitable for connection to a mains water supply having a pressure of not less than 205 kPa. A pressure test certificate shall be provided for each sink water heater quoting the manufacturer's serial number and confirming that a pressure test to manufacturer's standard or 50 kPa, whichever is greater, has been successfully applied.

The nominal power rating of the sink water heater shall be 3 kW.

7.2.10.8.3 Construction

The sink water heater shall be provided with an adjustable thermostat with ample current rating to maintain water temperature from 55°C to 78°C.

The sink water heater shall be provided with a non-resettable thermal cut-out to protect the water temperature inside the container from exceeding 90°C in order to provide additional safety protection.

Earthing terminal shall be provided.

The inner hot water container shall be suitable for local installation.

The construction material of the inner hot water container shall be chosen by the combined merits on expandability, thermal conductivity, susceptibility to surface fouling, reaction to water acidity and alkalinity on boiler applications, such as tinned copper, or equivalent.

The outer casing shall be drip-proof and constructed from heavy gauge sheet steel properly treated to prevent corrosion or equivalent material.

The outer casing shall be in white colour.

The thermal insulating material shall be of non-combustible and non-CFC type.

A swivel spout at outlet of 300 mm approx. in radius shall be provided.

The sink water heater shall be provided with a permanent warning label in English and Chinese characters as follows: "The outlet from the water heater must not be blocked or connected to any form of fitting with an isolating valve".

The following pipe fittings shall be provided at inlet side:

(a) A water control valve
(b) A non-return valve
(c) A water strainer

7.2.10.9 90-Litre AND 135-Litre THERMAL STORAGE ELECTRIC WATER HEATER

7.2.10.9.1 General Requirements

The water heater shall comply with the relevant requirements of Electrical Products (Safety) Regulation, (Cap.406G), Laws of Hong Kong.

The water heater shall comply with the relevant requirements of Waterworks Ordinance, (Cap.102), Laws of Hong Kong.

The water heater shall comply with Code of Practice for the Electricity (Wiring) Regulations issued by the EMSD.

The water heater shall comply with the relevant requirements of Boilers and Pressure Vessels Ordinance, (Cap.56), Laws of Hong Kong.

The power rating of the product shall range from 2.5 kW to 3 kW.

The water heater shall comply with the latest edition of the following standards:

(a) For unvented thermal storage type electric water heater

IEC 60335-2-21:2012+AMD1:2018 Household and similar electrical appliances – Safety – Part 2-21 : Particular requirements for storage water heaters; and

BS EN 12897:2006 Specification for indirectly heated unvented (closed) storage water heaters;

(b) For thermal cut out

BS EN IEC 60730-2-15:2019 Automatic electrical controls – Part 2-15: Particular requirements for automatic electrical air flow, water flow and water level sensing controls; and

(c) For temperature and pressure relief valve

BS 6283-2:1991 Safety and control devices for use in hot water systems. Specifications for temperature relief valves for pressures from 1 bar to 10 bar.

7.2.10.9.2 Performance Requirements

The hot water cylinder shall be suitable for a working pressure of 10 bar or below. A test certificate shall be provided for each water heater quoting the manufacturer's serial number and confirming that a pressure test to manufacturer's standard or 1.5 times the working pressure, whichever is greater, has been successfully applied.

The water heater shall have obtained a Grade 1 Energy Label under the Voluntary Energy Efficiency Labelling Scheme of Electrical and Mechanical Services Department.

The hot water storage capacity shall be: -

Size of water heater (litres)	Hot Water Storage Capacity (litres)
90	From 90 litres to 100 litres
135	From 135 litres to 155 litres

7.2.10.9.3 Specific Safety Requirements

The safety standard to which the product conforms and the storage capacity in litres (l) shall be clearly and permanently marked on the body of the product in additional to the marking requirements stipulated in the essential safety requirements for electrical products in Electrical Products (Safety) Regulation, (Cap. 406G), Laws of Hong Kong.

Manufacturer's installation instructions including recommendations and warnings to users and installers, etc., shall also be provided and clearly marked.

The construction material of the hot water cylinder shall be corrosion resistance, such as copper, stainless steel or other equivalent material. The cylinder shall be capable of withstanding 1.5 times the working pressure.

The water heater shall be fitted with a thermostat (with a maximum setting temperature of 80°C) to control the heating of the stored water.

The water heater shall be fitted with a thermal cut-out (complying with BS EN 60730-2-15:2019 and with a temperature setting of 85°C) to cut off the supply of electricity if the stored water is heated above the temperature setting of the thermostat and before the operation of the temperature and pressure relief valve is initiated. The thermal cut-out

shall be connected in series with the thermostat and shall be reset manually after dismantling of the enclosure of the product.

The water heater shall be fitted with

EITHER

(a) a non-resettable temperature relief valve (complying with BS 6283-2:1991), having a setting of 90°C, and complete with manual test easing gear; AND a pressure relief valve (complying with BS 6283-2:1991), having a set pressure of not greater than the maximum design pressure of the water heater or 10 bar, and complete with manual test easing gear; or

(b) a non-resettable temperature and pressure relief valve complying with the requirements of BS 6283 2:1991, having a set temperature of 90°C and a set pressure of the water heater or 10 bar, and complete with manual test easing gear.

7.2.10.9.4 Construction

The hot water cylinder shall be suitable for local installation.

The water heater shall be provided with an anti-vacuum valve complying with BS EN 13959:2004 or other relevant Parts to prevent heated water from being siphoned back to supply pipe during water shortage period.

A draining device shall be provided to discharge water and shall be arranged so as to be clear of all the electrical connections and terminals.

The outer casing shall be drip-proof and constructed from heavy gauge sheet steel properly treated to prevent corrosion or equivalent material.

The outer casing shall be in white colour.

The thermal insulating material shall be of non-combustible and non-CFC type.

The water heater shall be suitable for vertical floor or wall mounting. It shall be completed with water inlet and outlet suitable for connection to standard water pipe. The inlet and outlet pipes shall be clearly marked on the product and the British Standard Pipe (BSP) sizes shall be clearly stated in installation instructions.

Material used in the connection to the hot water cylinder shall be of corrosion resistant type, especially on the water side.

The electric terminal box with cover and suitable for fitting with waterproof metallic flexible conduit shall be provided.

7.2.10.10 ELECTRIC TEA URN

7.2.10.10.1 General Requirements

The tea urn shall be suitable for providing boiling water for tea.

The tea urn shall comply with the standard IEC 60335-2-75:2012+AMD1:2015+AMD2:2018.

All electrical components shall comply with the relevant IEC Standards, or of fully equivalent quality and capacity

7.2.10.10.2 Performance Requirements

The capacity of the tea urn shall be 14-20 litres.

The power rating shall range from 2.5 kW to 2.8 kW.

7.2.10.10.3 Construction

The water container of the tea urn shall be constructed from stainless sheet steel or material of equivalent quality.

The tea urn shall be of circular table standing model complete with a full size detachable top cover and two heat-insulated handles.

The tea urn shall be provided with either a simmerstat temperature control or 3 heat rotary switch.

The tea urn shall be provided with a self-resettable thermal cut-out against failure due to boiling dry.

The tea urn shall be provided with rapid draw off tap with heat-insulated handle.

The tea urn shall be fitted with a flexible power supply cable and a suitably fused 13 A plug complying with the Electrical Products (Safety) Regulation, (Cap.406G), Laws of Hong Kong. The minimum length of the flexible cable shall be 1.5 m.

Internal wiring of the tea urn shall be suitable for high temperature operation.

Plastic parts and sealing materials that come into contact with drinking water shall not release bisphenol A.

7.2.10.11 ELECTRIC FACE/HAND DRYER

7.2.10.11.1 General Requirements

The face / hand dryer shall comply with IEC 60335-2-23:2016+AMD1:2019.

The face/hand dryer shall be wall-mounting type.

The face/hand dryer shall be provided with a detachable 1.25 mm² 3-core PVC insulated and sheathed flexible cord of approximately 1 m in length.

Unless other effective precautions are taken to prevent electric shock, the face/hand dryer shall be a double insulated appliances classified as Class II.

7.2.10.11.2 Performance Requirements

The front cover shall withstand a static force of not less than 111 N for 1 minute and an impact of not less than 6.8 J for 1 minute.

The power rating of the heating element, if applied, shall not be less than 2 kW.

The power consumption shall not exceed 12Wh per drying process.

Airborne noise emission from the face/hand dryer, measured as sound power level, shall not exceed 70 dB (A) during operation.

The face/hand dryer shall have an automatically power off function.

7.2.10.11.3 Construction

The front cover shall be manufactured from a fully developing one piece metal or approved high strength plastic.

The thickness of the front cover shall not be less than 3 mm.

The starting method of the dryer shall be any of the following as specified in the Particular Specification:

(a) capacitive touch switch;

(b) insulated metal push button; and

(c) automatic sensing device.

Metallic covers shall be finished with acid resistant porcelain enamel or equivalent.

The front cover shall be firmly secured to the base of the product by recessed Allen head or similar type bolts.

The base shall be secured to the wall by at least three mounting bolts.

The air inlet shall be at the bottom and protected by metal vanes inside.

The air outlet shall be similarly protected by metal vanes inside the nozzle.

The air outlet shall be fixed with downward air discharge for hand dryer, but shall be movable to an upward direction when used as face dryer.

All metal parts shall be made of corrosion resistant materials such as stainless steel or equivalent.

The face/hand dryer shall be suitable for back and side cable entry with an insulated bushing.

The face/hand dryer shall be completed with internal electrical overload protection for the fan motor and thermal cut-out protection for the heater unit.

The face/hand dryer shall be marked with the symbol for drip-proof or splash-proof construction.

Product components (circuit boards, electrical, electronic and plastic components) shall comply with RoHS.

7.2.10.12 WALL CLOCK BATTERY-OPERATED

7.2.10.12.1 General Requirements

The clock shall be accompanied with the necessary battery adequate for operating the clock for at least 1 month.

7.2.10.12.2 Performance Requirements

The clock shall be tropicalised and dust-proof.

The accuracy of timekeeping shall not exceed ±20 sec/month at room temperature (25°C).

7.2.10.12.3 Construction

The clock-face shall either be round or square in shape as specified in the Particular Specification.

For round clock-face clock, the nominal clock-face diameter shall range between 300 mm and 350 mm.

For square clock-face clock, the nominal clock-face side length shall range between 300 mm and 350 mm.

The clock shall be flush mounted on the wall and is to be free of any projections on the rear surface.

The clock dial shall be white with large Arabic Numerals in black and graduated in minutes. Alternative colour shall subject to the approval of the Supervising Officer.

The hour, minute and second full sweep hands shall be of distinct colour.

The clock shall be completed with a clear glass or plastic front cover.

The voltage rating of the battery powering the product shall not exceed 1.5 V.

7.2.10.13 7-Litres AND 9-Litres DEHUMIDIFIER

7.2.10.13.1 General Requirements

The dehumidifier shall comply with IEC 60335-2-40:2018.

The dehumidifier shall be fitted with a 1.25 mm² 3-core PVC insulated and sheathed flexible cord of approximately 2 m in length; and a suitably fused 13 A plug.

7.2.10.13.2 Performance Requirements

The moisture removal capacity, when measured under the operating conditions at 27°C, 60% R.H. shall be as follows: -

Size (litres)	Minimum Moisture Removal Capacity
7	7 litres per 24 hours
9	9 litres per 24 hours

The power factor of the dehumidifier shall be not less than 0.85.

The noise level generated whilst in operation shall not exceed 60 dBA measured at 1.5 m from the product under a background noise level of not exceeding 50 dBA.

The dehumidifier shall have obtained a Grade 1 Energy Label under the Energy Efficiency Labelling Scheme of Electrical and Mechanical Services Department.

7.2.10.13.3 Construction

No “Controlled Refrigerant”, as defined under the Ozone Layer Protection (Controlled Refrigerants) Regulation, (Cap.403B), Laws of Hong Kong, shall be used.

7.2.10.14 ROOM COOLER

7.2.10.14.1 General Requirements

The room air cooler supplied shall conform to the safety standard IEC 60335-2-40:2018, in accordance with Electrical Products (Safety) Regulation, (Cap.406G), Laws of Hong Kong.

The room cooler shall be supplied with appropriate radio interference suppression device to meet the requirements prescribed in Telecommunications (Control of Interference) Regulations of the Telecommunications Ordinance (Cap.106).

The room cooler shall be fitted with a 3-core PVC insulated and sheathed flexible cord of approximately 2 m in length which shall be connected to a connection unit and controlled by a D.P. switch with pilot light. Size of the 3-core flexible cord shall have current carrying capacity not less than that of the circuit breaker protecting the room cooler.

7.2.10.14.2 Performance Requirements

All room coolers shall have a power factor of not less than 0.85 at full load.

All room coolers shall achieve the ratings as stated above.

The capacity of rating shall be proved by the production of printed manufacturer's rating sheets showing also the test condition.

All the ratings quoted shall conform to ISO 5151:2017.

The maximum noise level generated by the room coolers operating at high cool and high fan setting shall be in accordance with the table below. The noise level shall be measured at a distance of 1.5 m from the cool air discharge and at 1.2 m above the ground under a background noise level of less than 50 dBA.

Capacity	Noise Level
Less than 4.4kW	Not exceeding 60 dBA
4.4kW or above	Not exceeding 65 dBA

Room cooler shall be operated with inverter and have obtained a Grade 1 Energy Label under the Energy Efficiency Labelling Scheme of Electrical and Mechanical Services Department.

7.2.10.14.3 Construction

The refrigerant used in the room coolers shall be of non-CFC type and not contain the substances regulated in the Montreal Protocol on Substances that deplete the Ozone Layer (particularly HCFCs, 1,1,1-trichloroethane and carbon tetrachloride).

An adjustable thermostat control shall be provided for each room cooler. The thermostat shall be built into the case of the unit and not fixed on the outside. Only the adjusting knob or dial is to protrude.

7.2.10.15 REFRIGERATOR

7.2.10.15.1 General Requirements

The refrigerator shall comply with the safety standard IEC 60335-2-24:2010/AMD2:2017/ISH1:2018 Household and similar electrical appliances – Safety – Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances, and ice makers.

The refrigerator shall at least comprise two separate compartments, i.e. Fresh Food Storage Compartment and Frozen Food Storage Compartment.

For storage capacity over 270 Litres, the Fresh Food Storage Compartment shall have a chiller compartment (chilled room) with transparent front opening door.

The refrigerator shall be of the 'Frost-free' or 'Automatic defrost' type.

The refrigerator shall be fitted with a 0.75 mm² 3-core PVC insulated and sheathed flexible cord of approximately 2 m in length; and a suitably fused 13 A plug.

7.2.10.15.2 Performance Requirements

The refrigerator shall be completely suitable for operation under sub-tropical climate class. The range of ambient temperatures in which the equipment are intended to be used, and for which the required storage temperatures shall be fulfilled is between 18°C to 38°C. No condensation shall be present on the exterior of the refrigerator at all times.

The Fresh Food Storage Compartment and Frozen Food Storage Compartment shall be equipped with separate temperature control.

(a) Fresh Food Storage Compartment

The refrigeration system shall maintain the temperature between 0°C to 10°C and the mean temperature shall be 5°C within the compartment at all operating conditions.

(b) Frozen Food Storage Compartment

The storage temperature of the Frozen Food Storage Compartment shall be maintained at a temperature not warmer than -18°C at all operating conditions.

The refrigerator shall have obtained a Grade 1 Energy Label under the Energy Efficiency Labelling Scheme of Electrical and Mechanical Services Department.

7.2.10.15.3 Construction

(a) Cabinet

The cabinet shall be of all steel construction for maximum rigidity and robustness to form an assembly sufficiently rigid to prevent distortion during handling, transportation, etc. In addition, concealed adjustable feet shall be fitted to ensure that the cabinet will stand firm on uneven floor. High quality steel panel work treated with a suitable rust preventive primer and anti-corrosion undercoat and finished with white hard finish material giving maximum resistance to abrasion and corrosion.

(b) Doors

The refrigerator shall be fitted with flush-fitting door(s). The door shall be fitted with chromium plated/ matching coloured fasteners and semi-concealed door hinges. The interior of the door shall be complete with bottle racks, cheese and butter storage section.

The construction of the door shall withstand heavy usage and suitably braced or otherwise constructed to prevent distortion in usage.

The plastic door liner must be of uniform thickness (gauge) throughout particularly in relation to all inner radiused corners and be sufficiently rigid to prevent sagging when fully loaded with bottles, etc. The bottle retainer strips shall be robustly constructed and secured.

If the refrigerator is with only one door, the Fresh Food Storage Compartment and the Frozen Food Storage Compartment shall be separated well according to appropriate temperatures.

(c) Insulation Material

No “Controlled Product”, as defined under the Ozone Layer Protection (Products Containing Scheduled Substances) (Import Banning) Regulation, (Cap.403C), Laws of Hong Kong, shall be used as insulation material in the refrigerator.

(d) Internal Lighting

The Fresh Food Storage Compartment of the refrigerators shall be supplied with an interior light of sufficient capacity to illuminate the entire interior. This light complete with air-tight flame retardant lamp guard shall be activated by a door operated switch. The light and switch shall be protected from condensate drip.

(e) Refrigeration Unit

The refrigeration unit shall be hermetically sealed in a steel housing and fitted with an automatic self-resetting motor overload device; and

The refrigeration unit shall be free from radio or TV reception interference or if necessary shall be fitted with an appropriate suppression system as laid down in the Telecommunication (Control of Interference) Regulations, (Cap.106B), Laws of Hong Kong.

(f) Door Gasket

The door gasket shall be robust and manufactured from a rubber base material. It shall contain a fungoid inhibitor to prevent fungoid growth and discolouration. In the case of a magnetic gasket, the magnetic ceramic insert must be full length on all sides so fitted, with absence of gaps at the corners.

(g) Shelves and Internal Fittings

The shelves made of either wire or bar shall be adequately protected against rusting and corrosion and must be sufficiently rigid to prevent distortion under full load conditions. The mesh of the wires shall be closely enough to prevent small based containers from toppling and spilling their contents.

Shelves shall preferably be supported from full height adjustable supports, all must be of ample strength, easily adjustable to prevent the accidental tilting or release, of one end of a shelf and at least 3 shelves shall be provided.

(h) Refrigerant

No “Controlled Refrigerant”, as defined under the Ozone Layer Protection (Controlled Refrigerants) Regulation, (Cap.403B), Laws of Hong Kong, shall be used.

The refrigerant shall not contain the following substances regulated in the Montreal Protocol on Substances that deplete the Ozone Layer (particularly CFCs, HCFCs, 1,1,1-trichloroethane and carbon tetrachloride).

The refrigerants and foaming agents used for the insulation of the appliance shall have a global warming potential equal to or lower than 15 (rated as CO2 equivalents over a period of 100 years).

(i) Labelling

The refrigerator shall bear a label showing serial number, power consumption, voltage, amperes and frequency. The label shall be fixed rigidly at a conspicuous position on the equipment.

7.2.10.16 LED TABLE LAMP

7.2.10.16.1 General Requirements

The LED table lamp shall be the lighting fitting including the driver, lamp source, diffuser, flexible cord and all necessary accessories.

The LED table lamp shall be aesthetically pleasing, contemporary stylish appearance, user friendly, electrically/mechanically sound and appropriate for office environment. It shall be manufactured for use on working desk in offices as task lighting to provide localised lighting.

The LED table lamp shall be free standing type or clamp-mounted type and the LED lamp shall be either integral or built-in LED module or self-ballasted LED lamp as specified in the Particular Specification.

The LED table lamp shall be rated for continuous service at an ambient temperature of 40°C without affecting the performance requirements as stated in this General Specification.

The LED table lamp shall be manufactured in a process conforming to the relevant quality assurance standard ISO 9001:2015.

The LED table lamp shall be fully assembled and tested to required standards before delivery.

7.2.10.16.2 Safety Requirements

The LED table lamp shall comply with IEC 60598-2-4:12017.

The LED table lamp shall be 'Restriction of Hazardous Substances (RoHS)' compliance.

The LED table lamp shall comply with the risk group 'Exempt Group (RG 0)' unlimited of IEC 62471:2006 and IEC/TR 62778:2014.

The LED table lamp shall be suitably protected from electric shock and shall comply with the latest edition of the Guidance Notes for the Electrical Product (Safety) Regulation.

7.2.10.16.3 Performance Requirements

The LED table lamp shall have locally on/off or dimmable on/off switch that is easily reachable by user. For the light output to be dimmable as specified in the Particular Specification, the light output shall be

continuous dimmable or at least 3-step discrete dimmable settings ranging from 40-100% without flickering.

The LED table lamp source shall have suitable cover and/or diffuser built-in for glare control. The LED lamp source shall not be directly visible to the user when it is positioned at 600 mm above desk level.

The LED table lamp shall comply with the following performance requirements:

(a) Luminaire efficacy not lower than 30 lumen/watt including the ballast, thermal and lighting fixture losses.

(b) Colour Rendering Index (CRI) not lower than 80.

(c) For lumen maintenance requirements of the LED table lamp, it shall comply with clause 7.2.9.4.1(b).

(d) The nominal Correlated Colour Temperature (CCT) shall be 4,000K.

(e) Power factor not lower than 0.85 and 0.6 for built-in LED module and self-ballasted LED lamp respectively.

7.2.10.16.4 Electrical Requirements

The LED table lamp, including the electronic driver and LED module, shall be suitable for operation at 220 V±6%, 50 Hz±2% A.C. supply.

Where the offered LED table lamp is to receive extra low voltage D.C. input by using external driver, provision of an electrical switch at convenient position that can readily accessible from the desk chair shall be provided to switch off the luminaire.

The LED table lamp shall have minimum 2 metres of ordinary duty rubber insulated and sheathed flexible cord, 3-core with minimum cross sectional area of 0.75 mm², in conformance with BS 6500 or IEC 60245.

Suitable rated fuse protection shall be provided in the 13 Ampere socket plug to BS 1363-1:2016+A1:2018 which shall be permanently connected to each of the LED table lamp.

The LED driver and the extra low voltage D.C. driver shall comply with the standards as stated in Clause 7.2.9.2.1.

The Light Emitted Diode (LED) module shall comply IEC 62031:2018 LED modules for general lighting – Safety specifications, for the part of "LED modules without integral control gear for operation under constant voltage, constant current or constant power".

7.2.10.16.5 Mechanical Requirements

The LED table lamp shall have adjustable outreach arm for free adjustment of lighting angle by the user such that the LED lamp head can tilt and swivel in two axes to achieve an optimal ergonomic position.

The outreach arm shall have suitable length and flexibility to suit the intended application without obstruction to the user.

The hinges and/or springs for adjustment of outreach arm and/or angle of lamp head shall be robust for frequent adjustment and can hold the lamp head in sturdy position after adjustment.

The materials of the adjustable arm shall be mechanically sound and durable. No sharp edges shall be present.

The LED table lamp shall be self-balanced with the out reaching arm fully extended.

7.2.10.16.6 Testing Standards for Compliance

The relevant requirements as stated in Clause 7.2.10.16.1 to 7.2.10.16.4 of the LED table lamp shall be tested and certified by organisations accredited by HOKLAS or HKAS, or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS. The test reports shall be submitted for approval.

SUB-SECTION 7.2.11

LOW VOLTAGE CUBICLE SWITCHBOARD

7.2.11.1 GENERAL

This Section covers the design, supply and installation of verified power switchgear and controlgear assembly of Low Voltage Cubicle Switchboard (hereafter called the Switchboard).

7.2.11.2 DESIGN REQUIREMENTS

Unless otherwise specified, the scope of work shall include the design of the Switchboard and selection of equipment and components including due consideration of other components of the Electrical and other Installations to ensure that the Switchboard conforms to the specified requirements.

All design works including relevant information, data and calculations shall be submitted to the Supervising Officer for approval.

7.2.11.3 PERFORMANCE REQUIREMENTS

The Switchboard shall comply with IEC 61439-2:2011.

All materials and workmanship shall comply, where applicable, with all relevant IEC, B.S. or EN Standards and all relevant sections of this General Specification.

The Switchboard shall comply with the electromagnetic compatibility requirement of IEC 61439-1:2011 unless the exemption conditions stipulated in Clause J9.4.2 of Annex J of IEC 61439-1:2011 are satisfied.

The Works shall be carried out in a manner consistent with good practice in Hong Kong.

The Switchboard shall be of multi-cubicle type assembled from compartments housing the busbars, switches, etc. as shown on the Drawings, suitable for service conditions detailed in Clause 7.2.11.6 of this General Specification and complying where relevant, with the appropriate Standards and Codes of Practice listed in this General Specification. Where an alternative standard is proposed, the tenderer shall prove by means of adequate supporting documents that the alternative standard meets the requirements of the relevant Standard.

The Switchboard comprising a combination of one or more low-voltage switching devices together with associated control, measuring, signaling, protective, regulating equipment, etc., shall be completely assembled with all the internal electrical and mechanical interconnection and structural parts.

The Total Harmonic Distortion (THD) of incomer at or above 2000A shall be less than 4%.

Wireless temperature sensors shall be provided at the three phase and neutral of the main busbars / cable terminations of the ACB main incomers on both line and load sides and ACB feeders inside the Switchboard for early detection of abnormal temperature rises preventing insulation deterioration and lowering risks of insulation faults. The temperature sensor shall be suitable to operate at temperature range from -25°C to 115°C and have the accuracy of ±1°C. Signals from the sensors shall be monitored on a continuous basis and shall be transmitted to PQM system / iBMS / CCMS.

Dry contacts wired to terminals shall be provided for remote monitoring of incomer status (both healthy and fault), under voltage alarm of power supply and high temperature alarm.

7.2.11.4 CONSTRUCTION AND FINISH

The Switchboard shall be constructed from steel, self supporting, so formed as to give a rigid and robust construction without cross-struts, and shall be structurally, mechanically and electrically sound, with cubicle top, panels and doors of sheet steel or the equivalent metal, not less than 2 mm in thickness.

The Switchboard shall have clear accessibility to all internal components within it. Steel work shall be treated to prevent corrosion before being painted. Steel parts, normally left bright, shall be corrosion resistance plated.

The bottom of the Switchboard shall be closed and made to vermin-proof by means of non-magnetic, fire-proof barrier plates cut away where required to suit the cables as specified. In general, the Switchboard shall be suitable for indoor use to IP31 as specified in IEC 60529:1989/AMD2:2013/COR1:2019. In the event that top entry cabling facilities are required, the top of the Switchboard shall also be constructed in like manner.

Detachable panels at the back of the Switchboard shall each be provided with a pair of handles for easy fixing/removal of the panels.

The Switchboard shall be of uniform height and uniform depth front-to-back, throughout its length and shall present a neat and tidy appearance.

Unless otherwise specified, the internal separation of the Switchboard shall be constructed generally to Form 3b of IEC 61439-2:2011.

The switch/control units in each cubicle shall be arranged to form a multi-tier arrangement.

The compartment for housing the incoming/outgoing terminals for external conductors shall have ample dimensions for accommodating the external conductors, including space for spreading of the cores. Suitable mounting brackets or cable supports shall be provided to prevent the terminals or cables being subjected to stresses which may reduce their normal life or performance.

All switches shall be provided with mechanical interlocks so that their doors, covers, and the like can only be opened when the switches are in the off position and it shall not be possible to close the switches while the doors, covers and the like are opened, except by

overriding the interlock or using a tool. The interlock shall automatically be restored on reclosing the doors, covers and the like.

The exterior of each Switchboard shall be finished to a light grey or the manufacturer's nearest standard colour. The end plates shall be of non-corrosive type and finished to match with the colour of the switchboard whereas the external fixing bolts and set screws shall be of chrome-plated finish or equivalent anti-corrosion treatment.

The "space" provision for future outgoing circuits shall comprise blank panels, undrilled, and provision for accommodating fuseswitches and/or circuit breakers. Busbars shall be extended as necessary and drilled for future connection of conductors. The spaces scheduled or shown on the Drawings are indicative of minimum requirements and may be varied to suit the arrangement offered, subject to approval.

7.2.11.5 ELECTRICITY CHARACTERISTICS OF THE SWITCHBOARD

The electrical characteristics of the Switchboard shall be as follows unless otherwise specified: -

Rated operational voltage	:	380/220 V ± 6%, 3-phase, 4-wire, 50 Hz, ± 2%, AC;
Neutral earthing	:	Solid at transformer;
Rated short-time withstand current	:	50 kA for 1 second withstanding current; and
Power factor	:	Incoming 0.25 lagging.

7.2.11.6 SERVICE CONDITIONS

The service conditions stipulated in Clause 7.2.5.1.2 of this General Specification shall be applicable.

The Switchboard shall only be provided with the built-in natural cooling facilities as furnished in accordance with the recommendations endorsed by the short circuit testing organisation to suit the service conditions specified.

7.2.11.7 BUSBARS, WIRING AND EARTHING

The busbar chamber shall contain triple phase and neutral busbars of equal cross-sectional areas rated as shown on the Drawings or specified elsewhere. The configuration of the busbar assembly contained in the Switchboard shall be the same as shown on the verification test drawings. Any change in the configuration will require separate verification test certificates unless substantiation is approved by the Supervising Officer.

All busbars shall be made of hard drawn high conductivity copper to BS EN 13601:2013 and shall be electro-tinned. Construction, marking and arrangement of the busbars, connections and auxiliary wiring shall be to IEC 61439-1:2011.

External busbars for connection to the Switchboard shall be fully insulated and arranged in such a manner that they will not obstruct access to other equipment.

All neutral conductors shall have cross-sectional areas not less than that of the respective phase conductors. The phase and neutral conductors shall be identified by the colour brown, black, grey and blue respectively.

Whenever a vertical section of the Switchboard contains more than one outgoing circuit, busbar risers or droppers to which the outgoing circuits are connected shall be provided and shall be arranged in such manner that an internal short-circuit is not to be expected under normal operating conditions. The rating of the vertical busbar riser or dropper serving the multi-tier switchgears of a vertical section of a Switchboard shall be not less than the total rated current of all connected outgoing units including spare and space outgoing units or the current rating of the upstream protective device protecting the vertical busbar riser or dropper, whichever is the less.

Insulators and busbar supports shall be non-hygroscopic and non-deteriorating. The use of fibrous materials, linseed oil, varnish, etc. is prohibited.

All auxiliary circuit wiring shall be PVC-insulated with designated conductor temperature of 90ºC to BS 6231:2006. They shall, wherever possible, be grouped and placed together in a neat manner. Different insulant colours shall be provided to distinguish the various circuits at different voltage. All wires shall also have at both ends a coded ferrule of insulating materials permanently marked with suitable characters and codes. Each connection shall terminate at an approved type of terminal block, which shall also be suitably labelled.

Cable for auxiliary circuits shall be run inside cable compartments or special cable ways designed to provide adequate protection against mechanical damage. They shall also be bunched neatly and be identifiable throughout their length of run.

Wiring from the fixed part of the Switchboard to the movable part, such as hinged door, shall be enclosed by a flexible PVC tubing. If apparatus with a voltage exceeding the limits of extra-low voltage are attached to lid, door, etc., the continuity of the protective circuits shall be ensured in accordance with Clause 8.4.3.2.2 of IEC 61439-1:2011.

Connectors or soldered joints are not permitted in the auxiliary circuit wiring.

Exposed live terminals shall be suitably shrouded or covered.

A continuous tinned copper earthing bar of adequate rating as per IEC 61439-1:2011 shall be fixed at the rear interior, bottom portion throughout the length of the switchboard, bonding the framework of all modular sections. An earthing terminal shall be provided at the external portion of the Switchboard suitable for the connection of 25 x 3 mm copper tape. The position of the earthing terminal shall be subject to the approval of the Supervising Officer.

Where busbar trunkings are installed within switchroom for interconnections among LV cubicle switchboards and incoming mains connection of power supply company, the construction of busbar trunking shall comply with IEC 61439-2:2011 as a part of LV cubicle switchboard assembly. Each run of such busbar trunking shall be restricted to not more than 20m length and shall not be installed outside switchroom.

7.2.11.8 CIRCUIT BREAKERS, FUSESWITCHES AND CHANGEOVER SWITCHES

Unless otherwise specified, circuit breakers (including ACB, MCCB), fuseswitches (including switchfuses), and changeover switches shall comply with the requirements stipulated in Sub-section 7.2.5 of this General Specification. The MCCB shall be withdrawal or plug-in type if its rating is 100A 3-phase or above.

Circuit breakers shall have the breaking capacity to withstand the prospective fault level at the switchboard.

For all ACB and MCCB with rating over 400A, dry contacts wired to terminals shall be provided for remote monitoring of status (including but not limited to Open, Closed, Tripped, etc).

7.2.11.9 METERING, PROTECTIVE RELAYS AND INDICATING LAMPS

Metering facilities shall be provided for incoming and outgoing circuits. Unless otherwise specified, Digital Power Analyser complying with Clause 7.2.5.24 of this General Specification shall be used for main incoming circuits and Digital Multifunction Power Meter complying with Clause 7.2.5.20 of this General Specification shall be used for outgoing circuits. Supply healthy indicating lamps shall be provided at every main incoming circuit breaker or switch.

Wiring from the measuring devices shall be brought out and be terminated in approved type of rail-mounted termination/feed through blocks housed inside separate compartments accessible from the front. Test plugs shall also be provided at each termination points to measure the voltages and/or currents flowing in that particular measuring circuit by external testing instruments.

Instruments, meters and relays shall be of the flush mounted pattern, with bezels black finished, positioned on the front of the Switchboard. All terminals shall be suitably insulated and potential circuits shall be suitably fused, using H.R.C. fuses.

Separate current transformers (CT) in compliance with IEC 61869-2:2012 shall be used for measuring and protection applications. Current transformers shall have accuracy Class of "3" or better for use with ammeters, "1" or better for use with Watt-hour meters and "10P" or better for protection applications. The product of rated accuracy limit factor and rated output of the protection CT shall not be less than 10 times the total rated burden of the trip circuit including the relays, connection leads and overcurrent release where applicable.

Current transformers shall be mounted without reduction of area of busbars or connections and be arranged for easy removal.

Protective relays shall be to IEC 60255-1:2009 and of the type as shown on the Drawings or as specified. Where a protective relay consists of multi-elements, suitable labels shall be provided to indicate the phases to which the corresponding elements are connected.

Indicating lights shall be LED type of diameter minimum 22mm operating at 6V A.C./D.C. through a built-in transformer. The service life of indicating light shall be at least 100,000 hours at rated voltage and 25°C.

All air circuit breakers other than those used for controlling the incoming supply and unless specified, shall have overcurrent tripping facilities to give time delay overload current protection and instantaneous short circuit interruption. The time-current characteristics shall be submitted for inspection. Shunt trip coils operated by power supply from the mains shall not be used.

For air circuit breakers controlling the incoming supply to the Switchboard, the circuit protection shall be provided by the following devices: -

(a) Digital Protection Relay complying with Clause 7.2.5.23 of this General Specification; or

This relay shall have triple elements with current setting ranging from 50% to 200% in 25% tappings and with time setting from 0 to 1.3 seconds in variable steps. The relay shall be of draw-out-case type flush mounted on the front panel. The characteristic of the relay shall match with that of the Supply Company;

(b) Electromechanical Type I.D.M.T. Overcurrent Protection Relay and Earth Fault Relay:

Overcurrent protection relay shall have triple elements with current setting ranging from 50% to 200% in 25% tappings and with time setting from 0 to 1.3 seconds in variable steps. The relay shall be of draw-out-case type flush mounted on the front panel. The characteristic of the relay shall match with that of the Supply Company.

Earth fault relay shall be one single pole earth fault relay with current setting from 10% to 40% in 5% tappings and with time setting from 0 to 1.3 seconds. The relay shall be of draw-out-case type, flush mounted on the front panel. The characteristic of the relay shall match with that of the Supply Company.

Shunt-Trip Release of air circuit breakers shall be operated by a D.C. supply of 24 V or 30 V (other voltages may be specified to suit particular project subject to the approval of the Supervising Officer) obtained from the secondary batteries complete with battery charger, etc. of suitable rating.

7.2.11.10 SUPPLY COMPANY METERING

Provision shall be made, where specified and/or shown on the Drawings, for the accommodation of the Supply Company's metering equipment upon the Switchboard. The metering equipment will be supplied and mounted by the Supply Company on Site. The metering compartment shall be complete with a hinged glazed door for meter viewing.

The accommodation for the Supply Company's metering equipment shall include a suitable insulating panel for mounting the meters and suitable fuses to protect the voltage coil circuits to each meter. The "mains" side of the fuseholders shall be wired to the incoming supply mains. Fuses shall be of the H.R.C. type rated at 16 A, with provision for sealing to prevent unauthorised removal.

The Switchboard shall also be provided with suitable provisions of C.T. Chambers for mounting the Supply Company's current transformers (C.T.s) in accessible positions.

Wiring between the current transformers and the meters will be carried out by the Supply Company on Site, but adequate and appropriate cabling facilities for installing the said wiring shall be provided in the Switchboard.

7.2.11.11 LABELS

Laminated self-coloured material labels of ample sizes shall be provided for each of the units both at the front and in the cabling compartment on the Switchboard, engraved in English and Chinese characters. A means of fixing these labels shall be provided other than by adhesives.

During the progress of manufacture of the Switchboard, a schedule of labels shall be submitted for approval before engraving is carried out.

Warning labels shall be affixed to the rear panels and shall be coloured red with white lettering in both English and Chinese characters denoting 'DANGER- LIVE BUSBARS INSIDE/ 危險 – 內有帶電匯流排'.

Similar warning labels shall be affixed at the front and in the cabling compartment for each automatic/remote closing or changeover switching denoting Beware-automatic closing/注意 – 自動接合 in English and Chinese characters.

In addition to automatic screening shutters and barriers, warning labels shall also be provided for all live parts, such as test terminal blocks.

The Switchboard shall be provided with one or more plates, marked in a durable manner and located at a conspicuous place such that they are visible and legible when the Switchboard is installed. The following information shall be given on the nameplates: -

(a) The manufacturer's name;

(b) Type designation or identification number or other means of identification making it possible to obtain relevant information from the manufacturer;

(c) IEC 61439-2:2011;

(d) Rated current;

(e) Rated operation voltage (and frequency in case of AC);

(f) Rated insulation voltage;

(g) Short-circuit withstand strength;

(h) Degree of protection; and

(i) Rating of main busbars.

7.2.11.12 CABLE ARRANGEMENTS

The Switchboard shall be provided with all necessary cable lugs, etc., fixed in positions on mounting plates and straps, to suit the types and directions of entry of the cables as shown on the Drawings or as specified.

Cable conductors for all circuits within the Switchboard shall be arranged in a tidy manner and mechanically secured at regular intervals such that any movement occurring to the conductors, either under normal operation conditions (e.g. thermal expansion, vibration, etc.) or due to short circuit in any one of the circuits, shall not cause any damage or short circuit to any healthy bare live parts in the Switchboard.

7.2.11.13 AUTOMATIC INTERLOCKING FACILITY

When automatic interlocking facility is specified or shown on the Drawings, the configuration shall be that it is safe, reliable and well proven. Unless otherwise approved by the Supervising Officer, the mechanical part of the automatic interlocking facility shall be of rod-type to ensure a safe and reliable interlocking system. For locally assembly switchboard containing automatic interlocking facility, the interlocking configuration shall be endorsed by the respective licenser.

7.2.11.14 ANCILLARY EQUIPMENT

The Switchboard shall be supplied complete with one hydraulic operated handling truck in the main switchroom suitable for handling all sizes of air circuit breakers on the Switchboard, and one set of portable earthing equipment for each main incoming air circuit breaker. Portable earthing leads will not be accepted as an alternative to the earthing equipment.

The battery charger/battery sets shall comply with the requirements of Clause 7.2.5.21 of this General Specification unless otherwise specified below. The battery charger and batteries shall be housed in separate enclosures from the Switchboard and shall be the same type of enclosures as the Switchboard. All secondary batteries to be supplied with the Switchboard shall be of the nickel-metal-hydride type, sealed or ventilated, requiring

little or no maintenance and having long life. The capacity of the batteries, with charger disconnected, shall be adequate to trip the associated air circuit breaker(s) consecutively at least 20 times. In case there are more than one air circuit breakers being tripped by the same bank of batteries, the batteries shall be capable of tripping at least two air circuit breakers simultaneously.

Site tests shall be carried out for the charger and battery set after completion of the installations and the connection of the permanent supply according to the manufacturer's instruction in the presence of the Supervising Officer's inspectorate staff and in accordance with relevant Sections of this General Specification.

The Switchboard shall be supplied complete with all operating handles, jigs, etc. required for the normal charging, closing, opening, racking in and out operations of all circuit breakers of the Switchboard and shall be properly fixed in a neat manner on a wooden board with brass hooks inside the main switch room where the Switchboard is installed.

The Switchboard shall be provided with two rubber mats of ribbed surface, complying with IEC 61111:2009, laid in front of and at the rear of the Switchboard. The rubber mats shall be continuous sheets of minimum thickness of 10 mm, each of same length as the Switchboard and minimum width of not less than 1,000 mm or the width of the space between the front or back of the Switchboard to the adjacent wall.

7.2.11.15 Certification and Verification Test

Verification testing of typical Switchboard to IEC 61439-2:2011 shall be carried out by a competent and independent short circuit testing organisation internationally recognised as having equal standing as The Association of Short Circuit Testing Authorities (ASTA). The verification report issued by the testing organisation shall be submitted to the Supervising Officer for record. Appropriate technical information and litreature in English and copies of the verification test certificates and drawings must be made available for examination.

Temperature rise limits test of typical Switchboard shall be verified to IEC 61439-1:2011.

The whole busbars, including the conductors connecting the busbars to each outgoing circuit, shall be arranged to withstand short-circuit at any point. All conductors between the main busbars/droppers and the outgoing protective devices not short-circuit type tested to a fault current of 50 kA for 1 second at 0.25 lagging power factor shall be insulated by approved means to comply with the requirement that 'an internal short-circuit between phases and/or between phases and earth is only a remote possibility' as stipulated in IEC 61439-1:2011.

If modifications are made to a verified Switchboard, clause 10 of IEC 61439-1: 2011 shall be used to check if these modifications will affect the performance of the Switchboard. New verifications shall be carried out if an adverse effect is likely to occur and the method of 'verification testing' shall be used. The following certification bodies shall be considered eligible to be third party design checker for assessment and verification of switchboard design employing design calculation approach as allowed in IEC 61439-2:2011: -

(a) Certification bodies recognised by the Director of Electrical and Mechanical Services as Recognised Certification Bodies for testing of Low Voltage switchgear and control gear assemblies;

(b) A competent and independent short circuit testing organisation internationally recognised as having equal status as The Association of Short Circuit Testing Authorities (ASTA); or

(c) Local academia specialising in electrical engineering work.

A functional unit (ACB, MCCB, switchfuse, fuseswitch and changeover switch) in the verified Switchboard may be substituted with a similar unit of the same manufacturer used in the original verification provided the following conditions are satisfied and subject to the approval of the Supervising Officer:-

(i) Power loss and terminal temperature rise of the functional unit when tested in accordance with its product standard, is the same or lower;

(ii) The physical arrangement within the Switchboard shall be maintained;

(iii) The rating of the Switchboard shall be maintained; and

(iv) In addition to the temperature rise limits test, other requirements as listed in Annex D of IEC 61439-1:2011 including the short-circuit requirements shall be taken into consideration.

7.2.11.16 OPERATION INSTRUCTION/DRAWING AT THE MAIN SWITCH ROOM

For each Switchboard a schematic wiring diagram contained in a framed, transparent perspex at a conspicuous position adjacent to the Switchboard shall be provided. In case that the Switchboard has more than one incoming air circuit breakers with interlocking facility, a brief operation instruction listing out all the relevant switching steps and interlocks for commissioning/decommissioning of part or whole of the Switchboard shall also be provided in a similar manner to the schematic diagram.

SUB-SECTION 7.2.12

DIESEL GENERATING SET INSTALLATION

7.2.12.1 REQUIREMENTS OF DIESEL GENERATING SETS

7.2.12.1.1 Generating Set Rating

Each diesel generating set shall be of 3 phase, 4 wire output and rated at 50 Hertz, 380 V, 0.8 power factor lagging.

Each generating set shall comply with ISO 8528-5:2018 and shall be of Prime Power (PRP) rating for the transient and the steady state power requirements of the connected essential loads. Offers based on standby rating will not be considered. The actual rating of each generating set shall be clearly indicated on the name plate fixed on the generating set.

The electrical efficiency of each generating set shall be over 85%.

7.2.12.1.2 General Requirements of Diesel Engine

(a) The engine shall be a fresh water-cooled, four stroke, direct injection, naturally aspirated or pressure charged, diesel engine of an industrial type complying with the requirements of all parts of ISO 8528-5:2018 and continuously rated to meet the load requirements under site conditions at a crank shaft speed not exceeding 1500 rpm, and suitable for running on "Ultra Low Sulphur Diesel" (ULSD) fuel to BS EN 590:2013+A1:2017.

(b) The engine shall be complete with the following equipment: -

(i) Engine mounted instrument panel, incorporating lubrication oil pressure gauge, lubrication oil temperature gauge, cooling water outlet temperature gauge, tachometer and hour-meter. The tachometer shall sense the actual engine speed. Frequency sensing type is not acceptable. Ammeter indicating the charging rate of the engine driven dynamo shall also be provided. A digital type metering panel that can provide the same function is also acceptable;

(ii) Protective screens for flywheel, and coupling, if exposed, and other exposed moving parts;

(iii) Engine cooling system incorporating engine driven water circulating pump, thermostatically controlled water temperature regulating device, and engine driven tropicalised radiator with mechanically driven fan;

(iv) The air cleaner of the dry type or 'oil bath' type incorporating replaceable element;

(v) Lubricating oil system (full flow, replaceable element type filter);

(vi) Fuel oil system comprising filter, fuel transfer pump, injection pump and injectors;

(vii) Governor shall permit with manual adjustment of +5% of normal speed. The governing accuracy shall comply with performance Class G3 in ISO 8528-2:2018 " Types of speed governor used for generating sets". Governor shall sense the actual engine rotation. Governor for sensing the frequency of generator output voltage is not acceptable;

(viii) Fuel control solenoid (electrically operated) together with an emergency fuel shut off valve (manually operated);

(ix) Two-stage engine protective devices for high cooling water temperature and low lubricating oil pressure shall be provided. Engine over-speed protective device shall also be provided. The engine over-speed sensor shall sense the actual engine rotating speed and shall be free from harmonic interference;

(x) All wiring of the control and protection systems, carried out in suitable heat and oil resisting cable, shall be wired out to an appropriate cable termination block; and

(xi) Earth terminal for bonding the engine and alternator to the earthing system.

(c) In accordance with ISO 8528-5:2018, the additional engine power of 10% of the rated power of the generating set shall be provided for governing purpose only (e.g. transient load conditions and suddenly applied loads).

(d) The difference in height between the generator set and the daily service tank shall not exceed the maximum value recommended by the generator set manufacturer.

The equipment and accessories to be installed and the details of the fuel oil supply system shall be subject to the approval of the Supervising Officer.

(e) If an underground fuel oil storage-tank is installed, the associated piping, fittings and accessories shall be installed as required to complete the fuel oil system of the generator set. The underground fuel oil storage tank shall be complete with float control and other necessary accessories. A solenoid control valve energised by the starting circuit shall be installed in the fuel oil pipe from the daily service tank to the storage tank.

7.2.12.1.3 General Requirements of Alternator

(a) The alternator shall be of self-exciting, self-regulating and brushless type, complete with permanent magnet exciter and shall comply with the requirements of ISO 8528-3:2020.

(b) The voltage regulation of the alternator apart from satisfying the requirements of the electrical loads as specified in terms of steady state and transient conditions shall be of three phase sensing type.

The steady state and transient behaviour shall comply with performance Class G3 in ISO 8528-5:2018 The maximum percentage of voltage dip shall not exceed 20% of the rated value under all loading conditions including step load application. In case that electronic equipment and computers form a substantial amount of supply loads, the maximum voltage dip shall not exceed 10%.

(c) The machine shall be constructed with the type of enclosure to IP21 as specified in IEC 60529:1989/AMD2:2013/COR1:2019. Anti-condensation heating elements bounded to the winding enclosure of the alternator and suitable for connection to the mains electricity supply (220 V) shall be fitted to the alternator. The anti-condensation heaters shall be thermostatically controlled and arranged to cut off when the alternator is in operation. Heater element directed fixed to the winding is not acceptable. They shall be easily accessible for maintenance and replacement.

(d) A termination box shall be provided suitable for accommodating and terminating cables or busbar trunking entering from the bottom, sides or top. If busbar trunking is used for power-feeder between the alternator and switchboard, the special provision shall be made to prevent the vibration of the diesel generating set affecting the tightness of the terminations. Due to site condition, cable termination may only be made at a particular side of the alternator.

(e) The rating assigned to the alternator by the manufacturer shall be of maximum continuous rating.

(f) The alternator shall be provided with winding insulation of class H, but it shall be manufactured to operate continuously at temperature class F rating in accordance with IEC 60085:2007.

7.2.12.1.4 Starting System

An electrical battery starting system for each diesel generating set with a set of 12 or 24 V D.C. electric starting equipment comprising starter motor, battery charger, starting battery and all necessary wiring and switchgear shall be provided. The battery shall be nickel-cadmium type, with clear plastic cases complete with a hardwood floor stand with

hardwood cover suitable for installation adjacent to the starter motor. The battery shall be rated to give six engine cranking cycles each of six seconds within a 60 second period. The battery shall provide adequate power to supply the control circuit and to trip the main MCCB/ACB. Separate batteries shall be provided for engine starting and the shunt trip coil if their operating voltages are different. The connection bars of the batteries shall be protected with corrosion resistant petroleum jelly. A suitable double pole switch shall be provided to isolate the supply from the battery to the engine starter unit.

The battery charger shall be of 2 rate charging and of constant voltage type installed in the control cubicle, and arranged to maintain the batteries fully charged. In addition, when the engine is running, the batteries shall be charged by an engine-driven dynamo controlled by an AVR and cut out.

The battery charger shall be charged up to 75% battery capacity specified in the previous paragraph in 6 hours. Current limiting device shall be provided to limit the charging current with the limit recommended by the battery manufacturer.

7.2.12.1.5 Electrical Loads

The electrical loads to be connected to the diesel generating set will be of continuous duty-type. Motor loads will be designated as S1 in accordance with IEC 60034-1:2017.

Thyristor controlled lifts and other thyristor loadings such as uninterrupted power supply (UPS), variable voltage variable frequency speed controller (VVVF) etc. shall be connected to the generators. High current harmonics are generated by these thyristor loading which could have adverse effects on the diesel generating sets on voltage distortion, system instability, overheating of buffer windings, etc. The generator configuration shall take necessary precautions (including the provision of engine overspeed sensing device free from harmonic interference, etc.) to guard against the occurrence of the above adverse effects caused by the harmonics.

In addition, the generator sets shall be able to tolerate a reasonable amount of regenerative power from lift. The generator set shall be suitably sized to cater for the possible regenerative power. Appropriate dummy loads and associated accessories shall be provided, if necessary, to absorb the excessive regenerative power.

7.2.12.1.6 Suitability for Cold Starting and Step Load Acceptance

The generating set shall be suitable for cold starting and acceptance of step loads immediately after attaining normal voltage and frequency.

7.2.12.1.7 Radio Interference Suppression

The alternator shall be fully equipped for radio interference suppression to BS EN55011:2016.

7.2.12.1.8 Painting

All exposed ferrous metal surfaces of the machines, under-frame and auxiliary equipment shall, where applicable, be treated with rust-inhibiting primer paint, undercoat and finishing coat. Hot face parts shall be coated with heat-resisting paintwork, which can tolerate high temperatures up to 650°C without deterioration.

7.2.12.1.9 Base-frame Assembly

The generating set shall comprise a diesel engine directly coupled to an alternator and mounted in line on a steel section base-frame. This diesel alternator base-frame shall be provided with anti-vibration mountings complete with holding down adequate strength bolts and nuts for installation onto a concrete plinth. The complete assembly shall be equipped with four lifting eyes to facilitate lifting and transporting.

Grouting shall not be carried out until the final agreement from the Supervising Officer. Grout shall be composed of equal parts of cement and fine granular sand mixed with fresh water.

7.2.12.1.10 Welding

All welding shall be carried out only by welders of the recognised proficiency. The welding electrodes, equipment and process shall also be in accordance with BS EN 1011-2:2001 or other relevant International standards for arc welding or oxy-fuel gas welding.

Welding shall not be carried out under unfavourable conditions. All welded surfaces shall be clean and dry before any welding is to be done.

7.2.12.1.11 Structural Steel

Structural steel used shall comply with BS 7668:2016 Grade S355J0WH or BS EN 10025-5:2019 Grade S355J0WP. All forms of steel used shall be of the standard section with dimensions, tolerances and properties complying with BS EN 10635:2017 or ISO 630-1:2021. Supplier(s) of structural steel work shall provide certificates of the material.

All exposed edges shall be ground to produce a chamfer not less than 2 mm in width to ensure proper adherence of paint.

7.2.12.2 CONSTRUCTION OF CONTROL CUBICLE

7.2.12.2.1 The control cubicle shall be of totally enclosed type and meet the requirements of IP44 as specified in IEC 60529:1989 /AMD2:2013/COR1:2019 enclosures. The cubicle shall be painted against corrosion after completion of all drilling and operation.

7.2.12.2.2 All control cubicles shall have labels made from laminated self-coloured materials and engraved with descriptions in both English and Chinese to be agreed by Supervising Officer's Representative. Fixing of labels shall be by mechanical means.

7.2.12.2.3 The contactors, switch fuses, relays and all other necessary items shall be housed in the appropriate control panel which shall be arranged with front access for maintenance. It shall also be lockable to prevent unauthorised access and malicious damage to the equipment inside.

7.2.12.2.4 Each relay shall be labelled appropriately to its service either by function or by code, in which case a code index shall be securely attached to the panel for easy and positive identification.

7.2.12.2.5 A control cubicle shall be installed for each diesel generating set.

7.2.12.2.6 All circuits shall be accommodated in accordance with IEC 61439-1:-2020.

7.2.12.2.7 The cubicle shall be equipped with an anti-condensation heater which shall be thermostatically controlled.

7.2.12.2.8 The cubicle shall have adequate space mountings for cable terminal box or boxes suitable for armoured cables or busbar entering and leaving both at the top and the bottom of the control cubicle, for connection of mains feeders.

7.2.12.2.9 Terminal blocks and provision for conduit termination shall be provided for small outgoing wiring. All small wiring shall be appropriately ferruled and coded for identification.

7.2.12.2.10 The cubicle shall be so partitioned to allow maintenance of the panel in a safe manner without interrupting the power supply from the mains to the external loads.

7.2.12.2.11 The cubicle shall be constructed to Form 3b of IEC 61439-2:2020.

7.2.12.2.12 The cubicle shall be provided with two rubber mats of ribbed surface, complying with IEC 61111:2009, laid in front of and at the rear of the cubicle. The rubber mats shall be continuous sheets of minimum thickness of 10mm, each of the same length as the cubicle and minimum width of not less than 1,000mm or the space width between the front or back of the cubicle to the adjacent wall.

7.2.12.3 OPERATION REQUIREMENT

7.2.12.3.1 Automatic Operation

Unless otherwise specified, the generating set shall be arranged for automatic start, automatic full load transfer and automatic stop. All automatic operations shall be provided with manual override facilities.

The operation sequence shall be as follows: -

(a) Failure of one or more phases of the mains supply, or a reduction in voltage to less than 80% normal, shall initiate a timing device adjustable in the range of 0 to 5 seconds. If the failure persists at the expiry of this pre-set time delay, the engine start sequence shall be initiated.

(b) On receipt of the start signal the set shall run up to speed and accept the essential loads automatically as soon as possible and within a maximum period of 12 seconds. The automatic load transfer shall be by means of the change-over switch or remote opening/closing of ACB at the main L.V. switchboard.

(c) On restoring the mains supply, the set will continue to run and supply essential loads for an adjustable period of 0 to 10 minutes. Thereafter automatic transfer of essential load to mains supply shall take place as soon as the adjusted period expires.

(d) At the end of the adjustable period in (c) the set shall continue to run on no load for an adjustable period of 0-15 minutes.

(e) If the mains power fails again for a duration exceeding 0.5 second during the adjustable period specified in (c), the control timer setting of the adjustable period (0-10 minutes) shall be cancelled and when the mains power is restored again, the operating sequence will start again from (c).

(f) If the mains fail again during the adjustable period specified in (d) the essential loads will be connected immediately and automatically back to the set, and the operating sequence shall continue as if the connection had been made in the manner as described in (b).

(g) In the event of failure of the engine to start the set shall, after a pre-determined time delay, make a second attempt to start. A third attempt may be initiated after another pre-determined time delay. Eventually, if it fails to start, the starting circuits shall be lock-out, and a visible and audible alarm shall be given which shall remain until reset.

(h) Both electrical and mechanical interlocking devices shall be provided to prevent starting engagement when the engine is in motion.

(i) In the event of an electrical failure such as over-current, or short circuits, or earth fault during the operation of the generator set, the ACB/MCCB connecting the generating set and the L.V. Switchboard shall be tripped, the engine shall be shut down and both visual and audible warning signal shall be given.

(j) Provision shall be made for manual control of the set for testing purposes, including one "auto-off-manual" selector switch, "start" and "stop" push-buttons, and a "simulate mains failure" key switch.

(k) Restoration of normal mains supply during the starting period shall not interrupt the starting sequence but shall prevent the load transfer to the alternator. Therefore the operating sequence will follow the mode as described in (d).

(l) As the ACB is used for the protection/ isolation of the generator, an ACB lifting truck shall be provided.

7.2.12.3.2 Protection

Protective devices are required to guard against mechanical and electrical failure and any continuous running may result in severe damage to the generating set. In the event of a fault the devices shall shut down the engine and initiate both audible and visible alarms. The audible alarm shall be cancelled by an acknowledge push button. The setting for each of the systems being monitored shall be specified by the engine manufacturer.

Following are the general requirements for the protection of the generating set.

(a) Protection of Engine

Suitable protection against engine over-speed, coolant temperature and low oil pressure shall be provided.

(b) Protection of Alternator

Suitable protection against electrical short circuit, overload, earth fault of the stator and rotor windings, over/under-voltage and over/under-frequency, loss of excitation, under-speed and rotation failure of the alternator shall be provided.

7.2.12.4 CONTROL REQUIREMENT

7.2.12.4.1 Instruments and functions for control cubicle shall include: -

(a) Separate meters or a power analyser/digital meters to serve this purpose able to select to display the following operational figures.

- Voltage (V) or by a separate voltmeter and selector switch and fuse 0-500 V range.
- Current (A) or by a separate ammeter, current transformers and selector switch.
- Frequency (Hz) or by a frequency meter in 45 to 55 Hz range.
- Wattmeter
- Hour-meter.

(b) 4 Poles withdrawable air circuit breaker or 4 Poles MCCB complete with D.C. shunt trip facility and protection against overload and short circuit and earth fault utilising over-current and earth fault protection relay.

(c) 3-phase mains voltage sensing unit.

(d) Auto/off/manual selector switch.

(e) "Start", "Stop" push buttons for manual operation.

(f) "Simulate main failure" key switch.

(g) Diesel generating set anti-condensation element "On-off" switch.

(h) Automatic 2-rate battery charging equipment complete with voltmeter and charging rate ammeter.

(i) Automatic voltage regulation unit and excitation controls.

(j) "Engine Fault" automatic shut-down indication lamps, alarm, and reset buttons (same reset function provided at controller display is also acceptable).

(k) "Failure to start" indicating lamp, alarm and reset button (same reset function provided at controller display is also acceptable).

(l) "Diesel generating set Supply Available" indication lamp.

(m) "Mains Available" indication lamp.

(n) "Diesel generating set on Load" indication lamp.

(o) "Mains on Load" indication lamp.

(p) Diesel generating set output under-voltage and over-voltage protection device. The devices shall monitor the three phase supply and with an adjustable range.

(q) Lamp test push button.

(r) Any other function controls to meet the requirements of "Clause 3: Operation Requirements".

(s) Cable terminal box or boxes suitable for armoured cables or busbar trunking entering from the bottom or top of the control cubicle as appropriate for each site, for connection of mains cables.

(t) Clean contacts or communication/network ports shall be provided in the Control Cubicle for the following alarms/indications to enable them to be connected for remote indications: -

	Alarms/Indications	Location
(i)	Generator on load	Fire control main panel
(ii)	Generator fails to start	- ditto -
(iii)	Auto/off/manual selector switch in manual position	- ditto -
(iv)	Generator Engine Fault	- ditto -
(v)	Generator running	- ditto -
(vi)	Essential Power Supply ON/OFF	Lift Machine Room
(vii)	Essential Power Supply NORMAL/TRIP	- ditto -

(u) The fuel oil tank shall be fitted with two stages fuel capacity limiting control to alert building management and shut down non-FSI essential services when the remaining fuel capacity falls to 7 hours and 6.5 hours continuous running of the emergency generator respectively.

(v) Contacts shall be provided for controlling each generator room air supply and exhaust fans, remote radiator fans, cooling water booster pump etc. which shall be ON automatically when the diesel generating set is started. All indication lamps shall be operated at a voltage not greater than 50 V.

7.2.12.4.2 Digital Control System and Remote Monitoring

The emergency generator shall be completed with a digital control system, which shall possess self-diagnostic and event reporting functions to detect and report failure.

The emergency generator shall be provided with the remote monitor to allow monitoring of its status and operating conditions at remote mode. The remote monitoring signals shall be compatible with BACnet or other suitable communication protocol for connecting to the Building Management System (BMS), Integrated Building Management System (iBMS) or Central Control & Monitoring System (CCMS).

All necessary contactors, relays, micro switches, transducers, measuring & sensing devices, transformers, signal and control cables, conduits and other essential accessories to facilitate the monitoring by the BMS, iBMS or CCMS shall be provided. These provisions shall include termination works at dedicated terminal strips in individual control panels of equipment for connection to an interfacing panel in the Emergency Generator room of the Building.

Interfacing panel shall be stainless steel with a front lockable hinged door.

The following parameters of the diesel generating sets system shall be repeated and retrieved in the BMS or CCMS for remote monitoring and recording. Parameters, not limited to those with *, shall be retrieved in iBMS for remote monitoring.

- *Diesel engine status (on/off/fault)
- Over-speed
- Over-crane
- Fault shutdown
- Emergency stop
- System D.C. volts
- Engine rpm
- *Engine running hours
- *Running amps/ output current
- *Generator ac volts (Output Voltage)
- *Generator ac amps (Running Amps/Output Current)
- Generator frequency
- *High engine temperature
- Engine oil pressure
- Coolant temperature
- High coolant temperature
- *Low coolant level
- *Battery low voltage alarm
- *Battery charger fault
- *Lubrication oil temperature
- Low oil pressure
- Fuel oil pump fault
- *Oil tank low level alarms

7.2.12.5 INSTALLATION OF DIESEL GENERATING SETS

7.2.12.5.1 Position

Particular attention shall be paid to the construction dimensions and location of the air intake/outlet louvres. It shall ensure that the capacity of the radiator fan is sufficient for the air requirements of the generator set. The air discharge restriction of the radiator fan and the air intake restriction of the generator set shall be selected with appropriate noise attenuators.

The diesel generating sets shall be properly erected and aligned onto the concrete plinth and the vibration generated by the set shall be isolated from the generator room.

7.2.12.5.2 Guards and Insulations

All moving parts, bare exhaust manifolds, pipes and pressure charger (if any) shall be properly and completely guarded and or insulated in accordance with the relevant regulations. The guards shall be configured to against the serviceman from coming into contact with any part which is likely to cause injury to personnel. All guards shall be detachable.

7.2.12.5.3 Air-ducts

An exhaust air duct from the radiator to the louvres mounted in the wall shall be of 1 mm galvanised M.S. sheet and shall be properly supported near the radiator end. It shall then be connected to the radiator flanges through a flexible joint to isolate the vibrations generated by the diesel generating set. An inspection panel shall be provided for the ease of future maintenance.

7.2.12.5.4 Engine Exhaust System

The engine exhaust system shall comprise silencer, bellows, hangers, piping, clamps, flange couplings, heat resisting jointing. All installation works shall be carried out to suit actual site requirements.

The silencer shall be capable of attenuating the noise generated from the exhaust air to a level to cope with the Environment Protection Department’s requirement.

The complete exhaust from the exhaust manifold to the end of the exhaust pipe including the silencers, flexible joint and pressure charger (if any) shall be coated with heat-resisting paint, lagged with non-combustible insulating material and enclosed with aluminium cladding. Asbestos shall not be used for insulation. The exposed portion of the exhaust pipe outside the generator room shall be of stainless steel, grade 316.

The exhaust system shall not create a back-pressure exceeding the amount recommended by the engine manufacturer, and shall be sufficiently flexibly installed to allow for reasonable expansion and contraction.

The engine exhaust pipe hangers shall incorporate an anti-vibration spring mechanism.

A suitable water draining device shall be provided for the exhaust system so that no fluid shall enter the diesel generating set through the exhaust outlet.

The installation of the exhaust outlet shall comply with all requirements of the Environmental Protection Department. The exhaust outlet shall not be within 5 metres from any place accessible by the public, or any openable window or fresh air intake on the emitting or nearby building, not under any canopy or balcony. It must be at least 5 metres above ground level.

An air purifier e.g. catalytic converter shall be installed along the exhaust pipe as an additional mitigation measures where the emission from exhaust outlet may pose foreseeable pollution to the nearby sensitive receptors as required by the Environmental Protection Department. Adequate clearance is provided around the purifier to allow for maintenance access.

7.2.12.5.5 Electrical Works

Independent earthing system shall be provided for each neutral connection and earthing of the diesel generating set. The installation of diesel generating set shall be solidly and effectively earthed in accordance with the Code of Practice for the Electricity (Wiring) Regulations.

An earth fault protection relay and the necessary accessories shall be provided to complete the earth protection system.

Joints in copper earth bar shall be brazed together using pan head riveted and sweated.

When the plant is subject to vibration, or where circumstances necessitate, the earthing connections shall be made of flexible copper conductor having PVC sheath.

The exposed conductive part of all equipment shall be earthed into a separate earthing terminal.

Sufficient of clean contacts shall be provided in the control cubicle for each Air Circuit Breaker of the L.V. Main switchboard for the remote open/close operation of the respective Air Circuit Breaker.

The control cubicle shall have clean contacts and related transducers for indications of alarms and status at the Central Control and Monitoring System (CCMS).

7.2.12.6 ENGINE COOLING SYSTEM USING REMOTE RADIATOR

7.2.12.6.1 General

If remote radiator cooling is required, the following specification in this section shall be complied with.

7.2.12.6.2 Remote Radiators

The remote radiator shall be suitable for outdoor installation with ample capacity to comply with the cooling requirement of the diesel engine. The radiator shall be a forced draft type with the cooling core and fans.

The core shall be encased in a galvanised steel frame and covered with a removal guard of zinc plated or galvanised steel wire. The core shall be bolted to a heavy gauge galvanised steel structure that supports it at all points. The core shall withstand wind loads to 45 metre/sec for outdoor installation only. Core shall consist of the non-ferrous cooling coil tube mechanically expanded into brass alloy plate fins for a permanent bond. Vents and drains shall be provided in the core.

The fan shall be of the propeller type with aluminium blades. The fan motor shall be of the totally enclosed type, class B insulated. A zinc plated, close mesh steel wire fan guard shall be provided. Weatherproof push-lock turn reset emergency stop switch shall be provided to stop the fan in case of emergency.

The overall sound pressure level of radiator shall not exceed the value specified by the Environmental Protection Department.

7.2.12.6.3 Heat Exchangers

Heat exchanger shall be of the horizontal shell and tube pattern with the coolant from the engine flowing inside the tubes which shall be straight.

The shell shall consist of either a seamless steel or brass pipe or a fusion welded steel cylinder with the necessary parts and flange welded in place.

The tubes may be externally finned or grooved to increase exchange surface and shall be expanded into grooved holes in the tube plates and the ends belled. Welding of the tubes to the tube plate shall not be accepted.

The tubes shall be made of either copper or brass. The tube plates and supports shall be made of stainless steel.

7.2.12.6.4 Water Circulating Pumps

Two water circulating pumps (one duty and one standby) shall be provided for each diesel generating set. The two pumps shall work automatically and alternatively as duty and standby or controlled manually by a selector switch on the control panel.

The pump shall be centrifugal-type and direct driven through a flexible coupling by an electric motor fixed on a standard bed plate.

The pumps shall be constructed to meet the following requirement: -

Pump casing	:	Cast Iron;
Impeller	:	Leaded Gunmetal;
Shaft	:	Stainless Steel Grade 316;
Bearing	:	Ball or Ball and Roller;
Seals	:	Mechanical; and
Bolt and Nuts	:	Stainless Steel.

The pump motor shall be Class B insulation suitable for 380 V 50 Hz 3 phase supply. The speed of the motor shall not exceed 1,500 rpm.

7.2.12.6.5 Expansion Tank

An expansion tank of suitably capacity for each water circulating system with ballcock, valve, overflow, drain and all necessary accessories shall meet the local regulations and operational requirements.

The tank shall be fabricated from mild steel plates of 3 mm thickness welded onto a mild steel frame. The mild steel flat bars are to be intermittently welded on the inside of the tank to stiffen the tank.

All steel work, mild steel angle stand including the surfaces of the tank shall be painted with one coat of best quality primer and two coats of best quality paint. The colour of the tank shall be approved by the Supervising Officer or his Representative.

7.2.12.6.6 Pipework and Valve

All pipework shall be R250 copper pipe to BS EN 1057:2006/A1:2010. The jointing method for pipe size 65 mm and above shall be of the flanged brazing or bronze welded type.

All pipes shall be adequately pitched and supported with strong hangers, brackets and saddles. The support system shall be configured to consider the size of the pipelines, their content and construction materials, the vibration isolation components, the amount and direction of movement, the location of the pipeline in relation to the building fabric, other services, and the need for access. Adequate provision shall be provided for free expansion and contraction of the pipeline.

Gate valves shall be flanged cast iron body with bronze trim, cast iron wedge, bronze rising stem. Globe valves shall be flanged cast iron body, renewable bronze disc and seat, outside screw and bronze rising stem.

Disconnecting flanges shall be installed at valves and at suitable locations to clean and remove piping. Where pipes pass through walls or slabs, pipe sleeves shall be provided.

Pipes and valves shall be painted in colours with directional arrow indication.

7.2.12.6.7 Hydraulic Test

Water systems and circuits shall be hydraulically tested.

Test pressure for water circuits and components shall be 2 times working pressure, or 1.5 working pressure plus 3.5 bar, whichever is lower.

7.2.12.6.8 Power Supply and Control System

Power supply to the remote radiator and the pump shall be fed from the control cubicle. All cables shall be PVC insulated to IEC 60189-2:2007 and run in steel conduits or PVC armoured cable as appropriate.

Control panel housing fuseswitch, the starter and control circuit for the remote radiator and the water pump shall be provided. They shall be automatically started and stopped in line with the operation of the diesel generating set.

7.2.12.7 FUEL SUPPLY SYSTEM.

7.2.12.7.1 Underground Horizontal Fuel Storage Tank

(a) Construction

The construction of the underground fuel storage tank shall comply with BS EN 12285-1:2018 or other technically equivalent national or international standards.

All joints in the tank shell and dished ends shall comply with BS EN 1011-1:2009 and BS EN ISO 2560:2020.

Tank shells shall be made of rings. Each ring shall be formed from a single plate, or not more than two plates welded together, rolled into a true circle. No longitudinal weld in any ring shall lie within the bottom half of the tank circumference in accordance with BS EN 12285-1:2018 or other technically equivalent national or international standards. Cross seams are not allowed. Longitudinal seam welds in adjoining rings of the plate shall be staggered from one another by a minimum of 5 times tank wall thickness but not less than 25mm. Joints or seams shall not be placed in the positions of the cradles. All openings in the tank shall be located clear of the welding seams.

An end plate made of two smaller plates is acceptable. The welded joint between them shall be horizontal and above the centre of the tank end.

The inside surfaces of the tank shall be smooth and free from any obstruction apart from essential pipe connections. No internal bracing or gusset plates will be permitted inside the tanks.

Tank-hole covers and all flanges and pads associated with each manhole cover shall be provided and complete with bolts, washers and joint rings as shown on the Drawings.

The pressure gauge employed for the test shall be tested and calibrated by the organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognized by HOKLAS or HKAS before use. A pressure gauge with full-scale deflection readings more than 3 times the test pressure shall not be used.

Immediately after the hydraulic test of the tank, the tank shall be drained and dried out. A thick coat of linseed oil shall be applied on the interior surfaces of the tank to prevent rusting.

(b) Protection of Tank

All parts of the exterior surfaces of the tank shall be thoroughly cleaned by mechanical means to remove all rust, mill scale, grease and other foreign matters to achieve a bright, rust free and dry surface. The painting procedures shall comply with ISO 12944-5:2019.

(c) Calibration

The tank shall be calibrated after being installed in the tank chamber by dipstick. The measuring device shall be calibrated.

The dipstick shall be made from a 20 mm diameter brass pipe. When the tank has been calibrated, the dipstick shall be marked on all faces by clearly scribed lines of 100 litres intervals for the tanks up to 10,000 litres in capacity, and of 250 litres interval for those above 10,000 litres, and have the volume in figures stamped on two opposite faces at interval of 1,000 litres.

After calibration, the tank shall be thoroughly dried out and applied with a thick coat of linseed oil on the interior surface to prevent rusting.

The results of calibration shall be tabulated and submitted for record purposes.

7.2.12.7.2 Daily Service Fuel Tank

(a) Construction of the Daily Service Fuel Tank

The daily service tank shall be fabricated from mild steel plates welded onto a mild steel frame. The mild steel flat bars shall be intermittently welded on the inside of the tank to stiffen the tank.

(b) Accessories of Daily Service Fuel Tank

The tank shall be fitted with the following standard accessories:

(i) A tapped filling socket connection on top of the tank and be completed with all the necessary fittings and union coupling for connection to the filling pipe.

(ii) A tapped overflow socket connection close to the top and on the side of the tank and be completed with all the necessary fittings and union coupling for connection to the overflow pipe or plugged with a brass screw cap if it is not used.

(iii) A tapped outlet socket connection close to the bottom and on the side of strainers and be completed with union coupling for connection to the delivery pipe strainer.

(iv) A tapped drain socket connection at the bottom of the tank shall be complete with all the necessary fittings, including the 20 mm gate valve.

(v) A tapped return socket connection on the top of tank and be completed with all the necessary fittings and union coupling for the connection to the return pipe or plugged with a brass screw cap if it is not used.

(vi) A tapped vent socket connection on the top of tank and completed with all the necessary fittings and union coupling for the connection to the vent pipe.

(vii) One quick closing valve shall be installed on the delivery pipe and completed with all necessary linkage for operation outside the building. If steel wire linkage and pulleys are used, the wire shall be adjusted appropriately in length and protected; and the pulleys securely anchored.

(viii) The tank shall be fitted with an approved content gauge unit. Provide an accurate measuring device for the calibration of the content gauge and a supporting stand which shall be fabricated from angle iron complete with the strut and tie members as may be deemed necessary. They shall be configured in such a way that it will be possible to remove the tank without first lifting it. A mild steel oil drip tray welded to the angle bracket or stand shall also be included. The exact height of the frame shall be determined to suit site requirements.

(c) Painting of the Daily Service Fuel Tank

All parts of the exterior surfaces of the tank shall be thoroughly cleaned by mechanical means to remove all rust, mill scale, grease and other foreign matters to achieve a bright, rust-free and dry surface and then painted with one coat of zinc-rich primer, one coat of epoxy-based under coat and two finishing coats of approved paint.

The interior surface of the tank shall be thoroughly dried out and applied with a thick coat of linseed oil to prevent rusting.

7.2.12.7.3 Fuel Transfer Pumping System

(a) Electrical Fuel Transfer Pumps

Rotary fuel transfer pumps complete with all necessary accessories including filters, strainers, check valves, gate valves etc. shall be provided.

The pumps shall be positive displacement type, with a high-quality cast iron body, high tensile steel shafts and a built-in internal relief valve.

Each pump shall be capable of delivering 'ultra-low Sulphur' diesel fuel oil at 300 kPa 950 rpm maximum with capacity. A manual switch shall be provided for each pair of pumps to select the pump running mode as "duty" or "standby" respectively.

The coupling motor shall be flameproof 3 phase, 50 Hz, 380 V with no volt release and overload protection. It shall have an auto-off-manual switch with connections for remote start/stop operation by the level switch at the daily service tank. The duty pump shall be actuated when the fuel level in the daily service tank fall below 30% of the tank capacity, cut off automatically when the tank is 90% full. The pumps shall also be inoperative when the fuel level in the underground storage tank falls below a pre-set level.

Audible alarm shall be given off under the following conditions: -

(i) underground storage tank fuel level low; and

(ii) pump fail to start.

A composite pump control cubicle in the pump room incorporating the starters, safety and protection devices, all necessary wiring work, relays, fuel level control and alarm, push button and indication lights shall be provided. The cubicle shall be of the wall-mounted type, type of protection EEx d flameproof enclosures for operation in Zone 1 hazardous area as classified EIMCSP and IP66 enclosure to IEC 60529:1989/AMD2:2013/COR1:2019. The drawings and the official certificate issued by BASEEFA (British Approvals Services for Electrical Equipment in Flame Atmosphere) of the cubicle shall be submitted.

(b) Control Equipment

The following controls and indicator lights shall be incorporated into the control cubicle:

(i) A suitably rated main supply door-interlocked isolator with "Supply On" indicator light;

(ii) An "Automatic/Off/Manual" selector switch;

(iii) Push button manual "Start/Stop" of each of the pump set, and the corresponding indicator lights;

(iv) Indicator lights showing "pump running";

(v) Selector switch to select duty pump;

(vi) Clean contacts for connection to CCMS for the status monitoring of the pumps;

(vii) Engraved labels in both English and Chinese for all control operations shall be incorporated on the composite control cubicle; and

(viii) Indicator lights showing the remaining fuel capacity falls to 7 hours and 6.5 hours continuous running of the emergency generator, respectively.

(c) Hand Pump

A semi-rotary double acting hand pump shall be provided for each daily service tank and consist of a 25 mm diameter inlet and outlet and a 25 mm diameter flexible oil resistant inlet pipe of adequate length to suit site condition.

7.2.12.7.4 Pipeworks and Fittings

(a) General

Supply and install all necessary fittings and pipework as required by the emergency generating plants and as generally shown on the Drawings. However exact dimension of piping shall be determined on site and any modification of the pipe route indicated on Drawings requires prior approval from the Supervising Officer.

All pipes up to 80 mm diameter shall confirm with ISO 65:1981 and/or BS EN ISO 10380:2012 heavy quality and pipes 80 mm diameter and above with BS 1600:1999 or other technically equivalent national or international standards.

Flanges shall be slip-on-welding type in accordance with ISO 7005-1:2011 Class 150. Screwed fittings shall be made of malleable iron and threads shall comply with ISO 7-1:1994/Corr 1:2007.

All screwed joints shall be cleaned, threaded and pulled up tightly. All jointing materials shall be diesel resistant. Gaskets made of rubber or compressed asbestos fibre shall not be used.

Particular care shall be taken to ensure that all pipes and fittings are carefully reamed to ensure that the full bore of the pipe is maintained and where necessary, cleaned out before erection.

Square elbows shall not be used, where practicable, long sweep bends shall be used in preference to round elbows.

Valves shall be of 'fully way' type to allow free flow of fuel. A sample valve shall be submitted to the Supervising Officer for approval before installation. Valves shall be made of bronze.

Round piping supports and anchors as necessary to be suitably placed to the instruction of the Supervising Officer, to provide rigidity to reduce stresses due to unstable ground.

Jointing materials shall be diesel resistant.

A return diesel pipe shall also be provided from the generator back to the daily service tank.

(b) Protection of Buried Pipe

The procedures for the protection of the buried pipes shall be as follows: -

(i) Clean the outer surface of the pipe to remove all rust, mill scale, grease and other foreign matters to achieve a rust free and dry surface;

(ii) Apply one layer of petrolatum compound primer paste or approved equivalent as a primer to give a thin continuous coating over the area to be protected;

(iii) Apply petrolatum compound tape or approved equivalent spiral on the pipe with a minimum 55% overlap. Care shall be taken to ensure the tape is in contact with the underlying surface of the pipe and to smooth out any wrinkles or air pockets; and

(iv) Apply bitumen fabric-reinforced tape or approved equivalent on the pipe with a minimum 55% overlap as an outer wrap.

(c) Painting of Pipework

Other than the buried pipes, all pipework shall be painted with one coat of zinc-rich primer before installation and painted immediately after installation with one coat of epoxy-based undercoat and two finishing coats of best quality paint.

7.2.12.7.5 Diesel Fuel Level Switches

(a) General

The level switches shall be manufactured to: -

(i) IEC 60079-0:2017 Explosive Atmospheres; and

(ii) The Energy Institute Model Code of Safe Practice (Electrical) (EIMCSP).

(b) Classification

The level switch shall be of Group IIA and Temperature Class T1 in accordance with IEC 60079-0:2017.

The electrical components of the level switch installed in the vapour space above the fuel and inside the fuel tank(s) shall be of the type of protection of EEx ia which is suitable for installation in Zone 0 Hazardous Area as classified in EIMCSP.

The electrical components of the level switch installed outside of the fuel tank shall be of the type of protection of: -

- EEx ib; or

- EEx d; or

- EEx p which are all suitable for installation in Zone 1 Hazardous Area as classified in EIMCSP.

(c) Performance Requirements

Unless otherwise stated, the level switch (in general accompanied by a controller) shall be capable of controlling the On/Off operation of a remote system when a preset level of the diesel fuel in the storage tank is reached. Details of the procedure and the exact control level settings shall be as stated in the Specification. The level switch shall be suitable for on-site calibration of the level settings.

Sufficient level settings are required for fuel capacity limiting control to alert building management and shut down non-FSI essential services when the remaining fuel capacity falls to 7 hours and 6.5 hours continuous running of the emergency generator respectively.

(d) General Construction

The level switch shall consist of two major components - a level sensor and a switch unit, both of which shall meet the classification as specified in (b) above. Where applicable, the level switch shall be accompanied with a controller to perform the function as stated in (c) above.

The level sensing element shall be installed in a tube of stainless steel and placed inside the fuel storage tank. It shall be mounted horizontally or vertically depending on the principle of operation.

The switch unit shall be mounted on the tank with the level sensor to form an integral set. The unit shall be housed inside a cast iron or aluminium alloy casing. It shall be capable of detecting the signal from the sensor and transmitting it (in general through a controller) to control the on/off operation of a remote system.

(e) Certification

A copy of the certificate to prove the apparatus rating shall be submitted. Certificate issued by authorities other than BASEEFA (British Approvals Services for Electrical Equipment in Flame Atmosphere) shall be furnished with details of the relevant standard.

(f) Technical Information

A full descriptive technical brochure giving details of the equipment offered, including construction, dimensions, method of installation etc. shall be submitted.

7.2.12.8. ACOUSTIC TREATMENT INSTALLATION

7.2.12.8.1 Performance Requirements

The acoustic treatment package shall ensure that when the generator set is running under full load. The generated noise shall comply with the "Noise from Places other than Domestic Premises, Public Places or Construction Sites" under the Noise Control Ordinance.

For testing and commissioning purposes, the proposed points at which measurements have to be carried out according to the method set out in the "Technical Memorandum for The Assessment Of Noise From Places Other Than Domestic Premises, Public Places or Construction Sites".

7.2.12.8.2 Scope of work

The scope of work shall include but not limit to the followings: -

(a) Pipework acoustic sleeving;

(b) Duct Silencer for all air passage including air inlet louvre, air discharge outlet louvres, ventilation fan and coupled radiator;

(c) Mufflers/silencer for the engine exhaust air system including exhaust flues;

(d) Acoustic wall and ceiling lining inside Generator Room;

(e) Acoustic enclosures including silencer and acoustic lining for the remote radiator, if required;

(f) Other acoustic treatments required; and

(g) Measurement of Noise level at the specified point.

7.2.12.8.3 Installation of the Acoustic Treatment System

(a) Pipework Acoustic Sleeving

Wherever necessary to maintain acoustic integrity of the system acoustic seal sleeving to all pipes penetrating the building structure shall be provided.

Pipework sleeves shall consist of an inner pipe lined with mineral wool and clamping end plates with neoprene seals. Pipe in situ

shall be fitted with split clamping rings. Pipe temperatures above 115 ºC shall have silicon fibre seals.

Pipes shall be resiliently supported on either side of the penetration by resilient hangers.

Seals shall comply with FSD requirements wherever appropriate.

(b) Duct Silencers for All Air Passage

The duct silencers shall consist of an outer casing fabricated from galvanised steel sheet not less than 1.6 mm thick and splitters made from 0.8 mm perforated galvanised steel sheets which divide the silencer into separate longitudinal airways. Sound shall be attenuated by the sound absorptive fill in the splitter as air passes through those airways.

The sound absorbent material shall be non-combustible inorganic glassfibre or mineral wool, or other approved and equivalent material and shall have a glass fibre mat facing. The material shall be fitted in the splitters with at least 10% compactness. The material shall also be non-hygroscopic, resistant to attack by moulds and insects. The material shall be supported so that it does not require shakedown but remains intact during the life of the plant. Bird screen made of galvanised wire mesh shall be provided with all intake silencers.

The acoustic fill shall be suitable for continuous exposure up to 260°C with the galvanised steel sheet having a temperature limit of 400°C. A polyester membrane line up the silencer to prevent dust and/or water ingress into the sound absorbent fill. The absorbent fill in the splitters shall be firmly secured as to be free from erosion for channel velocity up to 30 m/s.

The shape of the splitters shall be configured for maximum possible sound attenuation with the minimum possible resistance to air flow. The maximum allowance pressure drop is 50 Pa. The minimum sound insertion loss (dB) of the silencer, tested in accordance with or other technically equivalent national or international standards, shall be as follows:

Octave Band Centre Frequency (Hz)

Frequency (Hz)	63	125	250	500	1 k	2 k	4 k
Minimum Insertion Loss (dB)	8	18	24	40	45	46	41

The silencer shall have fully welded seams or duct sealer to ensure air tightness. All weld affected parts shall be touched up with zinc-rich paint. All exposed ferrous parts, including the frame, shall be protected from corrosion by applying rust-inhibiting

primer paint, an undercoat and a finishing coat of colour as determined by the Supervising Officer on Site. All such primer and paint shall be resistant to heat up to the working temperature of 260°C.

(c) Mufflers for Engine Exhaust

Exhaust gas muffler (or mufflers) of low noise level type shall be provided for each engine such that the noise level standard/ requirement can be achieved.

In case that the above standard cannot be achieved with the installation of exhaust gas mufflers, acoustic enclosure shall be provided to attenuate the noise before the hot exhaust air is discharged. The acoustic enclosure shall withstand the hot engine exhaust air which may be up to 650°C.

(d) Acoustic Wall/Ceiling Lining Inside Generator Room

Acoustic treatment to the generator room walls, doors and ceiling wherever else necessary to reduce the room reverberant noise level and time is required.

Acoustic wall/ceiling lining shall be fabricated from sound absorptive material firmly held in position by G.I. channels and protected by perforated galvanised sheet steel.

The material shall be in the form of the high density rigid section fibreglass or rock-wood slabs or other similar approved material having a minimum thickness of 50 mm and a density around 48 kg/m^3. The acoustic fills shall be of Class 1 or 2 rate of surface flame spread as laid down in BS 476-7:1997 or other technically equivalent national or international standards.

The minimum random incidence absorption coefficient of the material when fixed as specified shall be as follows: -

Frequency (Hz)	125	250	500	1,000	2,000
Absorption Coefficient	0.26	0.78	1.11	1.10	1.04

Material shall be selected of suitable random incidence absorption coefficient to suit the site condition and equipment offered.

A polyester membrane shall be lined between the glass fibre and perforated sheet for better protection against dust and water.

The fixing GI channels shall be 25 x 50 x 1.0 mm thick and shall be fixed by fastener onto the wall surfaces at an interval of 600 mm approximately.

The protective perforated steel sheet shall be fabricated from a galvanised sheet of not less than 0.8 mm thick and secured by self-tapping screws to the G.I. channels. The holes shall be 2.4 mm diameter with 4.8 mm centre to centre distance. The perforated metal sheet shall be removable to enable future maintenance.

The acoustic lining shall not pack down or settle after installation. All metal surfaces shall be undercoated and finished with two coats of white gloss paint.

Samples and recognised test certificates for the absorption material shall be submitted to the Supervising Officer for approval.

(e) Acoustic Enclosure for Remote Radiators

Acoustic treatment to the remote radiator shall be provided to achieve the performance specified which includes the remote radiators with opening for air intake and discharge. Duct silencer shall be installed for every air passage. The sound-absorptive material for the duct silence shall withstand the high temperature generated from the remote radiator.

The whole acoustic enclosure shall facilitate easy access to the remote radiator for maintenance.

7.2.12.9 EXHAUST FAN FOR EMERGENCY GENERATOR ROOM

Ventilation of the generator room shall be achieved by an axial flow exhaust fan with air duct silencer and other accessories. The air flow capacity of the fan shall have a minimum value of 10 air change/hour.

The axial fan, duct work and silencer of the ventilation system shall comply with all relevant sections of this General Specification.

7.2.12.10 LIFTING HOIST

One manual lifting hoist complete with a trolley shall be supplied and installed for each diesel generating set. The hoist shall be chain driven for maintenance and relocation purposes.

The load chain shall be of malleable quality, electrically welded, pitched, and calibrated steel complying with ISO 1834:1999, ISO 1835:2018, ISO 3075:1980, ISO 3076:2012, ISO 3077:2001 and proof tested to twice the safe working load specified for the hoist and trolley.

The hooks shall comply fully with BS EN 1677-5:2001/A1:2008 or other technically equivalent national or international standards. They shall be able to rotate upon ball or roller bearings for ease of swivelling, and provided with a catch to prevent displacement of wire rope from the hook.

All moving parts of the hoist and trolley shall be greased or oiled after installation. Ball or roller bearings shall be packed with appropriate grease.

Standard I-beam completed with end stopper shall be provided and ensure that the construction of the stoppers of the I-beams is suitable to stop the trolley motion outside the operating range.

A qualified surveyor to carry out the formal test under load conditions is required. The hoist with trolley shall be tested to a proof load of at least 125% of the safe working load on site. Original surveyor certificate and copy of completed forms for Labour Department shall be submitted.

7.2.12.11 WARNING SIGN

A warning sign of reasonable size stating "Attention - Engine starts automatically without warning. Do not come close." in lettering not less than 10 mm high with Chinese translation (注意: 發動機會隨時啓動) shall be provided and fixed at a prominent position in the generator room.

The warning sign board shall be made from laminated self-coloured materials and engraved with the description as mentioned in the previous paragraph.

7.2.12.12 SCHEMATIC DIAGRAMS

The electrical and control schematic diagrams for the diesel generating set shall be fixed in a wooden frame with a transparent pane of a suitable size. These schematic diagrams shall be placed at a prominent position in the generator room.

7.2.12.13 SUBMISSION TO THE AUTHORITIES

All necessary information for the submission to the Authorities for the Diesel Generator Installation for the compliance of various Statutory Regulations, including but not limited to the Fire 'Service Regulations, the Dangerous Goods Regulations, and the Air Pollution Control Regulations shall be provided. The information shall include drawings, equipment catalogues, data sheets, calculations and other information as required by the relevant Authorities.

SUB-SECTION 7.2.13

HIGH VOLTAGE SWITCHGEAR AND EQUIPMENT

7.2.13.1 HIGH VOLTAGE - GENERAL

This section covers the design, manufacture, testing and delivery of high voltage induction motors and associated switchgear of rated voltages 3.3 kV, 6.6 kV or 11 kV.

Unless otherwise specified by the Electricity Supply Company, the following system fault level shall be assumed:

Table 7.2.13.1 System Fault Level

Nominal system voltage	3.3 kV	6.6 kV	11 kV
Maximum symmetrical fault level	150 MVA	225 MVA	380 MVA

All the high voltage electrical installation work shall be carried out by a Registered Electrical Contractor and Worker for Grade H electrical work as required by the Electricity Ordinance (Cap.406). After the completion of the electrical installation works, it shall be inspected, tested and certified by a Registered Electrical Worker to confirm that the requirements of the Code of Practice for the Electricity (Wiring) Regulations have been met. The Registered Electrical Worker and Registered Electrical Contractor shall sign the Work Completion Certificate for the individual high voltage electrical installation and submit to the Supervising Officer before the electrical installation is energised.

7.2.13.2 HIGH VOLTAGE - ELECTRIC MOTORS

7.2.13.2.1 Performance Requirements

(a) General Requirements

Type	:	High efficiency 3-phase motor;
Standards	:	IEC 60034-1:2017;
Duty rating	:	Maximum Continuous Rating (MCR), SI duty;
Insulation	:	Class F design for Class B operation, IEC 60034-1:2017;
Maximum speed	:	25 rev/s synchronous speed;
Vibration level	:	IEC 60034-14:2018; and
Power factor	:	0.85 minimum under full load conditions, otherwise power factor correction be incorporated.

(b) Electricity Supply

The electricity supply to the high voltage motors shall be 3.3 kV, 6.6 kV or 11 kV 3 phase, as specified in the Contract.

(c) Starting Performance

Unless otherwise specified, the motor shall be provided with auto-transformer starter to limit the starting current to not exceeding 2.5 times of full load current.

The motor shall be manufactured to permit not less than three starts per hour equally spaced during normal running conditions. The motor shall also be suitable for two starts in succession followed by a 30 minutes interval before attempting another starting sequence.

The minimum voltage at motor windings at starting shall be 50% nominal for motor with auto-transformer starter.

The starting (run-up) torque characteristics of motor at minimum voltage shall be adequate for driving the load to full running speed under the most arduous conditions specified. The accelerating torque at any speed up to the peak torque point shall not be less than 10% of the motor rated full load torque.

Motor with auto-transformer starting shall be with 50% rated voltage across its winding and without changing to its final connection, and shall run to at least 90% of its synchronous speed within 10 seconds.

(d) Power Rating

Motors shall be capable of operating continuously at any voltage in the range 90-110% of rated voltage and shall have power output of not less than 120% of the maximum power absorbed by the driven machines.

(e) Transient Recovery

Motors shall be capable of recovering normal operation in the event of a system disturbance causing temporary loss of supply voltage for periods of up to 0.2 seconds (fault clearance-time) followed by a sudden restoration to 80% rated voltage. At this voltage the motors shall then be capable of accelerating to ultimate recovery under the most arduous load conditions.

(f) Synchronous motors

Synchronous motors for applications requiring high starting torque shall be equipped with suitable converter drives to provide the high torque required at all starting conditions.

Synchronous motors shall be equipped with damper winding, or suitable converter drives to prevent hunting and halt.

7.2.13.2.2 Enclosure

For open type motor drive, the enclosure shall have the degree of protection of minimum IP44 unless otherwise specified. Dimensions and frame number of motors shall comply with IEC 60072-1:1991 and IEC 60072-2:1990.

The motor frame shall be manufactured to facilitate easy removal of rotor assembly and to permit access from both motor ends for cleaning and rewinding of the stator winding and replacement of the complete stator core assembly.

The motor shall be provided with suitable arrangement to facilitate lifting and handling during erection and overhaul.

7.2.13.2.3 Thermal Insulation & Characteristics

The motor windings and accessories shall be manufactured for Class F insulation with Class B maximum temperature limit to IEC 60034-1:2017.

Natural rubber insulated cables shall not be used between the stator windings and motor terminals.

7.2.13.2.4 Motor Stators & Windings

The motor winding insulation shall withstand voltage stress caused by switching of motor starter using SF_6 circuit breaker, vacuum circuit breaker or vacuum contactor.

Motors shall be manufactured to permit high voltage tests in accordance with IEC 60034-1:2017 to be conducted after erection on site.

End windings shall be rigidly braced to prevent their movement at the specified service duty.

The insulation system of stator windings shall be of the resin-rich type or the vacuum pressure impregnated type. Windings shall be given a surface treatment where necessary to prevent deterioration resulting from adverse environmental conditions and for corona shield.

Winding coils shall be of the pre-formed type. Random-wound type windings and hair-pin type windings are not acceptable. Stator slots shall be of the open type to facilitate easy insertion of replacement windings.

7.2.13.2.5 Rotor

Unless otherwise specified, the rotor shall have cage type copper/copper alloy winding.

The limits of vibration shall comply with IEC 60034-14:2018.

The rotor shall be dynamically balanced at its rated speed or a speed not less than 600 rpm to confirm that vibration levels are within the specified limit. Means for fixing balancing weights in-situ shall be provided at both ends of the rotor without the need to dismantle the motor for balancing on site.

For motors of 750 kW rating and above or where the induced shaft voltage exceeds 0.15 V, an insulated bearing arrangement shall be provided. Where such provision is made, all motor bearings shall be insulated from the stator frame and a removable earth bonding link shall be provided at the driving end to facilitate insulation tests. Oil and water pipes etc. where fitted shall be insulated to prevent a current return path through the bearings of the motor shaft. Care shall be taken to ensure that any insulation is not short circuited by the application of electrically conducting paints or fixing clips.

7.2.13.2.6 Bearings

(a) General

Bearings shall be exclusively of metric sizes.

Unless otherwise specified or approved, bearings for horizontal motors shall be provided in accordance with Table 7.2.13.2.6 below.

Table 7.2.13.2.6 Type of Bearing

Number of Poles	Motor Rating	Types of Bearing
4	Above 500 kW Up to 500 kW	Plain Rolling
6 or more	Above 750 kW Up to 750 kW	Plain Rolling

The motor manufacturer shall examine the external axial and radial load imposed from the shaft and the driven device in the selection of the type of bearing to be used. Where damage is likely to occur to rolling bearings due to thrust load or stationary vibration, plain type bearings shall be preferred. Consideration shall also be given to bearing service life, noise, losses and maintenance convenience in the selection of bearings. Where rolling type bearing is selected to be used, the manufacturer shall provide calculation to verify that the L10 life of bearing is not less than 50,000 hours at the most onerous operating conditions.

Bearings shall be easily accessible for inspection and shall be liberally rated to ensure cool, even running. Bearings shall be suitable for reverse rotation at 150% of the normal running speed.

Motor bearings supplied shall be prevented from damage by any stray currents as detailed in Clause 7.2.13.3.5.

Protective and auxiliary equipment applicable as per Clauses 7.2.13.2.11(b) and 7.2.13.2.11(c) shall be provided for bearings.

(b) Plain Type Bearings

Plain type bearings shall be self-lubricated. The lubrication oil shall be water-cooled unless otherwise specified. The cooler shall be such as to avoid any electrolytic action or corrosion. Bearings shall be manufactured to exclude the ingress of dust and water and adequately sealed to prevent leakage of oil.

The water pipes shall not run over or adjacent to the HV terminal boxes and shall not impede access to the bearing for inspection. The initial filling of bearing lubricating oil shall be supplied and delivered in an oil drum.

Bearings shall be provided with a filling hole, an air breather, an accessible drain plug and a clearly visible oil level indicator to show oil levels during running and at standstill. Sight level indicators of the type fitted externally to the bearing shall be manufactured to prevent rotation about the gland connection.

Besides the normal running operation, the lubrication shall also be adequate during starting and running down periods.

The bearing shall avoid oil being drawn into the winding through the shaft by centrifugal force or the effect of ventilation fan.

The bearing mounting bracket assembly shall be capable of completely detached from the stator, viz. no welding to the stator frame shall be permitted.

Bearing pads shall be self-aligned and shall not require any jacking screws for adjustment.

(c) Rolling Type Bearings

Rolling type bearings shall be adequately lubricated by grease and sealed against leakage of lubricant along the shaft. Construction shall be such that bearings can be dismantled and reassembled without risk of damage.

The bearing assembly shall prevent the entry of dust or water. It shall be provided with a separate grease nipple to serve each lubricating point and a grease relief device such that when the motor runs at its rated speed any surplus grease is ejected out of the bearing casing to a separate container.

Housings for ball/roller bearings shall be packed with approved lithium-based grease at the time of assembly. The required re-lubrication interval shall be more than 4,000 hours.

Grease nipples, oil cups and dip sticks shall be readily accessible without removal of guarding. Where necessary for accessibility, nipples shall be remotely mounted at a point as near as is practicable to the lubrication point.

7.2.13.2.7 Motor Foundation

A motor bedplate/foundation block shall be provided unless the motor is to be mounted on the soleplate of the driving equipment such as compressor or pump. Jacking screws shall be fitted at perpendicular directions on the foundation block for alignment of the coupling.

7.2.13.2.8 Provision for Cabling and Termination

(a) Cabling Provision at Bedplates

Provision shall be made in the steel bedplate where necessary to facilitate straight run of cable to the bottom of the motor cable terminal box.

(b) Cabling Provision at Cable Boxes

Unless otherwise specified or approved, the cable terminal box for the motor shall be positioned at the side of the motor. Cable entry shall be from below for all box types unless otherwise specified.

An earthing terminal with the same current carrying capacity as the line terminals with the minimum size suitable for 25 x 6 mm copper strip shall be provided. A tapped hole with screw external to the cable box would be acceptable.

Permanent terminal marking and direction of rotation in accordance with IEC 60034-8:2007+AMD1:2014 shall be provided in the cable boxes.

(c) Cabling Provision at Motor Casing

The terminal leads from cable box terminals or connectors to the windings for a distance of 150 mm beyond their point of entry into the motor frame, shall be adequately braced to withstand the forces produced by maximum fault current.

The phase windings shall be accessible for testing. For this purpose, neutral leads shall be brought out to a separate star-point terminal box and shorted with an insulated copper bar of cross-sectional area not less than the conductor of the terminal lead.

Studs shall be so fixed as to prevent the terminal leads from turning when the nuts are tightened down. Means shall be provided to prevent slackening of cable connections due to vibration.

(d) Motor Supply Cables

Motor terminations shall be suitable for connection of high voltage power supply cables which shall be cross linked polyethylene insulated, PVC-sheathed, galvanised steel wire and PVC covered XLPE/SWA/PVC copper cables as specified in Clause 7.2.13.6.

(e) Clearances and Creepage Distances

Electrical clearance and creepage distances shall comply with Table 7.2.13.2.8(e) below. These clearance and creepage distances shall also apply to terminals or connectors which have to be insulated on site, and shall apply even though the terminals or connectors are fully insulated, but are not intended to apply to permanently insulated conductors.

Table 7.2.13.2.8(e) Clearance and Creepage Distances for High Voltage Terminations

Rated Voltage	Minimum Clearance		Minimum Creepage Distances over Bushings and Surfaces Resistant	
	To Earth	Between Phases	To Earth	Between Phases
kV	mm	mm	mm	mm
3.3	50	50	59	75
6.6	63	90	90	132
11	75	125	125	190

7.2.13.2.9 Motor Termination Boxes

(a) Construction

Cable boxes for motor power supply shall be of a type fault-tested as follows:

3.3 kV — Phase-insulated pressure relief post type; and

6.6 kV, 11 kV — Phase-segregated containment pressure relief post type.

The cable box for motor line connections shall each comprise a sealing chamber and an air insulated termination chamber bolted together, of degree of protection to IP56. Sealing chamber is not required for the stator winding star point termination box.

Termination boxes shall be fabricated from mild steel of a minimum of 6 mm thickness. Cast iron boxes shall not be accepted.

The termination chamber shall be bolted to the motor casing such that its sides are vertical, with high tensile steel studs and nuts. The cable sealing chamber shall be fixed to the bottom of the termination chamber by means of high tensile steel bolts or studs and nuts.

The cable sealing chamber for XLPE cable shall be of the dry type suitable for cable termination in heat shrinkable sleeving. Sealing chamber shall be fitted with a horizontal gland plate suitable for bottom cable entry.

The termination chamber shall have an insulated assembly and be fitted with 3 stud terminals in insulating mouldings of epoxy resin, glass fibre, polyester or approved similar material and so arranged that the motor can be removed to another location with the termination chamber in-situ. No cable joint is permitted in the termination chamber. Porcelain insulators shall not be used. Cable-coupler type terminals shall not be acceptable.

Front access detachable cover plates shall be fixed by studs and nuts. Separate plates shall be supplied for sealing and termination chambers.

Joints shall be machined flat and fitted with neoprene rubber gaskets.

(b) Termination Box Auxiliaries

Brass cable glands shall be provided for motor supply cables. Cable lugs shall be supplied for the motor supply cable. Unless special lugs are used in the short circuit type test, cable lug shall be of the compression type manufactured from tin-plated seamless copper tubing with single bolt palm terminal. The cable lug shall be type-tested to IEC 61238-1-3:2018.

7.2.13.2.10 Markings and Data Plates

An instruction and a data plate, of stainless steel, brass or other approved non-tarnishing metal shall be provided. The instruction plate shall give the connections and phase rotation for the required direction of rotation. The required direction of rotation shall be marked on the motor.

The data plate shall be stamped with the information required by IEC 60034-1:2017. Data plates on which the above required information is only painted will not be accepted.

The motor serial number shall be stamped with metal dies on the driving end shaft face of the motor in addition to being stamped on the stator.

7.2.13.2.11 Temperature Detectors for Motor Protection

(a) Embedded Temperature Detectors (ETD)

Unless otherwise specified, embedded temperature detectors of linear characteristics, e.g. thermocouple or resistance thermometer, and complete with monitoring unit shall be provided to offer protection against over-heating on load and stalling of the motor. Resistance temperature detector (RTD) shall comply with IEC 60751:2008.

At least two detectors of the same characteristics suitably embedded in the stator shall be installed, positioned at points at which the highest temperatures are likely to occur, e.g. one detector between coil sides within the slots, one detector under the coils at the bottom of the slots and one detector between the coils and slot wedges. Detector leads shall be wired to an auxiliary cable box such that any ETD may be isolated for testing.

The ETD monitoring unit for each motor shall have the following features: -

(i) Alarm contacts to operate at a temperature of 120°C which is adjustable for individual detecting elements;

(ii) Trip contacts to operate at a temperature of 140°C which is adjustable for individual detecting elements; and

(iii) A common digital temperature gauge and selection buttons for reading the winding temperatures of the individual detecting elements.

(b) Temperature Detectors for Bearings

A temperature detector shall be installed for each bearing for high temperature alarm and trip operation.

Unless recommended otherwise by the motor manufacturer, alarms detectors shall operate 10°C lower than the trip detectors.

Insulated thermometer pockets shall be provided to enable easy insertion or removal of a temperature detector. Dial type thermometers or digital indicators, with independently adjustable alarm and trip contacts, shall be provided at the motor control switchboard to monitor the bearing temperatures. Contacts shall

be arranged to close for alarm indication or tripping and shall be so arranged that the operation of the alarm or tripping may be checked manually.

(c) Bearing Coolant Failure Detector

Where water cooled bearings are used a flow failure detector shall be provided.

Suitable timers and relays shall be provided to obviate any false alarm during the starting up of the motor set or on flow surges.

7.2.13.3 HIGH VOLTAGE - MOTOR CONTROL SWITCHBOARDS

7.2.13.3.1 General Requirements

(a) The motor control switchboards shall be of the single busbar, indoor air-insulated, metalclad type formed into complete switchboards. The high voltage switchgear and switchboards shall comply with IEC 62271-100:2008/AMD2:2017/COR1:2018 and IEC 62271-200:2011/COR1:2015 respectively.

(b) The power to the high voltage motors shall be distributed from the high voltage motor control switchboards through the motor starters incorporated in the switchboards. The control switchboards shall contain a motor starter for each motor set.

(c) The switchboards shall, but not be limited to, include the following equipment: -

(i) Incoming circuit breaker;

(ii) Motor starter;

(iii) Overcurrent and earth leakage protective relays and devices;

(iv) Motor temperature monitoring unit;

(v) Motor bearing temperature gauges;

(vi) Emergency stop button;

(vii) Local controls for ancillary equipment;

(viii) Sufficient terminals and cable glands for external cable connections;

(ix) Anti-condensation heater and associated thermostat;

(x) Isolators, fuses and other wiring ancillaries; and

(xi) Power factor correction capacitors and controlgear.

(d) Type test certificates shall be available for each rating of circuit breaker and switchboard to be supplied. The results of all type tests shall be recorded in type test reports containing sufficient data to prove compliance with the Specification. Type test certificates shall be issued preferably by the Association of Short-circuit Testing Authorities (ASTA) or N.V. tot Keuring van Elektrotechnische Materialen (KEMA). Test certificates issued by other organisations will only be accepted if the testing organisation is accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS.

(e) General Information

Table 7.2.13.3.1(1) General Information

Rated operational voltage	3.3 kV, 6.6 kV or 11 kV as specified, 3-phase
Earthing of system	Solid
System frequency	50 Hz
Installation type	Indoor
Power supply for circuit breaker Operation, controls and protection	110 V D.C. ± 15%
Power supply for auxiliary Equipment	220 V A.C. ± 10% 1-phase 50 Hz
Degree of protection	IP31
Insulation class	Class B

(f) Standards

The switchgear and cubicles for high voltage switchboard shall comply, in particular, with the following Standards where appropriate:

Table 7.2.13.3.1(2) Standards

IEC 60269-1:2006+AMD1:2009 +AMD2:2014	Low–voltage fuses – Part 1: General requirements
IEC 60051-1 to IEC 60051-9	Direct acting indicating analogue electrical measuring instruments and their accessories
IEC 60255-1:2009	Electrical protective relays
IEC 60282-1:2009/AMD1:2014 CSV	Fuses for voltages exceeding 1,000 V AC
IEC 61869-2:2012	Current transformers

IEC 61869-3:2011 & IEC 61869-5:2011	Voltage transformers
IEC 60947-5-1:2016/COR1:2016	Control Switches
IEC 60376:2018	Sulphur hexafluoride for electrical equipment
IEC 62271-200:2011/COR1:2015	A/C metal-enclosed switchgear and controlgear of rated voltage above 1 kV and up to and including 52 kV
IEC 62271-100:2008/AMD2:2017/COR1:2018	A/C circuit breakers for rated voltage above 1 kV
IEC 62052-11:2003/AMD1:2016/COR1:2018	Electricity meters
BS 6231:2006	PVC-insulated cables for switchgear and controlgear wiring
IEC 62271-1:2017	High-voltage switchgear and controlgear standards

7.2.13.3.2 General Construction

The switchboards shall consist of dust and vermin-proof cubicles segregated into single or multi-tier compartments. They shall be made from sheet steel of 2.5 mm minimum thickness.

The edges of hinged panel doors shall have deep return flanges for rigidity and fitting of gaskets. Gaskets shall be of neoprene or rubber, continuous without joints around corners and suitably arranged to minimise the transmission of vibration and to prevent the entry of dust. Hinged panel doors shall be fitted with chromium plated solid rod type detachable hinges and chromium plated car door type lockable handles.

Forced ventilation shall not be allowed under an ambient temperature of 40°C. Ventilating grills, where required, shall not be located on top of a panel.

Each switchgear unit shall comprise three main portions:

(a) Separate chambers at the top of the switchboard housing the busbars, current transformers and voltage transformers, and shall be accessible through bolted covers only;

(b) A compartment housing the relays and instruments; and

(c) A moving portion comprising a carriage complete with circuit breaker. The circuit breaker shall preferably be arranged for vertical isolation from the busbars.

The circuit breaker compartment shall be accessible through a hinged door fitted with a glazed window for viewing the circuit breaker mechanical status indicators.

The switchboard shall be mounted firmly on to the concrete floor finished to the standard requirements as recommended by the equipment manufacturer. The floor construction shall withstand the operating weight and impact loading of the switchboard. Individual panels shall be erected to true plumb vertically and horizontally on suitable guides/rails as standard accessories from the same manufacturer.

The relay and instrument compartment shall be located at the front of each switchgear unit and shall be provided with a hinged door for access to the internal wiring and terminals. Moulded gaskets of non-aging material shall be used to provide close sealing. The height of the instrument panel above floor level shall not exceed 2,400 mm. All panels constituting a complete switchboard shall be of equal height.

Bolted-on rear and top covers shall gain access to individual circuits without exposing other circuits which may be alive. Switchboards shall not be located across floor expansion joints.

Before steelworks is painted, it shall be treated and degreased by an approved method or chemical pickling and an approved anti-rusting priming coat applied. The panels shall be externally finished in semi-gloss stoved enamel or cellulose to a colour to be approved by the Supervising Officer.

7.2.13.3.3 Primary Busbars and Connections

Primary busbars and connections between the several pieces of apparatus forming the equipment of a switchboard shall be of high conductivity copper to BS EN 13601:2013. Construction, marking and arrangement of busbars, connections and auxiliary wiring shall be to IEC 62271-200:2011/COR1:2015 and BS 159:1992.

Primary busbars shall be contained in a separate compartments within the switchboard and access shall be possible only by means of bolted-on sheet steel covers which shall clearly be marked 'BUSBARS'. Busbars and busbar connections shall not be exposed when covers and doors are opened for access to the remainder of the switchgear. Busbars shall be readily extensible.

Each phase conductor of the primary busbars including all through joints and tapping connections shall, in addition to being spaced at such intervals as to give the necessary air clearance for the voltage rating, shall be epoxy encapsulated solid copper bars. Joints shall be insulated with moulded removable insulated covers. Taping shall not be accepted.

Primary busbars, connections and their supports shall be capable of carrying the short-time current associated with their short-circuit ratings for a period of 3 seconds.

Where busbar supports use insulation of moulded or resin bonded material, it shall have a durable anti-hygroscopic surface finish with high anti-tracking properties.

The connections from busbars in individual units shall have a continuous current rating of not less than that of the equipment comprising the unit.

At all points where connections or joints occur, the busbars and connecting pieces shall be tinned or silver-plated. The resistance of any length of conductor containing a joint shall not be greater than that of an equal length without a joint.

Jointing of sections of busbars shall be done by mechanical means. Soldered, braced, welded or riveted joints shall not be used in busbars. Jointing faces of copper conductors shall be tinned or silver plated, or applied with other approved treatment to maintain effective conductivity of the joint. All necessary busbar jointing bolts, nuts, and fixing accessories shall be provided. The recommended torque for tightening the bolts shall be stated in the maintenance manual.

Primary busbars and connections shall be clearly marked and shall be displayed for standard phase sequence in accordance with the cable colour coding system, i.e. L1, L2 and L3, counting from front to rear, top to bottom, or left to right as viewed from the switching device operating mechanism side to IEC 62271-100:2008/AMD2:2017/COR1:2018 or IEC 62271-200:2011/COR1:2015.

7.2.13.3.4 Circuit Breakers

(a) General

Unless otherwise specified, the 11 kV circuit breaker units shall be of the vacuum type complying with IEC 62271-100:21 and the 3.3 kV or 6.6 kV circuit breaker units shall be of the vacuum type or the Sulphur Hexafluoride (SF_6) type complying with IEC 62271-100:2008/AMD2:2017/COR1:2018. They shall be of a type with vertical or horizontal isolation, horizontal withdrawal facilities.

The moving portion of each circuit breaker unit shall consist of a three-pole circuit breaker with operating mechanism, primary and secondary disconnecting devices, auxiliary switches, position indicators and the necessary control wiring all mounted on a substantial steel framework. The framework and all metal part of the moving portion apart from current carrying parts, shall be solidly earthed via the fixed portion. The earthing of the moving portion shall be to the approval of the Supervising Officer. Means of registration shall be provided so that circuit breakers may be readily placed and secured in the correct position in the fixed portion.

Circuit breakers of the same current and voltage rating shall be fully interchangeable with one another. Means shall be provided to prevent circuit breakers from being placed into fixed housings of different ratings. This device shall also prevent damage to isolating and other contacts.

Each circuit breaker shall have remote control for opening and closing by authorised personnel inside the main switch room to enhance operation safety. The open switch and close switch of each circuit breaker shall be housed in a lockable box which is located near the door in the main switch room. The switches shall be labelled to identify the circuit breakers under control.

(b) Vacuum Circuit Breakers

For vacuum circuit breakers, means of confirming the validity of vacuum by the occurrence of flash-over when a voltage is applied between the vacuum interrupter contacts shall be included in the maintenance tools. Vacuum leakage shall be monitored to initiate an alarm and it shall not be possible to close a circuit breaker when vacuum leakage is serious enough to threaten safe operation of the switchgear.

Vacuum circuit breakers for motor circuits shall incorporate surge suppressers to minimise the effects of switching transient voltage on the motor insulation.

(c) SF_6 Circuit Breakers

A pressure switch shall be provided on the SF_6 gas compartment to monitor the gas pressure. The system of gas monitoring shall be temperature compensated.

Alarm and lockout feature shall be incorporated. Alarm signal shall be initiated and the breaker shall be inhibited from closing whenever the gas pressure drops below a preset level. The circuit breaker shall be prevented from operation. Means shall be provided in the gas compartment for the connection of service equipment and for the topping up of the gas.

The circuit breaker shall be suitable to interrupt its rated normal current with SF_6 gas at atmospheric pressure. The sealing of the gas compartment shall be manufactured so that there is no need for the SF_6 gas to be replenished within reasonable periods. The gas leakage shall not exceed 1% per annum at site ambient temperature.

An external contact indicator shall be provided to check the extent of contact wear. Means shall also be provided to allow access to the contacts of the interrupter units for necessary inspection and maintenance. All contact assemblies shall be replaceable.

Safeguards shall be provided to prevent incorrect replacement of contacts.

The designed electrical and mechanical life shall be at least 5,000 and 10,000 cycles respectively. The circuit breaker shall be capable of undergoing 40 cycles of fault breaking operations at 50% rated short-circuit breaking current or equivalent without any need of opening up the tank for inspection or contact replacement.

Instructions for post-fault maintenance, gas top-up contact and seal replacement shall be clearly detailed in the manual.

(d) Operating Mechanisms

The circuit breaker operating mechanism shall be of the following types as specified: -

(i) Stored energy operation by means of a manually charged spring with mechanical release;

(ii) Stored energy operation by means of a motor-charged spring with manual and electrical release; and

(iii) Solenoid operated.

The mechanism shall be of the trip free type so that the circuit breaker shall be free to open during the closing operation immediately its tripping device operates. The circuit breaker shall be capable of closing fully and latching against its rated making current.

Spring operated mechanisms shall have the following additional measures: -

(i) If the circuit breaker is opened and the springs charged the circuit breaker shall be able to be closed and then tripped;

(ii) If the circuit breaker is closed and the springs charged there shall be sufficient energy to trip, close and then trip the circuit breaker;

(iii) Mechanical indication and an auxiliary switch for remote electrical indication shall be provided to indicate the state of the springs;

(iv) Motor charged mechanisms shall be provided with means for charging the springs by hand, and also a shrouded push button for releasing the springs. An electrical release coil shall also be provided;

(v) Under normal operation, motor recharging of the operating springs shall commence immediately and automatically upon completion of each circuit breaker closing operation. The time required for spring recharged shall not exceed 30 seconds; and

(vi) It shall not be possible to close a circuit breaker, fitted with a motor charged closing mechanism, whilst the spring is being charged. It shall be necessary for the spring to be fully charged and the associated charging mechanism fully prepared for closing before it can be released to close the circuit breaker.

All circuit breaker operating mechanism shall be fitted with an electrical shunt trip release coil and in addition a mechanical hand tripping device.

The electrical tripping and closing devices shall be suitable for operation from a 110 V D.C. battery supply and but shall operate continuously with their coils at an ambient temperature of 40°C, over a voltage range as follow: -

Closing solenoid	:	80 to 120% of nominal voltage;
Spring charging motor	:	80 to 110% of nominal voltage;
Closing release coil	:	80 to 110% of nominal voltage; and
Shunt trip release coil	:	50 to 120% of nominal voltage.

except that under battery boost charge conditions when they shall be capable of operating at rated output and 130% of nominal voltage for up to two hours.

All operating coils for use on the D.C. supply shall be connected so that failure of insulation to earth does not cause the coil to become energised.

Tripping and closing circuits shall be provided with a fuse in each pole on each unit and shall be independent of each other on all other circuits.

Approved, positively driven mechanically operated indicating devices shall be provided to indicate whether a circuit breaker is in the open or closed service, isolated or earthed position.

(e) Isolating Devices

All circuit breakers shall be connected to their associated busbars and cables through isolating devices to IEC 62271-100:2008/AMD2:2017/COR1:2018 and IEC 62271-200:2011/COR1:2015 which shall be arranged for operation whilst the main circuit is live but no current passing.

The configuration shall be such that it is impossible for the isolating devices to be opened by forces due to current in the primary circuit and shall be interlocked with the circuit breaker so that it is impossible to make or break current with the isolating device. Attempted isolation shall not trip the circuit breaker.

When isolation is effected by withdrawal of the circuit breaker, provision shall be made for positively locating the circuit breaker in the service, isolated and, earthing positions. Stops shall be provided to prevent over-travel and each position shall be clearly indicated. Preferably a mechanical selector mechanism shall be utilised such that when a particular position is selected, it is impossible to locate the circuit breaker in any other position.

Isolating devices shall incorporate self-aligning contacts, the fixed contact of which shall be such that access can readily be obtained for maintenance purposes.

(f) Overcurrent and Earth Fault Protection

All circuit breakers other than those used for controlling the incoming supply, shall have overcurrent tripping facilities to give time delay overload current protection and instantaneous short circuit interruption. The time-current characteristics shall be submitted for inspection. Shunt trip coils operated by power supply from the mains shall not be used.

For circuit breakers controlling the incoming supply to the Switchboard, the circuit protection shall be provided by the following devices: -

(i) Overcurrent Protection Relay;

(ii) Earth Fault Relay; and

(iii) Shunt-Trip Release.

It shall be operated by a D.C. supply of 110 V obtained from the secondary batteries complete with battery charger, etc. of suitable rating.

(g) Safety Shutters

Metal shutter shall be provided to completely shroud fixed isolating contacts of the circuit breaker busbar and feeder circuits. These shutters shall be opened and closed automatically by the movement of the circuit breaker carriage and shall prevent access to fixed isolating contacts when the circuit breaker is withdrawn.

The shutters for fixed isolating contacts connected to busbars and cables shall have independent operating mechanisms. All shutters

shall have painted labels indicating whether they are busbar or feeder shutters.

To facilitate high voltage and current injection testing via isolating contacts, a device shall be provided for fixing, but not locking, shutters in the open position and for releasing them to the closed position. This device shall be arranged to be disengaged as soon as the circuit breaker is pushed into the service position to ensure that the automatic features of the shutters are restored.

Self-aligning plug and socket isolating devices shall be provided for all auxiliary circuits. The position of these devices shall be such that individual circuits on different units are in the same relative physical positions.

(h) Interlocking Gear

Interlocks shall be of the mechanical or key operated type and shall be provided to prevent the following operations: -

(i) A moving portion from being withdrawn from or inserted into the isolating contacts when the circuit breaker is closed;

(ii) The closing of the circuit breaker unless the movable portion is correctly plugged in or isolated from the equipment;

(iii) The movable portion being withdrawn or replaced unless the circuit breaker is isolated and in the appropriate position;

(iv) The movable portion being plugged in without the circuit breaker tank in position;

(v) The circuit breaker being closed in the 'SERVICE' or 'EARTH' location without completing the appropriate auxiliary circuits; and

(vi) To apply an earth to busbars until all circuit breakers which can feed the busbars, are locked open.

When key interlocking is employed, any attempt to remove the trapped key shall not cause closing or opening of the associated equipment.

Where a circuit breaker is fitted with means for mechanical or electrical operation, interlocks shall be provided so that it is impossible for the mechanical and electrical devices to operate simultaneously.

The earthing devices shall be provided with interlocks to ensure correct operation in conjunction with the associated circuit breaker.

In the case of circuit breaker earthing, the electrical tripping of the circuit breaker shall be rendered inoperative during earthing operations both when closing and when closed in the earthed position. It shall not be possible to return to the service position and close the circuit breaker until the electrical tripping is again operative.

A mechanical key interlocking system shall be provided whereby it is not possible to apply an earth to busbars until all circuit breakers which can feed the busbar are locked open. In addition it shall not be possible to earth busbars and cable circuit at the same time by means of the same circuit breaker.

In addition to safety interlocking which is integral to a circuit breaker unit to prevent wrong or dangerous operation of the unit itself, further interlocking shall be provided.

In general, interlocking shall be electrically isolating the closing contactor coil circuit of a circuit breaker being interrupted unless the necessary conditions for closure are met. The interlocking shall be configured on a system wide basis to ensure that subsequent operation of a non-interlocked circuit breaker does not result in a set of conditions that would contradict the original 'permission to close'.

(i) Interlocking Circuits

Where interlocking over a distance is required, two independent criteria shall be used, such as absence of a voltage and remote feeding circuit breaker open. Indication of the remote condition shall be by single purpose circuit, care being taken that the conductors used are adequately screened and shielded to minimise both transverse and longitudinal voltages resulting from electromagnetic induction and differences in earth potential. The cable containing cores for interlocking circuits shall be separate from all other multi-core cables.

All interlocking circuits shall be of the 'go and return' configuration, and in no instance will interconnection of batteries in different locations be permitted.

Where a circuit breaker is capable of manual operation in addition to electrical operation, except where such manual operation is possible only for maintenance purposes, key-operated interlocking shall additionally be provided, operative only in the instance of manual operation.

Electrical interlocks on withdrawable equipment shall be arranged so that when withdrawn, the equipment operation will be independent of the remote interlocking contacts. In addition, the interlocks shall be such that, when the equipment is withdrawn, the interlocking of associated apparatus is correct, and operation of the equipment in the withdrawn position will have no effect.

(j) Locking Facilities

Locking facilities shall be provided so that the circuit breaker can be prevented from being closed when it is open and from being manually tripped when it is closed. These facilities shall not require the fitting of any loose components prior to the insertion of the single padlock required. It shall not be possible, without the aid of tools, to gain access to the tripping toggle or any part of the mechanisms which would permit defeat of the locking of the manual trip. It shall not be possible to lock mechanically the trip mechanisms so as to render inoperative the electrical tripping.

In addition, the following padlocking facilities shall also be included: -

(i) Selector mechanisms on circuit breaker isolated and service positions; and

(ii) Safety shutters on primary contact isolating orifices in closed position.

All switchboard access doors, other than those which are interlocked with a switching device, shall be provided with an integral type locking facility.

7.2.13.3.5 Earthing and Earthing Devices

All metal parts other than those forming part of an electrical circuit shall be connected in an approved manner to a hard drawn, high conductivity copper earth busbar which shall run the full length of, and be bolted to, the main frame of the switchboard. At the position where joints occur, the earth busbar shall be tinned. The earth busbar shall be rated to carry currents equal in magnitude and duration to that associated with the short circuit rating of the equipment.

The configuration and construction of the equipment shall be such that all metal parts, other than the current carrying parts, or the withdrawal equipment are earthed before the primary connections are made.

Metal cases supports and bases of all instruments, relays or other associated components mounted on the switchgear shall be connected to the earth busbar by conductors of not less than 2.5 mm^2 cross-sectional area.

When components are provided for mounting separately each shall be provided with an earthing terminal of not less than 30 mm^2 cross sectional area.

Earthing devices shall be provided on all circuit breaker units whereby the circuit can be earthed. With the circuit earthed, shutters over unearthed fixed main isolating contacts shall be closed.

Busbar earthing facilities shall be provided on selected circuits of each separate switchboard, these circuits shall be agreed with the Supervising Officer.

Circuit and busbar earthing shall be of the transfer circuit breaker arrangement and it is preferred that the facilities shall be integral in the configuration and construction of the switchgear. Earthing devices for fitting to the circuit breakers are acceptable but they shall be supplied in a separate container together with a set of instructions for fitting and operating the equipment. Configurations effecting earthing by means of a separate fault-making switch are not acceptable.

Feeder and busbar earthing devices shall have a short circuit rating equal to that of their associated circuit breaker.

Padlocking facilities shall be provided for the purpose of preventing inadvertent earthing.

Labelling shall be provided to show whether the equipment is prepared for 'SERVICE', 'BUSBAR EARTH' or 'CIRCUIT EARTH'. Such indication shall be visible from the front of the equipment at all times. Duplicate labels in Chinese and English shall be provided.

7.2.13.3.6 Testing Facilities

All circuit breaker units shall be provided with facilities to enable applied high voltage tests to be carried out.

Provision shall also be made for temporarily completing the auxiliary circuits when the circuit breaker is isolated and if applicable, withdrawn to enable the functioning of the circuit breaker to be tested.

When current transformers and protective relays are fitted, facilities shall be provided for primary and secondary injection tests to be carried out.

These facilities shall preferably be such that wires and connections need not be disconnected for the tests to be carried out.

7.2.13.3.7 Mechanical Indication

Indication shall be provided to clearly indicate whether a circuit breaker is in the open or closed service, isolated or earthed position.

Positively driven mechanical indicating devices shall be provided on all equipment to indicate the following where applicable:

(a) Circuit breaker 'OPEN' or 'CLOSED'; and

(b) Circuit breaker 'SPRING CHARGED' or 'SPRING FREE'

7.2.13.3.8 Auxiliary Switches

Auxiliary switches of the double-break type and positively driven in both directions shall be provided on all circuit breakers and isolators for indication, control and interlocking.

Auxiliary switches shall be strong, have a positive wiping action when closing and shall be mounted in an accessible position clear of operating mechanisms.

They shall be manufactured to make, break and carry, without undue heating, the current of their associated circuit. Auxiliary switches shall be rated for 10A operational current, and shall be capable of breaking at least 2A at 110 V D.C.

No less than eight spare auxiliary switches shall be provided with each circuit breaker and no less than four with each isolator. Each spare contact shall be readily changeable from normally open to normally closed and vice versa. All auxiliary switches shall be wired up (via secondary disconnecting devices if on withdrawable equipment) to a terminal board on the front of the fixed portion, arranged in the same sequence for each individual unit of the same type.

7.2.13.3.9 Anti-Condensation Heaters

Anti-condensation heaters of an approved type shall be provided inside each cubicle. They shall be thermostatically controlled and shall operate at black heat and shall be shrouded and located so as not to cause injury to personnel or damage to equipment. The heaters shall be controlled from a double-pole miniature circuit breaker, with a lamp to indicate 'cubicle heaters on'. The circuit breaker and indicating lamp shall be mounted externally at one end of the switchboard. The heaters shall operate from 220 V 50 Hz single phase AC supply.

7.2.13.3.10 Current Transformers

Current transformers shall comply with IEC 61869-1:2007 and IEC 61869-2:2012 and shall be suitable for the operation of protective gear, instruments and/or metering equipment.

Current transformers shall be of the epoxy resin encapsulated type and shall have necessary output to operate the connected protective devices or instruments.

The primary windings shall have a short time current rating not less than that specified for the associated circuit breaker. The rated secondary current shall be 1 A or 5 A.

Protection current transformers shall be of Class 10P accuracy or better. The product of rated accuracy limit factor and rated output of the protection current transformer shall not be less than 10 times the rated burden of the trip circuit including the relays, connection leads and overcurrent release where applicable.

Measurement current transformers shall be suitably rated and have accuracy Class of 3 for use with ammeters, and Class 1 for other types of meters.

The polarity of the primary and secondary windings of each current transformer shall be clearly indicated and in addition labels shall be fitted in a readily accessible position to indicate the ratio, class and duty of each transformer. The current transformer particulars as specified in IEC 61869-2:2012 shall be given on an accessible plate mounted external to the current transformer.

All connections from secondary windings shall be brought out and taken by means of separate insulated leads to a terminal board mounted in an accessible position. Where multi-ratio secondary windings are required, a label shall be provided at the secondary terminal board clearly indicating the connections required for each ratio.

Current transformers for indication or metering shall have their secondary windings earthed at the switchgear. The secondary windings of current transformer for protection shall be earthed at the panel which accommodates the associated relay. The earth connection shall be made via a removable link.

Each current transformer shall have a certified maximum rating of at least 1.2 times the rated current.

Current transformers shall comply with IEC 61869-1:2007 and IEC 61869-2:2012 and shall be suitable for the operation of protective gear, instruments and/or metering equipment.

Current transformers shall be of the epoxy resin encapsulated type and shall have necessary output to operate the connected protective devices or instruments.

Each current transformer shall have a certified maximum rating of at least 1.2 times the rated current.

7.2.13.3.11 Voltage Transformers

Voltage transformers shall comply with IEC 61869-3:2011 and IEC 61869-5:2011 and suitable for the operation of protective gear, voltage regulating equipment, instruments and/or metering. All voltage transformers shall be of the dry type with epoxy encapsulation. The rated output per phase at a power factor 0.8 lagging shall not be less than 100 VA. The rated voltage factor shall be 1.2. They shall have a measuring accuracy class of 0.5 and a protective accuracy class of 3P.

Voltage transformers shall be capable of carrying continuously without injurious heating 50% burden above their rated burden. The rated primary voltage of voltage transformers shall be the appropriate nominal system voltage.

Unless specified otherwise, voltage transformer primary windings shall be connected to the circuit side of the current transformers remote from the busbars so as to be included in the protected zone of the associated feeder.

The primary of a single phase voltage transformer shall be connected across L1 and L2 or A and B phases, unless otherwise approved. L1 and L2 phases shall be used in a synchronising scheme, unless otherwise approved.

Voltage transformers shall be capable of being connected and disconnected from the equipment whilst in service. Facilities for padlocking in the service position shall be provided. Where isolating is carried out by withdrawal, a set of shutters, capable of being padlocked, shall be provided to cover the stationary isolating contacts. The shutters shall operate automatically by positive driven drive actuated by movement of the voltage transformer assembly.

The primary windings shall preferably be connected via renewable fuses with current limiting features which shall be readily accessible with the circuit alive and the secondary windings through fuses and links, labelled to indicate their function and phase colour, to the appropriate circuits.

For single phase voltage transformers, both ends of each secondary-winding shall be brought out to insulated links. For three phase voltage transformers, each phase end shall be brought out to fuses, and the neutral of the secondary winding shall be brought out to insulated links. The fuses and links shall then be brought out to insulated terminals located in a terminal box.

The primary and secondary fuses shall be capable of being removed and replaced when the circuit breaker is closed in the service position. Isolation of the primary fuses for this purpose shall be carried out, preferably by withdrawing the entire voltage transformer assembly. Additionally, it shall be possible to remove secondary fuses whilst the voltage transformer is padlocked in the service location.

For single phase units, separate earth links for each secondary winding shall be provided. Each of the neutral leads shall be connected together at a single point and earthed as close as possible to the voltage transformer.

Voltage transformer secondary windings shall be earthed at the switchgear through a link which can be removed for insulation testing.

Voltage transformers having the neutral point of their higher voltage windings earthed, shall be manufactured so that saturation of the core and dangerous over-heating arising therefrom shall not occur when 1.73 times normal voltage is applied to each winding for a period of 15 minutes.

Secondary circuits of voltage transformer shall not be parallel.

The secondary voltage connections to metering circuits shall be broken automatically when the circuit breaker is opened.

7.2.13.3.12 Cables Boxes

Cable boxes shall be suitable for terminating the cables directly into the switchgear. The dimensions and terminal arrangements, together with details of air insulated heat-shrinkable elastomeric PCP cable termination, shall be submitted for approval by the Supervising Officer before manufacture.

All cable boxes shall be suitable for use with air insulated heat-shrinkable elastomeric PCP cable termination and with joint faces which will ensure leak-free operation and exclude the entry of air, dust or moisture. The internal surfaces of cable boxes shall be cleaned of all scale and rust and after cleaning and priming, shall be finished with a hard setting paint compatible with the filling medium.

Where cable boxes are provided for three-core cables, the sweating sockets on the two outer phases shall be inclined towards the centre to minimise bending of the cable cores. Where there is more than one core per phase, the socket block shall be so configured as to minimise bending of the cable cores, and spacer clips shall be incorporated.

All cable terminals shall be of adequate size to ensure no overheating takes place at rated current.

The insulators and fittings shall be unaffected by atmospheric and climatic conditions, ozone, acids or alkalis, dust deposits or rapid temperature changes likely to arise when operating in the specified site conditions and shall be configured to facilitate cleaning.

7.2.13.3.13 Protective Relays

Unless otherwise specified, Clause 7.2.11.9 shall apply.

7.2.13.3.14 Control and Timer Relays

Control and timer relays shall be of the plug-in type, rack mounted, provided with cable connection terminal and anchored by quick fastening vibration-proof devices. Timer shall be of the solid-state type with proven reliability.

7.2.13.3.15 Indicating Instruments

Unless otherwise specified, Clause 7.2.11.9 shall apply.

7.2.13.3.16 Labels and Warning Notice

Laminated 'Traffolyte' or similar labels of ample size shall be provided for each of the units on the switchboards engraved in English and Chinese characters. Labels shall be fixed by screws on the non-detachable parts of the panel at a height of 1350 mm or above.

During the progress of manufacture of the switchboard, a schedule of labels shall be submitted for approval by the Supervising Officer before engraving is carried out.

'Danger - H.V. Live Terminals/ 危險 – 高壓帶電電極' warning labels shall be attached to the access covers of the air insulated cable boxes, CT chambers and busbar, and shall be coloured red with white lettering in both English and Chinese characters.

In addition to automatic screening shutters and barriers, warning labels shall also be provided for all live parts, such as test terminal blocks.

7.2.13.3.17 Ancillary Equipment

Battery charger/batteries system shall be provided for the proper functions of the switchgear in the switchboard.

The switchboard shall be supplied complete with one hydraulic operated handling device suitable for handling all sizes of air circuit breakers in the switchboard, and one set of portable earthing equipment for each main incoming air circuit breaker. Portable earthing leads will not be accepted as an alternative to the earthing equipment.

The switchboard shall be supplied complete with all operating handles, jigs, etc. required for the normal charging, closing, opening, racking in and out operations of all circuit breakers of the switchboard and shall be properly fixed in a neat manner on a board with brass hooks inside the main switch room where the switchboard is installed.

The switchboard shall be provided with two rubber mats of ribbed surface, complying with IEC 61111:2009, laid in front of and at the rear of the switchboard. The rubber mats shall be continuous sheets of 10 mm minimum thickness, each of the same length as the cubicle switchboard

and a minimum width of not less than 1,000 mm or the width of the space between the front or back of the switchboard to the adjacent wall.

7.2.13.3.18 Operation Diagram

For high voltage switchboards with interlocking facility, a brief operation instruction of the switchboards together with a detailed schematic wiring diagram, listing out all the relevant switching steps and interlocks for commissioning/decommissioning of part or whole of the high voltage switchboards shall be provided in a framed, transparent perspex sheet mounted adjacent to the switchboards.

7.2.13.4 HIGH VOLTAGE - AUTO-TRANSFORMERS

7.2.13.4.1 General

The auto-transformers for the auto-transformer motor starters shall comply with the following specific requirements: -

Type	:	Indoor and floor mounted type for no breaking starting of squirrel cage 3-phase induction motor;
Standard	:	IEC62271-106;
System Voltage	:	3.3 kV, 6.6 kV or 11 kV as specified;
Frequency	:	50 Hz;
Connections	:	Auto-star for auto-transformer starting;
Insulation Level	:	45 kV peak impulse voltage for 1/50 microsecond;
Cooling	:	Natural air cooled; and
Tappings	:	Off load tap changers with 60%, 75% and 85% of the line voltage to limit the starting current to 2.5 times of full load current.

The auto-transformers shall be mounted on wheels to facilitate positioning and removal. The transformers shall be externally finished in semi-gloss stoved enamel or cellulose.

7.2.13.4.2 Rating

The rating of the auto-transformer shall suit the starting duty of the motor. Motor starting time shall be taken as 10 seconds at 75% or higher taps and 15 seconds at 60% or lower taps unless otherwise specified in the Particular Specification.

7.2.13.4.3 Insulation

(a) Insulation Medium

Unless otherwise specified, for 11 kV nominal voltage, oil-filled transformers are preferred. Epoxy resin encapsulated auto-transformers shall be preferred for nominal voltage up to 6.6 kV. Other insulation materials are also acceptable if the type-test certificate is issued by accredited laboratories.

(b) Class

Oil immersed transformer windings shall be Class E insulation for Class E operation.

Epoxy resin encapsulated transformer windings and live parts in air shall be Class F or Class B insulation for Class B operation.

Oil immersed transformer windings shall be Class E insulation for Class E operation.

(c) Coordination of equipment insulation

Table 7.2.13.4.3 Coordination of Equipment Insulation

Rated system voltage	12 kV	7.2 kV	3.6 kV
Nominal system voltage	11 kV	6.6 kV	3.3 kV
Minimum impulse withstand voltage (1.2 kV per micro-second)	75 kV	60 kV	40 kV
Minimum power frequency withstand voltage (1 min)	28 kV	20 kV	10 kV

7.2.13.4.4 Transformer Windings

All windings, terminals and connections shall be of copper. To protect windings against high humidity, the core shall be protected by a resin encasement which shall be resistant to moisture but elastic enough to withstand the expansion and contraction caused by the loading cycles.

Impregnation shall be carried out under vacuum to obviate the presence of any air bubbles. Means shall be employed to eliminate any partial discharge or corona that may occur after a prolonged service period. For epoxy resin transformers, suitable fillers shall be mixed in the epoxy resin to provide high mechanical strength and resilience to shock.

Natural ventilation shall be used for attaining the rated output and air channels through winding spools to attain sufficient cooling shall not be accepted.

Internal electrical connections shall be brazed and/or fixed with bolts and nuts. Soldered or mechanically crimped joints shall not be accepted.

Core bolts where used shall be insulated from the respective magnetic circuits with material capable of withstanding a test voltage of 2,000 V rms for one minute.

7.2.13.4.5 Tap Changers

The off-load tap changers shall be accessible through the transformer top cover plate by means of copper links. The transformer top cover plate shall be fitted with an electrical and mechanical interlock to prevent access to the transformer tapping links until the auto-transformer starter circuit breakers are open and the 'START' and 'RUN' circuit breakers are in the 'CIRCUIT EARTH' position.

7.2.13.4.6 Internal Earthing of Transformers

Metal parts of the transformer with the exception of individual core laminations, core bolts and associated individual clamping plates shall be maintained at some fixed potential. Where metal parts of the core are connected to earth this shall be done by way of accessible links to allow the insulation between core and earth to be tested. This insulation shall be able to withstand a test voltage of 2,000 V rms.

The magnetic circuit shall be earthed to the clamping structure at one point only through a removable link placed in an accessible position beneath an inspection opening in the tank cover. The connection to the link shall be on the same side of the core as the main earth connection.

Where coil clamping rings are of metal at earth potential, each ring shall be connected to the adjacent core clamping structure.

7.2.13.4.7 Enclosure

(a) General

The enclosure shall be of rigid construction and shall not be damaged at short-circuit faults. Exterior corners and edges shall be rounded to give a smooth overall appearance. The configuration of the enclosure shall ensure adequate ventilation and air circulation without forced cooling or additional electric fans.

The enclosure shall allow the complete auto transformer to be lifted by crane or jacks, transported by road, rail or water, skidding in any direction on plates or rails without over-straining any joints and without causing subsequent leakage of insulation material.

The tank or enclosure exterior shall be fitted with a M12 stud at the bottom of the unit suitable for termination of a copper earthing bar of 32 x 3 mm.

(b) Enclosures for Epoxy Resin Cast Auto-transformers - Additional Requirements

Unless otherwise specified, a splash-proof enclosure of degree of protection to IEC 60529:1989/AMD2:2013/COR1:2019, IP32 shall be provided covering the entire unit. The enclosure shall be sheet steel of 2 mm minimum thickness and suitably braced to form a rigid structure. The enclosure shall be bolted to the transformer frame and shall be easily removable when required. Access panels and openings shall be provided to facilitate routine inspection and maintenance, and changing of tap position without the need for dismantling the enclosure completely.

(c) Enclosure (Tank) for Oil-filled Auto-transformers

(i) General

A rectangular totally enclosed tank to IP65 shall be supplied covering the entire unit.

Oil tank shall be fabricated from weldable structural steel to BS EN 10025-1:2004, BS EN 10029:2010 or products having equivalent functions or performance, with all welding to BS EN 1011-1:2009 or equivalent. Fabricated under bases shall be provided with skids and detachable rollers. The exterior of the tank shall be of plain sheet steel without stiffeners. Tank stiffeners shall be continuously welded.

Wherever possible the transformer tank and its accessories shall be configured without pockets wherein gas may collect. All joints of the oil tank other than those which may have to be broken shall be welded. Caulking of defective welded joints will not be permitted. All joint faces shall be configured to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

Unless otherwise approved, oil resisting synthetic rubber gaskets shall not be used, except where the synthetic rubber is used as a bonding medium for cork or similar material.

(ii) Pressure Relief Device

Each tank shall be fitted with an approved pressure relief device to protect the tank from damage and control the explosion of oil under internal fault conditions. The device shall operate at a static pressure of less than the hydraulic test pressure for transformer tank but not exceeding 70 kPa. Means shall be provided to prevent the ingress of moisture and dust.

Unless otherwise approved the relief device shall be mounted on the main tank and, if on the cover, shall be fitted with a skirt projecting 25 mm inside the tank to prevent gas accumulation. If a diaphragm is used, it shall be situated above the maximum oil level.

(iii) Tank Cover

Each tank cover shall be of adequate strength, and shall not distort when lifted. Inspection openings shall be provided as necessary for changing tap position. Each inspection opening shall not be less than 450 mm by 360 mm and shall not weigh more than 25 kg. The tank cover shall be provided with lifting welded eyes. The bolt holds in all cover plates shall be provided with washers which will prevent the collection of moisture in the bolt hole.

The tank cover shall be fitted with pockets for a thermometer and for the bulbs of the winding or oil temperature indicators. Protection shall be provided where necessary for each capillary tube. The thermometer pocket shall be fitted with a captive screwed cap to prevent the ingress of water. The pockets shall be located in the position of maximum oil temperatures at full rated power and it shall be possible to remove the instrument bulbs without lowering the oil level in the tank.

(iv) Transformer Auxiliaries

Each transformer shall be fitted with: -

- An oil level indicator of prismatic glass visible from ground level and indicating the oil levels over the range specified. The oil level indicator shall be marked to indicate the correct oil level with the oil at a temperature of 15°C, 50°C and 90°C; and

- An oil seal silica gel breather or other approved type device complete with dehydrating agent, indicator and sight glass. Breathers shall be at least one size larger than the size that would be fitted in temperate climate and shall be mounted approximately 1,000 mm above ground level.

(v) Transformer Auxiliaries

Each transformer shall be fitted with: -

- An oil level indicator of prismatic glass visible from ground level and indicating the oil levels over the range specified. The oil level indicator shall be marked to indicate the correct oil level with the oil at a temperature of 15°C, 50°C and 90°C; and

- An oil seal silica gel breather or other approved type device complete with dehydrating agent, indicator and sight glass. Breathers shall be at least one size larger than the size that would be fitted in temperate climate and shall be mounted approximately 1,000 mm above ground level.

(vi) Transformer Oil

The transformer oil shall comply with IEC 60296:2012. The first filling of transformer oil shall be supplied with the Contract. All oil that may be used for works processing or testing shall be compatible with the oil to be used on site.

(vii) Valves and Flanges

All valves up to and including 100 mm shall be of gunmetal. Larger valves may have cast iron bodies with gunmetal fittings. They shall be of the full way type with internal screw and shall be opened by turning counter-clockwise when facing the handwheel. Butterfly type valves shall only be used for isolation of radiator.

Means shall be provided for padlocking the valve in the open and closed positions.

Every valve shall be provided with a mechanical indicator to show clearly the position of the valve.

All valves shall be provided with flanges having machined faces.

Each transformer shall be fitted with the following: -

- One 50 mm filter valve at the top and one 50 mm combined filter and drain at the bottom of the tank mounted diagonally opposite to each other for connection to oil circulating equipment;

- A robust sampling device at the top and bottom of the main tank. The sampling devices shall not be fitted on the filter valves specified above;

- A drain valve for oil tank; and

- Flanged type air release plugs as necessary.

All valves opening to atmosphere shall be fitted with blank flanges.

7.2.13.4.8 Finishes

(a) Surface Preparation

Before untreated steelwork is painted it shall be thoroughly cleaned by an approved method such as grit blasting to the relevant parts of ISO 8501 series or chemical pickling and an approved anti-rusting priming coat applied. Treated steelwork shall be suitably cleaned and degreased.

(b) Painting - External Surfaces

Panel surfaces shall have not less than one primer coat, two stoved undercoats and two top stoved coats of paint. Undercoats shall be epoxy based and easily distinguishable in shade or colour from the priming and finishing coats. The two final coats shall have a total minimum dry film thickness of 0.075 mm with each coat separately stoved in an air-circulating oven. The final paint coating shall be of semi-matt finish and the colour shall be approved by the Supervising Officer.

Oil tanks and other accessories shall be coated with air-drying paints by cold airless spray to a minimum total dry film thickness of 0.127 mm.

Bright/gloss parts shall be protected with a coat of readily removable composition which shall be effective in preventing corrosion during transport and storage.

(c) Painting - Internal Surfaces

In oil tank, interior surfaces shall be painted in an identical manner to the external surface with air-drying oil and petrol-proof paint. The finishing colour of oil tank shall be red.

For epoxy resin transformer enclosures, the interior surfaces shall be finished in white with anti-condensation paint.

7.2.13.4.9 Rating Plates and Diagrams

The following plates shall be fixed to the transformer enclosure or tank at 1700 mm average height above ground level:

(a) A rating plate bearing the data specified in IEC 60076-1:2011 and the duty rating;

(b) A diagram plate showing the internal connections and in addition a plan view of the transformer giving the correct physical relationship of the terminals. The percentage tapping shall be indicated for each tap;

(c) For oil immersed transformers, a plate showing the location and function of all valves and air release cocks or plugs. This plate shall also warn operators to refer to the Maintenance instructions before applying vacuum treatment; and

(d) Identification plates for the purpose of each removable inspection cover e.g. tap changer access etc.

The above plates shall be of stainless steel or brass.

External plates and labels shall be fixed by phosphor bronze, stainless steel or brass screws with 3 mm thick fibre washers at the front and back of the fixing holes. Tapping holes in transformer tank walls for fixing plates will not be accepted.

7.2.13.4.10 Cable Boxes

The auto-transformer cable boxes complete with cable glands shall be suitable for the termination of high voltage power cables.

Cable boxes shall be air insulated and manufactured to suit the termination of high voltage cables.

Cable boxes shall accommodate all cable joint fittings or sealing-ends required by the manufacturers of the cables, including stress cones or other approved means for grading the voltage stress on the terminal insulation of cables.

Provision for earthing the body of each cable box shall be made.

Cable boxes for three-core cable shall have seating sockets on the two outer phases inclined towards the centre to minimise bending of the cable cores. Where there is more than one core of cable per phase, the socket block configuration shall minimise bending of the cable cores.

7.2.13.5 HIGH VOLTAGE - POWER FACTOR CORRECTION CAPACITORS

The power factor correction capacitors for the high voltage chiller motors shall improve the overall power factor of the chiller motors to 0.95 lagging at rated output power. The kVAr rating of the capacitor shall not exceed 85% of the no load magnetising kVAr of the chiller motor.

Specific requirements of the power factor correction capacitors shall be as follows: -

Type	:	Low loss dielectric type, indoor and enclosed in floor-mounted cubicles;
Rated Capacity	:	To suit the power factor to be improved;
System voltage	:	3.3 kV, 6.6 kV or 11 kV as specified;
Frequency	:	50 Hz;
Connection	:	Delta-connected single-phase units;
Insulation Level	:	45 kV peak impulse voltage for 1/50 microseconds; and
Protection	:	3 line connected high voltage HBC fuses to IEC 60282-1:2009/AMD1:2014 with striker pin.

The output ratings of the power factor correction capacitor may require modification subject to the no-load magnetising kVAr rating of the high voltage motors to be driven.

The power factor correction capacitors shall be provided with combined jacking and haulage lugs to facilitate positioning. The capacitors shall be externally finished where applicable in semi-gloss stoved enamel or cellulose.

The power factor correction capacitors shall be protected by high voltage high breaking capacity fuses with striker pins to IEC 60282-1:2009/AMD1:2014. The striker pin shall be arranged to operate an auxiliary contact to trip the starter circuit breakers.

The power factor correction capacitor cable box complete with cable glands shall be suitable for the termination of the high voltage power cables.

The Installation shall strictly follow the equipment manufacturer's recommendations.

7.2.13.6 HIGH VOLTAGE - POWER CABLES

7.2.13.6.1 General

All high voltage power cables shall be insulated with cross-linked polyethylene. The 3.3 kV power cables shall comply with IEC 60502-1:2004+AMD1:2009 CSV whereas 6.6 kV and up to 33 kV power cables shall comply with IEC 60502-2:2014. Where specified, cables shall be wire armoured and finished overall with a continuous outer sheathing of polyvinyl chloride (PVC).

All cables shall be manufactured for operation on a system earthed either direct or through resistance or reactance at one or more neutral points.

No straight through cable joints shall be installed without the approval of the Supervising Officer.

For identification the rating of the cable shall be impressed into the outer insulation at regular intervals.

The radius of each bend or change in direction in the route of a cable shall not be less than eight times the overall diameter of the cable or as technically recommended by the cable manufacturer whichever is more stringent.

7.2.13.6.2 Cross-Linked Polyethylene (XLPE) Cables

High voltage cross-linked polyethylene insulated (XLPE) cables shall be of the 1,900/3,300 V grade for 3.3 kV power cables, 3,800/6,600 V grade for 6.6 kV power cables and 6,350/11,000 V grade for 11 kV power cables.

Multi-core cables shall comprise stranded annealed copper conductors. The insulation shall consist of cross-linked polyethylene applied by extrusion, bedded in a minimum of two layers of suitable tape. Armouring, where specified, shall comprise a single layer of galvanised steel wires or aluminium strip and the cable shall be served with an extruded layer of PVC.

Single core cables shall comprise circular copper conductors and where armoured shall comprise non-magnetic aluminium wire or strip.

7.2.13.6.3 Conductors

Copper conductors shall be stranded and shall consist of plain annealed copper. Before stranding, the conductors shall be approximately circular in section, smooth, uniform in quality, free from scale, inequalities, spills, splits and other defects. There shall be no joints in the wire except those made in the base rod or wire before final drawing.

The term 'annealed' signifies that the wire before stranding is capable of at least 15 percent elongation without fracture, the test piece being not less than 150 mm and not more than 300 mm long.

The stranded conductor shall be clean and reasonably uniform in size and shape and its surface shall be free from sharp edges.

In the formation of shaped conductors containing less than 19 strands the same number of strands shall be used as for a circular conductor of equivalent area.

For conductors having 19 strands or more the number of strands shall be the same as in a circular conductor of equivalent area, subject to a maximum permissible variation of plus or minus one strand. All the strands in any given shaped conductor shall be of the same nominal size.

7.2.13.6.4 Cable Terminations

Cables shall be terminated in approved non-ferrous mechanical glands which comply with BS EN 62444:2013 complete with compression devices for securing the cable sheath. An armour clamp may be required for bonding to metal sheaths. Where the cables are installed in entirely dry situations, the gland shall have a compressible gasket or packing for securing the inner sheath and means of anchoring the armour. For cables installed wholly or partly in outdoor or damp conditions compressible sealing and clamping features shall be provided for securing the inner and outer sheaths and also the armour; barriers shall be incorporated to prevent the ingress of moisture. Other types of cable termination can be used subject to the approval of Supervising Officer.

SUB-SECTION 7.2.14

INTELLIGENT LIGHTING MANAGEMENT SYSTEM

7.2.14.1 GENERAL

Where specified in the Particular Specification or shown on the Drawings, Intelligent Lighting Management (ILM) System shall be provided for overall control of lighting system.

All materials and equipment of the ILM system shall be products of manufacturer certified under ISO 9001:2015 quality assurance standard. The ILM system shall be of proprietary product and have well-proven relevant local job references. For new ILM system which has not been installed before, demonstration on the performance of the ILM system shall be provided to the satisfaction of the Supervising Officer before approval of it.

7.2.14.2 SYSTEM REQUIREMENT

7.2.14.2.1 The ILM system shall consist of servers, user/operator workstations, router/gateway and/or interfacing unit, controllers, lighting control modules, field devices and distributed intelligence communication bus network that enables complete control, monitoring & configuration of the lighting system from the operator workstation. The user/operator workstation shall comprise of the followings: -

(a) Keyboard and mouse; and

(b) minimum 23" LED or LCD monitor display.

Where specified, the ILM system shall be controlled via web or mobile application.

7.2.14.2.2 Field devices shall include, but not limited to, local lighting control switches, dimming control switches, lighting scene controller, infrared/radio frequency receiver/transmitter, occupancy sensors, photocell and daylight sensors, venetian blind switches, air conditioning sensors and other devices as specified.

7.2.14.2.3 The ILM system shall be fully addressable and configured in a total system integrated approach, allowing the connected field devices be independently supervised by the intelligent lighting control modules.

7.2.14.2.4 The ILM system and equipment including the lightings shall be configured in high degree of flexibility in ease of extension, modification, adaptability and re-programming of the lighting installation by the building operator to cater for future addition, alteration and rezoning/re-grouping of lighting control.

7.2.14.2.5 The ILM system shall be a widely distributed intelligent system, any single point failure shall not impair the operation of the whole system.

7.2.14.2.6 The ILM system shall be of decentralised and non-master slave configuration having addressable lighting control modules widely distributed throughout the areas as specified for connection of lighting fittings, lighting circuits and various field devices to suit the lighting control requirements. With the distribution of lighting control modules amid the lighting fittings and/or lighting circuits, the control of its connected lighting fittings and field devices shall be effectively performed under direct supervision of the lighting control module.

7.2.14.2.7 The ILM system shall be capable of interfacing with CCMS/ iBMS via high-level interface such that the CCMS is allowed under password-authentication to retrieve various lighting control parameters without direct access to the workstation of the ILM system.

7.2.14.2.8 Where specified, the ILM system shall be capable of interfacing with the control of air-conditioning units, such as variable air volume box or fan coil unit, etc. in such a manner that the aforesaid air-conditioning units can be automatically switched Off/On or reset temperature set-point when "No occupant" is detected by the occupancy sensor or the local lighting switch is switched off.

7.2.14.2.9 The ILM system shall be provided with maintenance by-pass or other similar feature so that the lighting fittings can be locally isolated for "ON" switching in case of ad-hoc need, emergency or equipment failure.

7.2.14.2.10 The lighting management software shall include simple to use diagnostics for checking the correct operation of the system, enabling the user, through multi-level password protection, to access Graphical User Interfaces (GUI's) for the following settings: -

(a) to programme "Time Events" of individual or group of lighting fittings;

(b) to programme "Holiday Events" of individual or group of lighting fittings; and

(c) to programme the "Scene Settings" of group of lighting fittings.

7.2.14.2.11 The ILM system shall allow the building management to gain control of the lighting management, including viewing of operation status of the connected lighting, graphic display of geographical locations of lighting fittings and field devices and energy consumption report from the operator workstation, web or mobile application as specified.

7.2.14.2.12 Where specified for situation requiring high flexibility of grouping/zoning of lighting control, the lighting control system shall be of digital addressable type. This lighting control system interface shall employ digital communication protocol for interchange of data information amongst its connected field devices and electronic ballast. Full system compatibility with electronic ballast or driver in conformance with relevant standards under Sub-section 7.2.7 or 7.2.9 shall be provided. The digital addressable lighting control system shall have minimum 64 individual addresses, 16 group addresses and 16 scene light value settings. For large scale of lighting control installation where the number of address point exceeds 64 nos., the digital addressable lighting control system shall work in conjunction with the ILM system platform specified in this section.

7.2.14.3 COMMUNICATION BUS

The communication bus shall be of Cat 5 unshielded twisted pair (UTP) cable or similar to be approved by the Supervising Officer. The communication bus shall be of low smoke zero halogen type. Where the ILM system of digital addressable type is specified, the communication bus shall be of the type as recommended by the system manufacturer.

The communication bus shall be 'free topology' structure, allowing connections looping from one field device to another or branching at any point over the communication bus. New field devices shall be allowable to be added freely over the communication bus without the need of system re-configuration.

7.2.14.4 LIGHTING CONTROL MODULES

Lighting control module shall be microprocessor based having intelligence and be able to continue to operate all local control functions in the event of failure of any higher hierarchy control systems.

Lighting control module shall be equipped with input/output relays, overcurrent protective devices, channels/modules for receiving wiring connections of field devices and lighting fittings. Each channel shall be individually addressed and programmable to control lighting circuit over the communication bus. Number of input/output channels required to be provided in lighting control module shall depend on the contract requirement. Unless otherwise approved by the Supervising Officer, number of lighting fittings connected to each of the controllable channels shall not be more than two (2) in order to allow a high flexibility of configuration of lighting zone/group.

Appropriate software shall be resided in the lighting control module for performing direct digital control of connected field devices and lighting without the support from the operator workstation.

SUB-SECTION 7.2.15

ELECTRIC VEHICLES CHARGING FACILITIES

7.2.15.1 GENERAL

Electric vehicle (EV) charging facilities shall comply with the relevant requirements of the Electricity Ordinance (Cap. 406), its subsidiary Regulations and Code of Practice for the Electricity (Wiring) Regulations. Electrical work on EV charging facilities including installation, commissioning, inspection, testing, maintenance and modification shall be carried out by Registered Electrical Contractors and Registered Electrical Workers of the appropriate grade. The classification of charging mode shall refer to Code of Practice for the Electricity (Wiring) Regulations.

The EV charging facilities installation shall be selected and erected to conform to the following relevant standards or other similar recognised international standards: -

IEC 61851-1	:	General requirements;
IEC 61851-21-1	:	Electric vehicle on-board charger EMC requirements for conductive connection to A.C./D.C. supply; and
IEC 61851-21-2	:	Electric vehicle requirements for conductive connection to an A.C./D.C. supply - EMC requirements for off board electric vehicle charging systems.

7.2.15.2 FINAL CIRCUIT

Each final circuit of EV charging facility shall be installed as a separate radial circuit of the fixed electrical installation. Electric cable for the final circuit shall be protected by means of metal sheath or armour, or installed in conduits.

7.2.15.3 PROTECTIVE DEVICE

Each final circuit shall be individually protected by a high breaking capacity (HBC) fuse or miniature circuit breaker (MCB) of suitable rating.

An earth leakage protective device shall be provided for each final circuit. Either a residual current operated circuit-breaker with integral over-current protection (RCBO) or residual current device (RCD) with characteristics of type A and residual operating current not exceeding 30mA is acceptable.

A current breaking device (an ON/OFF switch or others) shall be provided at the upstream of the socket outlet at the charging facility for switching on after plugging and switching off before unplugging the charging cable assembly.

7.2.15.4 SOCKET OUTLET AND CONNECTORS

The EV charging facilities shall be installed in accordance with IEC 61851 or equivalent. Socket outlet and associated electrical equipment shall be suitably protected from ingress of dust and water to an index of protection of IPX3 for use at indoor car park. If the EV charging installation is for outdoor use, the equipment shall be selected with a degree of protection of at least IP44 in accordance with IEC 60529:1989/AMD2:2013/COR1:2019 to protect against water splashes and the ingress of very small objects respectively. One socket outlet or connector shall supply only one EV. No extension unit other than charging cable assembly specifically manufactured for EV charging shall be used.

The socket outlets or connectors shall comply with the following standards or equivalent: -

IEC 60309	:	Plugs, socket-outlets and couplers for industrial purposes
IEC 62196-1	:	Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 1: General requirements
IEC 62196-2	:	Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 2: Dimensional compatibility and interchangeability requirements for A.C. pin and contact-tube accessories
IEC 62196-3	:	Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 3: Dimensional compatibility and interchangeability requirements for D.C. and A.C./D.C. pin and contact-tube vehicle couplers

An electrical or mechanical system shall be provided to prevent the plugging/unplugging of the plug unless the socket-outlet or the vehicle connector has been switch off from the supply.

7.2.15.5 PROTECTION FOR SAFETY

The EV charging facility shall be installed in a position to minimise the likelihood of vehicle impact damage.

A means of isolating the EV charging equipment circuit shall be provided. This isolating device shall be located in a position that is readily accessible for maintenance purposes and shall be suitably identified by marking and/or labelling.

A current breaking device (an ON/OFF switch or others) shall be provided at the upstream of the socket outlet at the charging facility for switching on after plugging and switching off before unplugging the charging cable assembly.

Except for circuits using the protective measure of electrical separation, each charging point shall be protected by its own RCD of at least Type A, having the characteristic specified in Code 11J of Code of Practice for the Electricity (Wiring) Regulations.

Each charging point incorporating a socket outlet or connector complying with the IEC 62196 series, protective measures against D.C. fault current shall be taken, except where provided by the EV supply equipment. RCD Type B or RCD Type A with appropriate equipment that provides disconnection of the supply in case of D.C. fault current above 6mA shall be provided for each connection point.

SUB-SECTION 7.2.16

POWER QUALITY MONITORING SYSTEM AND BUILDING ENERGY MANAGEMENT SYSTEM

7.2.16.1 POWER QUALITY MONITORING SYSTEM

7.2.16.1.1 The Power Quality Monitoring (PQM) System shall comprise microprocessor based digital protection relays, digital power analysers, digital multifunction power meters, high performance communication bus and system software to measure and record various electrical parameters including, but not limited to the followings: -

(a) Current for each phase

(b) Neutral current

(c) Percentage of current unbalance

(d) True RMS value of phase-neutral voltage for each phase

(e) Active power, kW for each phase and three-phase total

(f) Reactive power, kVAr for each phase and three-phase total

(g) Apparent power, kVA for each phase and three-phase total with instantaneous and average over configurable time periods

(h) Frequency, Hz

(i) Power factor

(j) Total harmonic distortion for voltage and current

(k) Total energy consumption of building with On/Off peak (kVA)

(l) Real time electricity consumption from meters (kWh)

(m) Maximum and minimum current demand

(n) Over voltage

(o) Voltage dip

7.2.16.1.2 Digital power analysers and/or digital multifunction power meters shall be provided according to the requirements as stated in relevant sections of this General Specification and networked by digital possessing devices via a common network protocol to PQM system. Requirements of the digital power analysers, digital multifunction power meters and energy meters shall refer to relevant sections of this General Specification.

7.2.16.1.3 For high complexity projects, PQM system shall also be able to capture the following power quality phenomena: -

(a) Sag / swell monitoring and capture

(b) Transient detection in about 130ms

(c) Symmetrical component recording, zero, negative and positive

(d) Sampling rate, max. sample per cycle to be 128

(e) 3-Phase vector diagram display

(f) Transient detection that can detect CBEMA (Computer Business Equipment Manufacturer's Association) Type 1 disturbances, with duration of 75uS to 20mS for 50Hz

(g) Waveform

(i) Triggered by setpoint, schedule, and / or external signal;

(ii) Setpoint, min response time to be 0.5 cycle;

(iii) Min /Max logs for any recorded parameters;

(iv) Waveform logs 96 cycles; and

(v) Resolution of log 0.001 resolution in second

7.2.16.1.4 A comprehensive monitoring of the entire electrical infrastructure by combing the functions of digital power analysers, digital multifunction power meters and digital protection relays shall be performed by the PQM system.

7.2.16.1.5 The PQM system shall also interface with digital protection relays, circuit breakers and other necessary accessories installed in Switchboard and allow all its signals be relayed to, displayed and analysed by the PQM system. Operating status and trip alarm status of protection relays and ACBs of Switchboard shall be comprehensively displayed in form of schematic graphic format at operator workstations. In addition, a separate audio and visual alarm signal shall be provided in areas where the operator workstations / central terminal are installed. In case of occurrence of circuit trip alarm, the PQM system shall initiate the alarm signal for alerting the building operators.

7.2.16.2 BUILDING ENERGY MANAGEMENT SYSTEM

7.2.16.2.1 Building Energy Management (BEM) system shall be provided for, including but not limited to, lighting installation, air-conditioning installation, fire service installation, broadcast reception installation, burglar alarm and security installation, lift and escalator installation, emergency generator installation, electronic installation, gondola installation, information technology installation, telecommunication etc.

7.2.16.2.2 Unless the BEM system is integrated with PQM system, the BEM system shall interface with PQM system to obtain data collected from digital power analysers / digital multifunction power meters for calculating the energy sharing by all users of shared or common facilities and for energy monitoring and audit.

7.2.16.2.3 Digital energy meters shall be provided and networked to BEM system for calculating the electricity consumption of each floor/functional area so that apportionment of electricity charges for each floor/functional area of the buildings can be obtained.

7.2.16.2.4 BEM system shall also interface with CCMS for collection of energy consumption of chilled / heating water distribution of air-conditioning installation. The BEM system shall accord the monthly electricity consumption to calculate proportioned chilled/heating water energy consumption of each A/C equipment including but not limited to AHU, PAU, fan coil units, etc. In addition, the BEM system shall be able to calculate the monthly energy consumption performance of the central chiller plant in term of coefficient of performance.

7.2.16.2.5 The stored local energy data shall be downloaded to the BEM system server for data consolidation and energy analysis. The recorded energy data from the BEM system shall correlate with the recorded monthly electricity consumption readings of the power utility company. The BEM system shall analyses the energy usage pattern of all building services system for each user group and/or department of each floor based on the collected energy data including but not limited to the followings: -

(a) lighting power (normal/essential/emergency);

(b) other equipment power (normal/essential);

(c) air conditioning equipment power (normal/essential) (air-side/water-side);

(d) air conditioning equipment for chilled / heating water distribution which are collected from CCMS; and

(e) other systems (normal/essential).

7.2.16.2.6 The BEM system shall also perform the following analysis: -

(a) Analyse the coefficient of performance of central chiller plant;

(b) Analyse electricity generation by photovoltaic installations and / or other renewable energy technology installations;

(c) Allocate the energy cost for each of the user group and/or department in the format of hourly, daily, weekly, monthly, bi-monthly and annually basis;

(d) Provide energy data enquiry for Office hour, Non-Office hour, On-Peak and Off-Peak usage after the configuration of tariff scheme; and

(e) Provide grouped 30 mins max demand simulation and analysis.

7.2.16.2.7 The BEM system shall provide real time energy consumption status for each user group and/or department of each floor. An alarm notification of excessive energy consumption shall be provided upon exceeding the set point which could be predetermined by the building management for each of the user group and/or department.

7.2.16.2.8 The BEM system shall be capable of allowing the building operator to generate monthly report of building electricity consumption for review by the building management handily. The report shall include but not limited to the following information: -

(a) Energy charge and usage from the electricity bill record with different cut-off date from each month;

(b) Building electricity consumption, including energy apportionment of chilled water and heating water supply of central air-conditioning plant, for each of the user group and/or department;

(c) Line chart, bar chart and pie chart and raw energy data export;

(d) User defined charting based on users' formula and the collected energy data;

(e) Energy Utilisation Index and Energy Performance Index for energy audit;

(f) Loaded energy and correlated energy tables for cross checking with monthly end user report ; and

(g) Export / transmit data to servers / database as specified via intranet outside the building.

7.2.16.2.9 The Works shall include the liaison with all parties on the transfer of energy data to the BEM system for proper apportionment of the building energy consumption for each user group and/or department. Appropriate transducers, current transformers, communication ports and associated accessories to facilitate the communication interface shall be provided.

7.2.16.2.10 The PQM and BEM system could be combined into one system subject to full system compliance with the requirements as stated in this Section.

7.2.16.3 SYSTEM REQUIREMENTS

7.2.16.3.1 Operator workstations for PQM/ BEM system servers shall be provided in main switch room, management office, maintenance office or other areas as required by the Supervising Officer and/or specified in the Particular Specification. Sufficient interfacing marshalling cabinets shall be allowed near the PQM / BEM system workstation for wiring interface between different installations / systems.

7.2.16.3.2 The PQM operator workstation shall provide comprehensive information (in the format of graphic and text mode) of the operating condition for each electrical switchgear, including but not limited to digital power analysers, digital multifunction power meters, circuit breakers and digital protection relays. The provision of local operator terminal shall ease the operator to effectively overview the condition of the entire electrical distribution system on the graphic user interface display.

7.2.16.3.3 For the BEM operator workstation, the analysed data shall be displayed in an interactive versatile graphic display to ease the building management in monitoring of the energy consumption pattern and view in details the trending of energy consumption profile for each user group and/or department, and each of the BS/E&M installation.

7.2.16.3.4 The PQM / BEM system shall be able to expand memory and enhance programming language and to upgrade all existing controllers and all other associated equipment without interrupting its operation. The system shall be able to expand 20% of the system hardware and software points without adverse effect on the system performance. The installations shall be expandable at all levels as described above using the same software interface that replacement of either the workstation software or field controllers are not required.

7.2.16.3.5 The energy & power quality data shall be trended every 15 minutes and include hourly, daily, monthly and annual data. The monitoring facilities shall be capable of maintaining all data collected for a minimum of 36 months continuously without downloading for back up storage. Each of these local digital processing device shall be equipped with sufficient memory and 1-hour battery backup.

7.2.16.3.6 The network shall be capable of integration of the open system protocols such as BACnet, Modbus, etc. All equipment using BACnet system shall conform to ANSI/ASHRAE Standard 135-2016 "A Data Communication Protocol for Building Automation and Control Networks (BACnet)" and associated addendum with relevant BACnet Device Profiles and Families as stipulated in this General Specification.

7.2.16.3.7 All system software including operating software and the third parties software shall be installed, initialised, started-up and debugged. All necessary revisions / updates to the software as required to provide a complete and operable system shall be covered.

7.2.16.3.8 The mobile application accessibility of the PQM / BEM system shall comply with the 'Mobile Application Accessibility Handbook' issued by OGCIO for access, analysis and information sharing in mobile devices.

7.2.16.3.9 The PQM / BEM servers and operator workstations shall comprise, but not limited to, the following hardware: -

(a) Computer capable to meet the requirement of the PQM / BEM software;

(b) Mouse and keyboard;

(c) Minimum 23" monitor;

(d) UPS capable of backup for more than 1 hour of operation for the PC, monitor as well as other UPS connected equipment;

(e) A 16-bit/full duplex audio system c/w speakers; and

(f) Other hardware as specified in the Particular Specification.

7.2.16.3.10 All equipment, where applicable, shall have obtained a Recognition Type Energy Label under the Energy Efficiency Labelling Scheme of EMSD.

7.2.16.3.11 The PQM/BEM system shall be able to connect, communicate and interoperate with the Integrated Building Management System (iBMS) at remote site via BACnet open communication protocol.

7.2.16.3.12 The PQM/BEM system shall, through BACnet controllers, exporting system data under an authentic protocol that interfaced with other systems as directed by the Supervising Officer. All relevant data of the system architecture shall be submitted to the Supervising Officer for approval. The point abbreviation and definition shall be proposed for Supervising Officer's approval prior to the setup of the BACnet controllers.

7.2.16.3.13 Detailed requirements of the iBMS enabling works including but not limited to the demonstration of compatibility, software, data interfacing, BACnet controllers, testing and commissioning shall refer to relevant sections of this General Specification and Particular Specification.

SECTION 7.3

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 7.3.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

7.3.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

7.3.1.2 TESTING OF EXTERNAL LIGHTING

Testing of the illumination level and distribution of external lighting installations shall be carried out after dark under the direction of the Supervising Officer. All labour, instruments and materials necessary to carry out the test shall be provided including adjustment of the luminaires to achieve the desired illumination level and performance to the satisfaction of the Supervising Officer.

7.3.1.3 TESTING OF LIGHTNING PROTECTION SYSTEM

On completion of the installation, the lightning protection system shall be tested for continuity between air terminations and earthing terminations and the resistance shall be recorded. The earthing resistance of each earthing electrode shall also be tested and recorded.

All instruments used for testing shall be properly calibrated.

7.3.1.4 TESTING OF SWEEP FANS

Sweep fans shall be subject to function test for not less than 72 hours of continuous running and shall show no abnormal conditions such as overheat, failing to oscillate and, etc. during the testing period.

7.3.1.5 INSPECTION AND TESTING FOR LOW VOLTAGE CUBICLE SWITCHBOARD INSTALLATION

7.3.1.5.1 Testing before Connection of Power Supply

The following tests shall be carried out after completion of installations of the Switchboard and before the connection of the incoming supply cable: -

(i)	Dielectric Test	:	This shall be carried out at power frequency as defined in IEC 61439-1:2011;
(ii)	Insulation Test	:	This shall be carried out by means of a 1,000 V "Megger" tester or similar instrument;
(iii)	Secondary Injection Test	:	This shall be carried out using AC and shall check (approximately) that protection relays or devices function in accordance with their performance curves by a test at the lowest setting and two further tests of current and timing;
(iv)	Primary Injection Test	:	This shall be carried out to prove the correct operation of protective devices or system when set at the agreed setting;
(v)	Polarity Check for CT	:	This shall be carried out to ensure that all CTs are correctly connected;
(vi)	Functional Test	:	This shall be carried out to ensure that all devices operate properly as intended;
(vii)	Contact Resistance Test	:	This shall be carried out by means of "Ductor" tester or similar instrument to ensure that contacts and joints for switchgears, cables, busbars as well as the contacts and joints for outgoing cables and busbars are maintained in good condition; and
(viii)	Temperature Rise Limits Test	:	This shall be carried out according to clause 10.10.2.3.5 of IEC 61439-1:2011.

Note: Tests (i) to (iii) and (v) to (vii) must be carried out on site and tests (iv) and (viii) can be carried out in factory.

7.3.1.5.2 Testing after Connection of Supply

The following tests shall be carried out after the incoming supply cables are connected and the "Switchboard" successfully commissioned on no load: -

- Phase-to-phase voltage test;
- Phase-to-neutral voltage test;
- Phase-to-earth voltage test;
- Neutral-to-earth voltage test; and
- Phase sequence test on each and every outgoing circuit.

All tests shall be witnessed by and carried out to the satisfaction of the Supervising Officer and all test results must be submitted in quadruplicate to the Supervising Officer for record purposes.

7.3.1.6 TESTING OF DIESEL GENERATING SET

7.3.1.6.1 Testing of Diesel Generating Sets

(a) The complete and fully assembled diesel generating set shall also be tested at the manufacturer's works before despatch, including full operating tests as well as tests on control, protections such as over-voltage protection, under-voltage protection, engine over-speed protection and protection device overload trip, alarms, governor trials and fuel consumption tests, and tests showing the step load acceptance capability, in accordance with the relevant British Standard Specification.

(b) The performance tests for all equipment and systems installed shall be tested in accordance with "Testing and Commissioning Procedure for Emergency Generator Installation in Government Buildings of the HKSAR". This shall include the necessary adjustment and setting of all controls, checking the operation of all overload protection and safety devices and the commissioning of the completed installation.

(c) All apparatus, fuels, tools and instruments necessary for testing the installation shall be available. Test methods and measurements shall be in accordance with ISO 8528-6:2005. All readings given by the measuring instrument shall be in S.I. units.

(d) Diesel fuel, water, lubricants etc. shall be provided for all tests including dummy load test, actual load test and other fire service

test. Sufficient quantities of these consumables shall be topped up before carrying out such tests. Two additional fire service tests shall be allowed following satisfactory completion of dummy load tests.

(e) Four copies of certified results of the tests are required to show that the installation of diesel generating set has been tested and commissioned.

(f) Sound pressure level measurement, with octave band frequency analysis shall be conducted.

7.3.1.6.2 Testing of Control Cubicle

(a) Performance tests for Control Cubicle shall be conducted in accordance with "Testing and Commissioning Procedure for Electrical Installation in Government Buildings of the HKSAR".

(b) Electrical resistance test (Ductor Test) and temperature rise test for the control cubicle shall be carried out before the cubicle is accepted and energised. The test shall include the measurement of electrical resistance for all joints, connections and internal resistance of protective devices e.g. ACB, MCCB, F/SW etc. All instruments used inclusive of make, serial number shall be recorded and the results of the measurements shall be properly documented.

7.3.1.6.3 Testing of Daily Service Tank, Fuel Storage Tank and Pipework

(a) The daily service tank, fuel storage tank and the completed pipework shall be hydraulically tested for a period of time not less than 2 hours without undue deformation and leaking. The following test pressure shall be used: -

(i) 70 kPa for the daily service tank and the fuel storage tank; and

(ii) 700 kPa for the completed pipework, valves and fittings.

(b) Pressure gauges with full scale deflection readings more than 3 times the test pressures shall not be used. The pressure gauges employed in test shall be tested and calibrated by organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS and HKAS before use.

(c) Immediately after the hydraulic testing, the daily service tank and fuel storage tank must be drained and dried out and a thick coat of linseed oil or equivalent coating shall be applied on the interior surfaces of the tank to prevent rusting. All pipework, fittings and

valves after tests shall be drained, dried and flushed out with linseed oil to remove all traces of water to prevent rusting.

(d) The following information shall be permanently and clearly marked on a nameplate to be attached to daily service tank and fuel storage tank in an agreed position: -

(i) Installation contractor's company name;

(ii) Gross capacity in litres; and

(iii) Date of hydraulic test.

7.3.1.6.4 Testing of Noise Control System

After the completion of the acoustic installation, a sound pressure level measurement, with octave band frequency analysis, at the agreed points shall be conducted.

The method of measurement shall generally be in accordance with BS 4142:2014+A1:2019 or other technically equivalent national or international standards. Measurement shall be taken by an industrial grades sound level meter.

7.3.1.6.5 Testing of Exhaust Fan

The testing of Exhaust Fan and all accessories shall comply with the requirements in accordance with the Testing and Commissioning Procedure for Air-conditioning, Refrigeration, Ventilation and Central Control and Monitoring System Installation in Government Buildings of the HKSAR.

SUB-SECTION 7.3.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

7.3.2.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during Maintenance Period shall also comply with the specific requirements in this Sub-section.

Operation, servicing and maintenance of the Installations, if specified, shall also refer to the equipment manufacturer's recommendations and specifications.

7.3.2.2 PROVISION OF SPARE FUSES IN MAIN SWITCH ROOM

One complete set of spare fuses for each rating of switchfuse, fuseswitch and fuses in control circuit installed shall be supplied upon commencement of Maintenance Period. The spare fuses shall be hung on a wooden board fixed at a convenient position inside the main switch room.

The wooden board shall be smoothed on the front face and edges, and shall be painted to the approval of the Supervising Officer.

7.3.2.3 ROUTINE INSPECTION AND SERVICING

Routine inspection and servicing shall be carried out for the Installations. The scope shall include, but not limited to, the following: -

Infra-red scan of bus duct	:	3 months interval
Servicing of switchgear at L.V. switchboard	:	6 months interval
Calibration of the instruments of L.V. switchboard	:	6 months interval

A comprehensive maintenance schedule shall be submitted to the Supervising Officer for approval before the commencement of the Maintenance Period.

7.3.2.4 FINAL INSPECTION BEFORE THE END OF MAINTENANCE PERIOD FOR LOW VOLTAGE CUBICLE SWITCHBOARD

The following tests shall be carried out before the expiry date of the Maintenance Period or at a timing specified by the Supervising Officer if he considers that the electrical loads supplied by the LVSB at such time period is more representative of the full load condition, and defects so identified shall be rectified: -

Insulation Test	:	This shall be carried out by means of a 1,000V "Megger" tester or similar instrument.
Contact Resistance Test	:	This shall be required as determined by the Supervising Officer if the thermographic scanning below detects abnormal hot spots and the Switchboard needs to be overhauled, and be carried out after the overhaul by means of "Ductor" tester or similar instrument to ensure that contacts and joints for switchgears, cables, busbars as well as the contacts and joints for outgoing cables and busbars are maintained in good condition.
Functional Test	:	This shall be carried out to ensure that all devices operate properly as intended.
Thermographic Scanning	:	This shall be carried out to ascertain whether abnormal hot spots exist at the switchgears, cables, busbars, joints and other components of the Switchboard.

An Inspection and Test Report shall be submitted to the Supervising Officer within two weeks before the expiry date of the Maintenance Period. Such Inspection and Test Report shall incorporate records of the tests and state clearly also the following: -

(a) The LVSB is operated in good condition;

(b) The work carried out and any adjustments made during Maintenance Period; and

(c) Any recommendation on the necessary improvement or rectification on the LVSB.

The test and inspection shall be carried out with the prior approval of the Supervising Officer if such would require shut-down of the LVSB and the work may be carried out at any time outside normal hours as required by the Supervising Officer.

7.3.2.5 TESTING OF EMERGENCY LIGHTING, EXIT SIGN AND EMERGENCY GENERATOR INSTALLATIONS

Where there are emergency lighting, exit sign and emergency generator installations included in the Installations, the contractor carry out the electrical installation works shall be responsible for the following duties: -

(a) Confirmation to the contractor carrying out the fire service installation works on the completion and readiness of these installations for fire service inspection by FSD;

(b) Provision of drawings and necessary information to the contractor carrying out the fire service installation works for inclusion in the submission to FSD for comments and inspection;

(c) Co-ordination with the contractor carrying out the fire service installation works to inspect and witness the final tests of these installations and rectification of any works found not complying with the fire service requirements of FSD; and

(d) Co-ordination with the contractor carrying out the fire service installation works to carry out the final functional test and performance test under load conditions complying with the fire services requirements of FSD.

7.3.2.6 ELECTRICAL HEALTHY CHECK

Where there is an incomer circuit at or above 2000A in switchboard, the contractor carrying out the electrical installation works shall conduct the following studies according to the requirements stipulated in the ANSI/NETA ATS-2017: -

(a) Coordination Studies including Discrimination Protection Settings down to three levels of sub-main distribution boards and the related out-going circuits;

(b) Load-flow Studies for all branches and nodes in the switchboard; and

(c) Harmonic-analysis Studies for all branches and nodes in the switchboard.

The study report shall be submitted to the Supervising Officer within two weeks before the expiry date of the Maintenance Period.

The test and inspection shall be carried out with the prior approval of the Supervising Officer if such would require shut-down of the LVSB and the work may be carried out at any time outside normal hours as required by the Supervising Officer.

The study report shall be certified by the Registered Professional Engineer and the format shall be approved by the Supervising Officer.

The study report shall list out any abnormalities as compared with latest statutory requirements on electrical installation or manufacturer's suggestion and recommendations to address the abnormalities identified.

PART 8 – FIRE SERVICE INSTALLATION

SECTION 8.1

INSTALLATION AND EQUIPMENT REQUIREMENTS

SUB-SECTION 8.1.1

PIPEWORK, VALVES AND FITTINGS

8.1.1.1 STEEL PIPES AND FITTINGS FOR EXPOSED PIPEWORK

Pipes and fittings shall be sized to withstand at least 2 times of the working pressure and be tested to withstand at least 1.5 times of the working pressure. Working pressure is the maximum pressure anticipated during the working or operational period. In case a more stringent requirement is specified under the technical standards, rules and codes for individual Fire Service Installation, the requirement whichever is more stringent shall be followed.

For operation at working pressure on or below 1,600 kPa, pipes up to and including 150 mm diameter shall be galvanised mild steel of at least medium grade to BS EN 10255:2004, ISO 65:1981 or BS EN 10217-1:2019 for screwing to BS EN 10226-1:2004, ISO 7-1:1994, BS EN 10226-1:2004, BS EN10226-2:2005 and BS EN10226-3:2005 pipe threads. Fittings shall be to BS EN 10241:2000 or BS EN 10242:1995.

For operation at working pressure on or below 1,600 kPa, pipes and fittings above 150 mm diameter shall be ductile iron to BS EN 545:2010 with minimum thickness in full compliance with the following Table 8.1.1.1. The ductile iron pipes and fittings shall be coated externally with a layer of metallic zinc, covered by a finishing layer of a bituminous product to BS 3416:1991 Type II and lined internally with bitumen, cement mortar or other materials with equivalent functions and performance approved by the Supervising Officer.

Table 8.1.1.1 Minimum Ductile Iron Pipe & Fitting Thickness

Nominal Size DN (mm)	Class	Minimum Pipe & Fitting Thickness (mm)
80	100	5.62
100	100	5.8
150	100	6.35
200	64	6.9
250	64	7.45
300	64	8
350	64	8.55
400	50	9.1
450	50	9.65
500	50	10.2
600	50	11.3

For operation at working pressure above 1,600 kPa, pipes of or below 150 mm diameter shall be at least galvanised mild steel pipe of heavy grade to BS EN 10255:2004 or ISO

65:1981, or other materials with equivalent functions and performance approved by the Supervising Officer to suit the high-pressure requirement. Fittings shall be to BS EN 10241:2000 or BS EN 10242:1995 and the pressure rating of the fittings shall be greater than the system working pressure.

For operation at working pressure above 1,600 kPa, pipes above 150 mm diameter shall be at least carbon steel of grade P265TR1 to BS EN 10216-1:2013, BS EN 10217-1:2019 or other materials with equivalent functions and performance approved by the Supervising Officer to suit the high-pressure requirement and shall have dimensions to BS EN 10220:2002. All fittings shall be butt-welding type carbon steel for pressure purposes to BS EN 10253-1:1999 or BS EN 10253-2:2007.

For high-rise building or high-pressure system with working pressure above 1,600 kPa, pipes and fittings shall be of higher pressure rating to suit the worst operating conditions.

Selection of pressure number PN or pressure class of fittings, joints, and accessories shall be based on the weakest component of the fittings, joints and accessories such as seating, etc. to stand for the required test pressure (at least 1.5 times of working pressure). Details shall be submitted to the Supervising Officer for approval.

Where galvanised steel pipe is specified, the zinc content shall comply with BS EN ISO 1461:2009 or BS EN 10240:1998 by weight of zinc. The pipe shall have a complete uniformly adherent coating of zinc.

8.1.1.2 COPPER PIPEWORK

Where copper pipe is specified, the copper pipe shall comprise of seamless half hard (designation R250 in accordance with BS EN 1173:2008) copper tubes up to and including 28mm diameter and hard drawn (designation R290 in accordance with BS EN 1173:2008) copper tubes larger than 28mm diameter with both manufactured to BS EN 1057:2006+A1:2010 and of appropriate gauge to suit the working pressure of the system.

8.1.1.3 UNDERGROUND PIPEWORK

Pipes laid underground shall conform to one of the following specifications: -

(a) BS EN 10255:2004 or ISO 65:1981 - Steel tubes and tubular of heavy grade for screwing to BS EN 10226-1:2004, ISO 7-1:1994, BSEN 10226-1-:2004, BS EN10226-2:2005 or BS EN10226-3:2005 pipe threads, or

(b) BS EN 545:2010 - Ductile iron pipes and fittings, with minimum thickness in full compliance with Table 8.1.1.1. The ductile iron pipes and fittings shall be coated externally with a layer of metallic zinc, covered by a finishing layer of a bituminous product to BS 3416:1991 Type II and lined internally with bitumen or cement mortar or other materials with equivalent functions and performance approved by the Supervising Officer.

If not specified in the Particular Specification, for pipe diameter greater than or equal to 80mm, ductile iron pipes and fittings in item (b) above shall be used.

Ductile iron pipes laid underground shall be coated externally with a layer of metallic zinc, covered by a finishing layer of a bituminous product. Metallic zinc content shall be not less than 99.9% by mass. The zinc coating shall be applied at the manufacturer's works to the oxide skin of the pipe surface. The zinc coating shall cover the external surface of the pipe to a mean density of 200 g/m^2.

Mechanical pipe couplings of approved type that can provide the required allowance for angular deflection and contraction and expansion shall be used for joints in underground pipes unless otherwise specified.

The routing and details of all the underground piping shall be submitted to the Supervising Officer for approval.

8.1.1.4 PIPE SIZES

Where pipe sizes are stated in the Particular Specification or Drawings, this is intended to be the nominal bore in the case of steel tubes and the nominal outside diameter in the case of copper tubes.

8.1.1.5 JOINTS IN STEEL PIPEWORK

Joints in steel pipe shall be made in accordance with the following general requirements, using the accepted quality materials and skilled labour.

Flanged joints and flanged fittings shall be used for steel pipe of diameter larger than 150 mm. Flanged joints and flanged fittings shall also be used for steel pipe with working pressure higher than 1,600 kPa unless otherwise approved by the Supervising Officer.

All flanged joints and fittings used shall be of factory-applied flanges. Welded flanges fabricated on Site shall not be accepted unless otherwise specified. Flanges shall be raised face to BS EN 1092-1:2018, BS EN 1092-2:1997, BS EN 1092-3:2003 and BS EN 1515-1:2000. Flanges for steel pipes shall be wrought iron or annealed steel, machined full face and galvanised, suitable for the working pressures and test pressures to which they will be subjected. For flanged joint pipes, provisions shall be allowed and provided in the piping system to absorb all types of thermal movement, vibration, deflection and water hammering effect after installation.

Steel pipes less than or equal to 150 mm and operated at working pressure below 1,600 kPa shall be jointed with screwed fittings, screwed flanges, or screwed unions. Screwed joints shall have tapered threads to ISO 7-1:1994, BSEN 10226-1-:2004, BS EN10226-2:2005 or BS EN10226-3:2005 and shall be made with approved jointing material. Where the process of cutting of threads removes galvanisation, an approved cold galvanising finish shall be applied to restore the integrity of the pipe protective finish. All fittings shall be galvanised. Screwed fittings other than sockets shall be of galvanised malleable iron to BS EN 10242:1995. The pipes shall be fitted with screwed flanges for jointing valves and other equipment having flange connections.

Mechanical pipe couplings shall be employed for steel pipes of diameter larger than 50 mm up to 150 mm with working pressure on or below 1,600 kPa unless otherwise specified. For working pressure on or below 1,000 kPa, mechanical pipe couplings shall be of pressure class PN16, and for working pressure from 1,000 kPa to 1,600 kPa, the pressure class of mechanical pipe couplings shall be PN25.

For steel pipes of diameter larger than 50 mm up to 150 mm outside plant room when exposed to view, mechanical pipe coupling may be used only if prior approval is obtained from the Supervising Officer on its aesthetical appearance.

Flange adapter for plain-ended pipe shall not be used generally and may only be used for steel pipes of diameter larger than 50 mm up to 150 mm with working pressure on or below 1,000 kPa when approved by the Supervising Officer for connection to stationary equipment, apparatus and pipe fitting with flanged end.

The mechanical pipe couplings and its associated fittings shall be self-centred, engaged and locked in place onto the grooved or shouldered pipe and pipe fitting ends. The pipe connection shall result in a positive watertight couple providing reasonable allowance for angular pipe deflection, contraction and expansion. The housing clamps shall consist of two or more malleable iron castings, ductile iron or rolled steel segment and securely held together by two or more track head square or oval-neck heat treated carbon steel bolts and nuts with a composition water sealing gasket so configured that the internal water pressure will increase the water tightness of the seal.

All pipes fittings connected to mechanical pipe couplings shall be of galvanised steel, or ductile iron castings grooved or shouldered ended suitable for the pipe couplings. The grooves on pipe shall be roll-grooved, or as approved by the Supervising Officer, without the removal of any metal. Pipe grooving shall be formed in accordance with the mechanical pipe coupling manufacturer's latest specifications. Flanged or threaded end valves may be used with grooved adapters.

Couplings or flange adapters for plain-ended pipes shall be cast iron, ductile iron or steel, slip-on type, or as approved by the Supervising Officer: -

Coupling shall consist of: -

(a) Housing;

(b) Sealing rings or gasket; and

(c) Bolts and nuts.

Flange adapter shall consist of: -

(a) End flanges/sleeves;

(b) Gasket; and

(c) Studs or bolts and nuts.

Before couplings are assembled, pipe ends and outsides of gaskets shall be lightly coated with grease, graphite paste or lubricants in accordance with the manufacturer's recommendations to facilitate installation.

The entire mechanical pipe coupling installation shall be in accordance with the published manufacturer's recommendations and selected to withstand 2 times of working pressure of the pipe and be tested to 1.5 times of working pressure of the pipe. Where the pipes are laid underground, suitable mechanical pipe coupling of approved type that can provide the required allowance for angular deflection at ground settlement and contraction and expansion at changes of temperature shall be used.

Jointing of steel pipes by welding on site is only permitted where specified or with the expressed permission of the Supervising Officer. Only non-galvanised pipes of 50 mm bore or larger will be considered to be joined by welding on site.

Welding of steel pipes shall be in accordance with the recommendations contained in BS 2633:1987 and BS 2971:1991, and machined fully over the raised and flat faces.

Where visual inspection or test reveals a welding joint which is reasonably believed to be unacceptable, the Supervising Officer shall be entitled to have such welding examined by radiography or other approved inspection method and independently assessed at no extra cost. All unacceptable works shall be rectified to the satisfaction of the Supervising Officer.

8.1.1.6 JOINTS IN COPPER PIPEWORK

Joint fittings for copper pipes of diameter up to and including 54 mm shall be of the capillary or compression type to BS EN 1254-1:1998 and BS EN 1254-2:1998. For copper pipework above 54 mm, fittings shall be of the capillary type joint. Only non-corrosive type of flux shall be used for jointing.

Brazing for copper pipes shall be in accordance with the recommendations contained in BS EN ISO 10564:1997.

Where visual inspection or hydraulic test reveals a welding joint which is reasonably believed to be unacceptable, the Supervising Officer shall be entitled to have such welding examined by radiography or other approved inspection method and independently assessed at no extra cost. All unacceptable works shall be rectified to the satisfaction of the Supervising Officer.

8.1.1.7 DISMANTLING FACILITIES

All pipe runs shall be arranged for ease of dismantling, servicing, repair, replacement, and re-erection. At dismantling points or where the pipe is connected to an appliance, ground-in spherical seated unions shall be used for pipe up to 50 mm diameter and flanges shall be used for pipework at 65 mm diameter and above.

Disconnecting flanges, mechanical pipe coupling or screwed unions, as applicable, shall be provided at suitable locations and at all valves and equipment, for ease of dismantling for maintenance and replacement.

Unions shall be of ground-in spherical seated type with hexagon bodies. Unions for steel pipes shall be of forged steel heavy-duty pattern and unions for copper pipes shall be of gunmetal. The flanged joints shall be to ISO 7005-1:2011, ISO 7005-3:1988, BS EN 1092-1:2018 or BS EN 1092-2:1997 of appropriate type and made with flat ring gaskets suitable for the pressure and temperature and extending to the inside of the bolt circles.

For non-welded pipework, connections shall be by means of screwed fittings, flanges or unions. The use of 'long screws' will not normally be permitted. Flanges shall be completed with appropriate gaskets, nuts, bolts and washers for connecting up all plant and equipment such that it can easily be removed for servicing or replacement.

8.1.1.8 PIPEWORK INSTALLATION

Pitcher tees, bends, twin elbows etc. of pipework installation shall be of the same size as the pipes connected to them. Bushings shall not be used. Square tees shall only be used where short sweep fittings would cause air to be trapped. Long radius elbows shall be used in order to minimise hydraulic resistance and reduce turbulence. Short radius elbows may be used for pipe size up to 50 mm diameter, and for pipes installed inside false ceiling or inside concealed void with limited spaces. Short radius elbows for pipe larger than 50 mm diameter in areas other than the spaces inside false ceiling and concealed void may be used subjected to the approval by the Supervising Officer where long radius elbows will not fit within a limited space or are not manufactured.

Tubes shall be reamed after cutting and shall be free from burrs, rust, scale, and other defects and shall be thoroughly cleaned and treated for corrosion protection before and after erection.

Open ends left during the progress of the work shall be properly blanked off with approved metal or wood plugs or blank caps or counter flanges.

Joints shall not be made in the thickness of any wall, floor or ceiling.

Pipework shall follow the contours of walls. Venting pipes and drain pipes shall be suitably graded to ensure proper venting and draining. Generally, pipework shall avoid running near to or above electrical equipment, electrical appliances, cables, trunkings and conduits. The clearance between pipework and the wall and any other fixtures shall be not less than 25 mm.

Where two or more pipe runs follow the same route, all pipes shall run parallel with one another and to the building structure without prejudice to the necessary allowances for venting, drainage or other reasonable restrictions.

Pipework connections to the suction and delivery outlets of pumps and other vibrating machines shall be isolated from such sources of vibration by means of anti-vibration devices with allowable stress levels as per PD 5500:2018.

The anti-vibration devices or couplings shall be of flexible metallic hose with corrugated seamless hose body. They shall be of the annular and close-pitched type as per following unless otherwise specified: -

(a) For all ferrous applications, the hose body and the braid shall be manufactured from stainless steel materials. End terminations shall be carbon steel threaded male nipples to BS EN 10226-1:2004 for 65 mm size and below and flanges to BS EN 1092-1:2018 or BS EN 1092-2:1997 for 75 mm and above.

(b) For copper or non-ferrous pipes, the hose body and the braid shall be manufactured in bronze throughout. End terminations shall be copper female ferules suitable for soldering.

The anti-vibration devices shall be capable of attenuating the vibration of the plant such that the bulk of the vibrations are prevented from being transferred to the pipework. The length of the flexible metallic hoses shall be in accordance with the manufacturer's recommendation.

Wherever anti-vibration devices are installed, the adjacent pipework shall be adequately supported by guide type brackets.

8.1.1.9 PIPEWORK SUPPORTS

All pipework shall be properly supported with substantial hangers, anchors, brackets, saddles, guide etc. with adequate provision for expansion and contraction and for corrosion protection.

Pipework supports shall be arranged as close as practicably possible to joints and changes of direction and each support shall take its share of the load. The spacing of the supports shall not exceed the values given in Table 8.1.1.9.

Table 8.1.1.9 Spacing of pipework support for mild steel and copper pipes

Nominal pipe size, mm	Spacing for vertical runs, m	Spacing for horizontal runs, m
Mild Steel		
15	2.5	2
20 and 25	3	2.5
32	3	3
40 and 50	3.5	3
65 and 80	4.5	3.5
100	4.5	4
125	5	4.5
150	5	5
200 and above	7.5	7.5
Copper		
15	1.5	1
22 and 28	2	1.5
35 and 42	2.5	2
54	3	2.5
76, 108 and above	3.5	3

Vertical rising pipework shall be supported at the base, or as indicated, to withstand the total weight of the riser. Branches from risers shall not be used as a means of support for the riser. If such base has to be rested on an intermediate floor slab, particular attention shall be drawn to the Supervising Officer for structural reinforcement to the floor slab and also allowed for additional treatment to the base as required by the Supervising Officer.

Where pipework up to 50 mm is fixed to solid structure, brackets may be of the screw-on or long shank built-in type. Fixings to timber or to light-weight structure shall be of screw-on pattern. Brackets and supports for mild steel tube shall be galvanised steel or malleable iron and galvanised. Brackets for copper tubes shall be brass or gunmetal. The pipe clip shall be detachable without disturbing the fixing.

Brackets screwed to walls shall be securely fixed by expanding plugs of adequate size or other purpose-designed fixing devices of non-combustible materials. Wood plug is not permitted.

Pipework of 65 mm size and larger subjected to expansion and contraction shall be suspended on swivel hangers or hangers having equivalent functions and performance to cater for expansion and contraction. The pipe hangers and supports shall be galvanised steel or approved materials for supporting the load of all the pipes filled with water.

Hangers for horizontal pipework at high level shall be supported from angle or channel galvanised irons supplied and installed and suitable for building-in or otherwise secured to the structure. Tee hangers supported on two legs instead of one-leg angle hangers shall be used. Adjustable galvanised steel hangers shall be used. Pipe rings shall be of malleable iron or fabricated steel and galvanised, made in halves and secured by bolts or machine screws. Alternatively, galvanised malleable iron hinged pipe rings may be used. Calliper type hook is not permitted.

Where integral pipe hangers or supports are required for housing the fire service pipes and pipes for other services, the integral pipe hangers or supports shall be of material and type approved by the Supervising Officer and supplied by one manufacturer with all the accessories. Structural and load calculation shall be submitted for approval. The laying of pipes on the integral pipe hangers or supports shall be fully co-ordinated with other services before installation so that every pipe on the hanger is accessible for maintenance and future inspection.

8.1.1.10 EXPANSION JOINTS

8.1.1.10.1 General

Expansion joints shall be of metallic type fitted for all pipework passing through building expansion joints and where necessary as specified. All expansion joints shall be manufactured with a long cycle life to suit a pipe system with at least 20 years life expectancy and be installed properly without misalignment.

Non-metallic flexible connector of single sphere or double sphere type made from rubber, EPDM, fabric or similar materials shall not be used for the expansion joint.

8.1.1.10.2 Axial Movement Pattern

Axial pattern bellow expansion joints shall have screwed or flanged ends as appropriate to facilitate replacement. They shall incorporate internal liners if required and shall be manufactured from BS EN 10088-1:2014 No. 1.4401 stainless steel or other materials with equivalent functions and performance to the approval of the Supervising Officer and shall capable to withstand at least 2 times of the system pressure. External protective sleeves shall be fitted.

End termination to be carbon steel threaded male to ISO 7-1:1994 or carbon steel flanges to ISO 7005-1:2011 or BS EN 1092-1:2018 to suit the line pressures.

For copper or non-ferrous pipes, expansion joints shall be manufactured in stainless steel throughout. The bellow expansion joints shall be installed with pre-cold setting to their required length to suit the temperature condition at the time of installation. The joints shall be rated suitable for the required amount of designed axial movement and shall be capable of performing the required cycles to suit a pipe system with at least 20 years life expectancy. Mild steel outer protection sleeves shall be fitted to the bellows only when the units are open to the environment and exposed to risk of damage or when it is necessary to carry lagging over the joint.

Units shall be installed in strict accordance with the manufacturers' recommendations. Manufacturers of expansion joints shall be approved to BS EN ISO 9001:2015.

8.1.1.10.3 Angular or Lateral Movement Pattern

These bellow expansion joints shall generally comply with the requirement of anti-vibration devices or couplings as specified in this General Specification. Hinge and shackle or centre joining tube, tie bars and spherical nut arrangement shall be carbon steel to ISO 9692-1:2013 to contain the pressure thrust. End termination shall be flanged to ISO 7005-1:2011 or BS EN 1092-1:2018 to suit the line pressures.

The joints shall meet the required angular movement or the required movement in all directions perpendicular to the axis of the bellows.

8.1.1.10.4 Provision for Anchors and Guides

Anchors and guides shall be installed according to the recommendations of the expansion joint manufacturer and the details shall be submitted to the Supervising Officer for approval before manufacture commences.

(a) Anchors

Allowances shall be made for anchors capable of withstanding the maximum stresses created within the pipework system, and have

adequate safety margin. These shall be positioned as indicated on the layout drawings or as necessary shop drawing/details.

For steel pipework, the pipes shall be welded to the anchors using heavy steel straps. For copper pipework, the pipes shall be brazed to the anchors using heavy copper straps.

(b) Guides - Axial Movement Pattern

The pipework shall be guided along its length and the guides shall be capable of withstanding not less than 15% of the maximum stresses created within the pipework system and have an adequate safety margin.

Guides shall be adjustable in both directions in the lateral plane, so that pipework can be accurately aligned with the expansion joint.

Each guide shall not be less than 2 pipe diameters' long and shall have a minimum manufacturing clearance of the pipe diameter.

The distance from the expansion joint to the first guide shall not be greater than 4 pipe diameters, and the distance between the first guide and the second guide shall not be more than 14 pipe diameters. Guides thereafter shall be spaced in accordance with normal pressure performance requirements as a minimum standard.

(c) Guides - Angular or Lateral Movement Pattern

Directional guiding shall be applied, such as side plates, local to the expansion joint, the remainder of the pipework shall be supported pipework hangers.

A combination of axial, angular or lateral movement guides in one location shall not be permitted.

8.1.1.11 PROTECTION OF UNDERGROUND PIPEWORK

Underground pipes shall be protected against corrosion and mechanical damage. Galvanised steel pipework, non-ductile iron pipe and fitting, steel flange joint, bolt and nuts shall be cleaned after jointing and treated and coated with at least two coats of good quality bituminous paint and wrapped with corrosion and water resistance self-amalgamating tapes and mastics, or protective materials as approved by the Supervising Officer, having minimum 55% overlapping before laying, and bedded in washed sand free of all salts or sieved soil before the trench is back filled. All joints and supports shall be appropriately wrapped. Pipework shall be hydraulically tested before the trench is back filled. Underground pipework shall be provided with suitable and approved couplings which shall allow for angular deflection, contraction and expansion. Adequate anchor blocks shall be provided at appropriate intermittent positions of the pipes to the approval of the Supervising Officer for thrust bearing. Anchor blocks, trench, backfilling

of trench and sand bed are included under the builder's works detailed in other parts of this General Specification.

8.1.1.12 PIPE ENTRIES INTO BUILDINGS

Pipe entries into buildings shall be sealed with mastic compound and plugged after installation of pipework to prevent the ingress or egress of water or vermin.

8.1.1.13 VENTING AND DRAINING

Devices for air venting (e.g. automatic air vents, or air cocks where specified) shall be provided at the highest points of the sections where they are intended for venting throughout the piping system.

The automatic air vent shall have gunmetal or brass bodies, non-corrodible valves seats, non-ferrous or stainless steel floats and guides. Each automatic air vent shall be controlled by a lock-shield valve or valve with suitable locking device to the acceptance of the Supervising Officer for the purpose. Air release pipes shall be run to discharge at the nearest suitable visible point. Air cocks shall be nickel-plated, of the spoutless pattern and with screwed taper thread.

The drain valves shall be fitted on the lowest points of pipework and where necessary for water drainage of the system. The drain valves shall be checked to have closed before the system is put into operation.

The drain valves shall be connected to the nearest building floor drain or drain point of adequate size. Three loose keys of forged mild steel shall be provided for each type of drain cocks and drain valves installed.

8.1.1.14 VALVES, TAPS AND COCKS

Valves, taps and cocks shall be of the types and working pressures suitable for the systems to which they are connected. Letters of approval issued by the WSD shall be submitted for inspection upon requested.

Wherever applicable, the following standards for cocks and valves shall be relevant: -

BS 1552:1995	Specification for open bottom taper plug valves for 1st, 2nd and 3rd family gases up to 200 mbar.
BS EN 13547:2013	Industrial valves. Copper alloy ball valves.
BS 5163-1:2004	Valves for waterworks purposes. Predominantly key-operated cast iron gate valves. Code of practice.
BS EN 1171:2015	Industrial valves. Cast iron gate valves
BS EN 12288:2010	Industrial valves. Copper alloy gate valves

BS EN 16767:2016	Industrial valves. Steel and cast iron check valves.
BS EN 13397:2002	Industrial valves. Diaphragm valves made of metallic materials
BS EN 13789:2010	Industrial valves. Cast iron globe valves

Valves and fittings of PN16 shall be used for working pressure up to 1,000 kPa. Valves and fittings of PN25 or heavier duty shall be used for working pressure up to 1,600 kPa. Valves and fittings of heavy duty of appropriate pressure rating approved by the Supervising Officer shall be used for high-pressure system above 1,600 kPa. All components in the Fire Service Installations and equipment shall withstand at least 2 times of the working pressure and be tested to at least 1.5 times of the working pressure unless otherwise specified. The working pressure is the maximum pressure anticipated during the working period and it may be higher than the normal system pressure.

All valves shall be arranged so that clockwise rotation of the spindle shall serve to shut off the valve. Valves shall not be installed at locations with a change in direction of the pipework.

Isolating valves shall be of the full way gate type. Regulating valves shall be of globe type. Globe valves shall be positioned so as not to prevent draining of the system.

Bodies of valves and cocks up to 50 mm shall be of cast gunmetal or bronze. Valves having heavy pattern hot-pressed bodies may be used subject to the approval of the Supervising Officer. Valves over 50 mm shall have cast iron or ductile iron bodies with bolted cast iron or ductile iron bonnet and wedge with bronze seat rings or resilient seats, forged manganese bronze or high tensile bronze or stainless steel spindle, with graphite packing and compressed fibre. Castings and pressings shall be of good quality, clean and smooth and free from scale or flaws.

All working parts shall be of gunmetal or bronze or stainless steel. Spindles shall be of high tensile bronze, forged brass or stainless steel with Teflon or approved packing to the manufacturer's standard. Glands shall be machined to provide a naming fit between the spindle and the stuffing box. Stuffing boxes shall be properly packed, or fitted with 'O' rings. Gate valves shall have split or solid wedge gates of cast iron or ductile iron with bronze seat rings or resilient seats. Disc valves shall have renewable discs free to rotate on the spindle.

Valves and cocks for screwed jointed pipework installation shall have taper screwed ends. Flanges of flanged valves shall be to BS EN 1092-1: 2018 or BS EN 1092-2:1997 for PN16 or PN25 for higher pressure rating.

Operating hand wheels shall be of malleable iron, cast iron, ductile iron, or of approved composition having metal insert for securing positively to the stem.

Outlets valves of fire service water tanks, and all essential valves which have to be kept OPEN for proper functioning of hydrant/hose reel systems, sprinkler installation, other automatic fixed installations such as foam systems, ring main systems and street fire hydrant systems, and elsewhere as specified, shall follow the Stop Valves Management System (SVMS) stipulated in FSD Circular Letter No. 6/2016 and all its subsequent amendments issued by FSD. All related materials, such as log book, security devices

including chains, padlocks, durable warning labels and tamper-proof serially numbered security tags and locks, shall be to the acceptance of FSD and to the satisfaction of the Supervising Officer.

Non-return valves (check valves) shall be so constructed that minimum resistance is offered in the normal direction of flow. The body of the check valves shall be made of cast iron to BS EN 1561:2011 or BS EN 1563:2018 while the flaps/discs shall be made of bronze to ISO 197-4:1983 or BS EN 1982:2017 or stainless steel. The discs of check valves shall be of light construction and pivoting on a gunmetal, bronze or stainless steel trim. Each valve shall be fitted with a stop to prevent undue movement of the flap and shall be as silent as possible in operation.

The discs of lift check valves shall be provided with means of guiding the discs and preventing components from becoming detached in service.

Recoil check valves with size 100 mm and above shall have removable cover on top of the outlet body casing to facilitate inspection of bearings and movement door.

Silent check valves shall have large bearing surfaces, function equally well in all positions, drop-tight seating, and stainless steel trim.

Pressure reducing valves for direct connection in hose reel branch pipes, and elsewhere as specified, shall be of approved spring-loaded relay-operated type or otherwise constructed to prevent high pressure build-up on the low pressure side. Each reducing valve shall be installed with an isolating valve and strainer on the high-pressure side, excess pressure isolating valve or relief valve on the low pressure side, pressure gauge with mild steel siphon and bronze cock followed by down-stream side isolating valve. Pressure reducing valve shall be of reliable construction and comply with BS EN 1567:1999.

Pressure reducing valves shall be installed in set of two valves to provide backup in case of failure of any one valve. Unions shall be provided on the pressure reducing valve side of both isolation valves in order to facilitate removal of the pressure reducing valve set for servicing or replacement. Where indicated, a bypass valve shall also be installed.

Pressure reducing valves for hydrant outlets (parity valves) shall be of the type having relief connection to drain unless otherwise specified.

Butterfly valve shall be capable of bubble tight shut off. Butterfly valve shall comply with BS EN 593:2017.

8.1.1.15 PRESSURE GAUGES

Pressure gauges shall be provided at suction and discharge sides of water pumps and in other parts of the Installations as required and used solely to indicate the pressure.

Pressure gauges shall conform to BS EN 837-1:1998 and shall have brass cases with dials not less than 100 mm diameter. They shall be provided with an adjustable red pointer set to indicate the normal working pressure or head of the system. They shall be calibrated in kPa to a maximum of not less than 1/3 times and not more than 2 times the operating pressure of the respective equipment/system and shall be accurate to 1.5% of

full scale reading, unless otherwise specified. Divisions of scale shall not exceed 20 kPa for a maximum scale value of 1,000 kPa, 50 kPa for a maximum scale value of 1,600 kPa and 100 kPa for maximum values in excess of 1,600 kPa. Pressure gauges shall be fitted with an isolating valve/lever handle cocks and shall have siphon pipes, pigtail with 2 complete turns minimum or pulsating damper, fitted between them and the system pipework.

8.1.1.16 ELECTRIC ALARM PRESSURE SWITCHES

Electric alarm pressure switches shall have contact sets of silver or approved alloy rated to suit the working voltage and current of the circuits controlled and shall have independent adjustments for the cut-in and cut-out points and for the operating differential. Electric alarm pressure switches shall be of LPCB approved type or approved by similar widely recognised independent regulatory body. The maximum working pressures of all pressure switches shall be at least 300 kPa above the maximum pressure of the water inside the pipework at the positions of installation of the switches. Pressure switch shall be supplied and installed with necessary ancillary facilities and isolating valves for maintenance and hydrostatic pressure test purpose complying with LPC Rules for Sprinkler Installations and of arrangement shown in LPC Rules. All isolating valves where provided shall be complete with padlocks.

8.1.1.17 WATER FLOW ALARM SWITCHES

Water flow alarm switches shall be of magnetic or vane type having the water side completely separated from the electrical side. Contacts shall be suitable for the working voltage and current of the circuits controlled, and shall be of silver or approved alloy. Water flow alarm switches shall be of a type approved by LPCB or similar widely recognised independent regulatory body. They shall be capable of standing a test pressure of minimum 1,600 kPa or 1.5 times the working pressure whichever is higher for 6 hours without showing any sign of leakage.

8.1.1.18 PIPELINE STRAINERS

Water strainers shall be installed in all pipelines upstream of all water pumps. For pipelines of nominal bores between 15 mm and 50 mm diameter inclusive, strainers shall be screwed gunmetal or bronze body “Y” type with brass or stainless steel screen. For pipelines of nominal bores of 65 mm diameter or above, strainers shall be flanged with “Y” type cast iron body, brass or stainless steel screen. Straining cages shall have 1.5 mm diameter perforations or finer if indicated. Cage shall be at least five times the cross-sectional area of the pipe.

8.1.1.19 BALL FLOAT VALVES

Ball float valves up to 50 mm shall be of cast gunmetal or bronze body. Ball float valves over 50 mm shall be of cast iron body. They shall be with nickel or copper alloy and stainless steel working parts. They shall be of a slow closing type and of minimum PN10 pressure rating or higher to suit the system pressure.

8.1.1.20 VORTEX INHIBITORS

Vortex inhibitors shall be LPCB approved type or approved by similar widely recognised independent regulatory body for PN16 and flanged. They shall be used for operation under positive head conditions.

8.1.1.21 ORIFICE PLATES

Orifice plates for system balancing, pump churning water circuits, where applicable, shall be supplied and installed as required for proper commissioning of the systems, whether they are shown in Drawings or not. Wherever necessary to suit the pump or system performance or in respect of system balance, an orifice plates shall be supplied and installed even if they are not indicated in Drawings.

Orifice plates shall be generally constructed and installed according to LPC Rules for Sprinkler Installations. They shall be manufactured by factories producing LPCB approved equipment or UL listed sprinkler equipment, or from suppliers approved by similar widely recognised independent regulatory body, and acceptable to the Supervising Officer. Orifice plate that has been factory calibrated and produced by a factory having a recognised quality control system in place may be used if they are acceptable by the FSD. The flow characteristic data of the orifice plate shall be included in the operation and maintenance manual.

8.1.1.22 PUDDLE FLANGE

Connect pipes to concrete tanks with short thread flanged connections having a puddle flange either cast or welded on. Ensure that the connections are properly aligned both in the horizontal and vertical planes when being cast into the concrete. Compact around the puddle flange to ensure a water tight joint.

Puddle flanges for fire service systems shall be of ductile iron pipe to BS EN 545:2010 with puddle flange or cast iron to BS EN 1561 with flanged type to BS EN 1092-1:2018, BS EN 1092-2:1997, BS EN 1092-3:2003 or thread-in screw type to BS EN 10226-1:2004 whenever applicable.

8.1.1.23 CLEANING AND DRAINING

All piping shall be cleaned and shall be free of scale, dirt etc., before installation. During the course of the installation, all open ends of pipes shall be plugged or capped to prevent ingress of dirt. After installation and sealing of joints, all piping shall be thoroughly flushed with clean water under pressure, to the satisfaction of the Supervising Officer. Water used for this purpose shall be discharged as directed. Any temporary pipework and equipment necessary for the above cleaning and draining work shall be provided.

SUB-SECTION 8.1.2

HYDRANT AND HOSE REEL SYSTEM

8.1.2.1 GENERAL

The general requirements of the hydrant and hose reel system and the individual equipment installations shall comply with the Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment issued by the FSD (hereinafter as FSDCoP), FSD Requirements and Circular Letters.

The fire service inlets, hydrant outlet valves and hose reels shall be FSD approved type. These equipment items shall be stamped with relevant British Standard Mark or accompanied with a valid letter of approval issued by WSD.

8.1.2.2 FIRE SERVICE INLETS AND HYDRANT OUTLETS

Fire service inlets shall be of twin type comprising screw-down globe type stop valve with male screwed outlet of suitable bore and two 65 mm horizontal male instantaneous inlet connections complete with integral spring loaded resilient-seated non-return valves.

Hydrant outlets shall be single or double type comprising screw-down globe type stop valve for each outlet branch and with male screwed inlet of suitable bore and 65 mm female instantaneous outlets. Outlet branches shall incline at 70° from the centre line of the hand wheel, and at 90° to each other where applicable. The coupling control shall be located at the side of each outlet branch. A bronze blanking cap held captive by a suitable chain shall be fitted to each female outlet.

The fire service inlets and hydrant outlets shall be of full gunmetal construction except for the hand wheel which shall be of cast iron or hard aluminium alloy.

The inlet and outlets fittings shall be supplied and manufactured to the quality of materials, construction, and dimensions as detailed in the following standard/specification or equivalent and approved: -

(a) Hydrant assembly to BS 5041-1:1987;

(b) Major valve components of gunmetal to BS EN 1982:2017;

(c) Globe & check valve shall be of copper alloy of service rating 1,000 kPa to BS 5154: 1991 or BS EN 12288:2010;

(d) Male round thread or female instantaneous terminals of 65 mm diameter to BS 336:2010;

(e) All fittings shall be tested to at least 2,000 kPa.

8.1.2.3 VENTING AND DRAINING

All hydrant risers shall be supplied and installed with automatic air vents of 15 mm size at the highest points and drain valves at the lowest points of the systems as specified in this General Specification.

8.1.2.4 PRESSURE REDUCING HYDRANT OUTLETS

Pressure reducing hydrant outlet shall be supplied and installed at outlet locations where the static and pump pressure exceeds 700 kPa.

The pressure reducing hydrant outlet shall be in the form of a parity valve incorporated in the hydrant outlet and valve assembly with suitable connection to the drain pipe not less than 40 mm diameter. Alternatively, where specified, the pressure reducing hydrant outlet can be in the form of self-contained type without the use of the parity valve and drain pipe. It shall be capable to reduce the running pressure and satisfy the flow test requirements. The pressure reducing mechanism of the valve shall be located at downstream of the valve seat. Pressure reduction shall be achieved by means of hydraulic pressure balancing with metal diaphragm. The 100% effectiveness pressure reducing performance shall be maintained at all times of operation.

8.1.2.5 HOSE REELS

Hose reels shall be of fixed or swing-out type to suit the site installation conditions, and to the acceptance of the Supervising Officer. The construction, testing, performance, working pressure etc. shall be to the relevant FSD Requirements and related Circular Letters. The length of hose shall be 30 m and the internal bore of the hose reel tubing shall be not less than 19mm. Additional length of hose shall be provided where specified in the Particular Specification.

Drums shall be constructed of die cast light alloy, hydraulically balanced, free from denting and twisting, and finished in red enamel. The hub and shaft shall be of brass, fitted with a device to prevent overrun of the hose, having a glandless centre seal. The entire assembly shall be drip free. Hoses shall be of reinforced rubber or P.V.C. tubing approved by the Supervising Officer and shall be fitted with a copper alloy nozzle having slow-closure type lever-operated cock.

A hose guide complete with nylon or similar runners shall be supplied and installed adjacent to fixed type hose reels to enable the free run out of the hose in any direction.

For the wall fixed type, wall-mounting brackets of substantial construction shall be capable in supporting the entire weight of the hose reel and tubing under all operating conditions as required.

For the swing-out type, the support brackets and the swing-out arm shall enable the whole hose reel assembly to be swung through 180^{o} in a horizontal plan.

Each hose reel nozzle shall be housed inside a glass fronted metal box. The box shall be fabricated from sheet metal not less than 0.8 mm thick with a hinged door with front break glass and padlocking facility. The metal box shall be painted and finished to the

satisfaction of the Supervising Officer. The break glass shall be of fragile type not more than 1.5 mm thick. The break glass shall be easily replaced. Common key shall be used for the padlocks. Five common keys shall be provided. A metal or plastic striker about 300 mm long, secured by steel chains, shall be provided for each box for the purpose of breaking the glass panel in case of emergency. An operation instruction notice of the hose reel engraved on a stainless steel sheet shall be provided and fixed by screws to the wall in a prominent position adjacent to each hose reel, to the satisfaction of the Supervising Officer.

In case only the hose reel and/or its associated pumping system are activated while fire alarm signal is not received from other fire service systems such as manual call points, sprinkler system, automatic fire alarm system etc., no fire signal shall be sent via the fire alarm direct link to the FSD's approved centre unless otherwise specified. A visual indication and audible alarm shall however be energised on the master panel of fire alarm control system as well as on all local and repeater panels.

8.1.2.6 CABINETS

Cabinets housing the fire service inlets, hydrant outlets and hose reels shall be provided by the Building Contractor unless otherwise specified. All necessary information for the cabinet including dimensions and weights, based on BS 5041-1:1987, shall be furnished for approval in order to enable these cabinets to be constructed. All details shall be included in the builder's work drawings for construction by the Building Contractor unless otherwise specified.

Where hose reels are located in cabinets or recesses to which doors are fitted, the doors shall bear the words "FIRE HOSE REEL (消防喉轆)" in both English and Chinese characters prominently and easily identifiable from all lines of sight within the surrounding, to the acceptance of the Supervising Officer. In the case of doors which can only be opened by pushing in first, they shall also be annotated "PUSH TO OPEN (按下開門)" in both English and Chinese. Hose reel cabinets fitted with doors shall not be locked. They shall be easily identified and shall be opened without difficulty at the time of emergency. All doors and equipment shall be properly labelled by the Building Contractor unless otherwise specified.

8.1.2.7 STREET HYDRANT SYSTEM

Street hydrants shall be of pedestal type manufactured of cast iron. The construction of the street hydrants shall comply with the requirements of the WSD and the FSD. They shall be in accordance with the Standard Mains Laying Practice of the WSD.

The valve spindle shall be ideally 250mm and in any case shall not be more than 500mm below the pit cover.

The hydrant, when tested in accordance with the provision of BS EN ISO 5167-1:2003 and PD ISO/TR 9464:2008 with one 65 mm outlet working, shall be capable of delivering water flow not less than 2,000 litres per minute (33.3 l/sec.) with a minimum running pressure of 170 kPa at the outlet. In the case of twin 65 mm outlets with both outlets delivering water at the same time, the minimum water flow shall be not less than 4,000 litres per minutes (66.7 l/sec.) and a minimum running pressure of 170 kPa.

Where the minimum standards are not achievable with direct supply from town mains, the water supply shall be augmented by water tanks and booster pumps.

The pressure and water flow available from WSD shall be checked in advance and necessary tests shall be arranged on the pressure and flow from town mains water supply at a nearby location approved by the Supervising Officer at early stage after the commencement of the Contract. The provision of booster pumps and tanks for the street hydrant system shall be submitted to the Supervising Officer for approval at early stage if the water supply pressure and flow from the town mains are not adequate to meet with the requirements of the FSD. In addition, all relevant parties shall be liaised with for the timely application of the excavation permit, if required, in relation to the connection of permanent water supply for the street hydrant installation. The application process shall be closely monitored, so as to ensure that the permanent water supply source shall be available well before the completion of the Installations and the formal Fire Service Inspection by FSD. Any delay in the completion of the Installations due to the unavailability of the permanent water supply, or inadequate pressure and flow of the street hydrant system found only during the testing and commissioning of the system is not acceptable unless justification can be provided that all practical steps have been taken to co-ordinate with relevant parties to apply for the related excavation permit and permanent water connection timely, and to obtain the information and arrange all necessary tests at early stage.

WSD Circular Letter No. 1/2007 on the reduction of minimum residual pressure shall be noted and the necessity of water tanks and booster pumps shall be checked at early stage.

Inspection and testing on the street fire hydrant system shall be in compliance with the checklist as stipulated in the FSDCoP and all its subsequent amendments issued by FSD, besides the relevant BSB Testing & Commissioning Procedures.

8.1.2.8 TANKS AND WATER PUMPS

Two sets of automatic fire pumps, one as duty and one as standby, each capable of delivering the required flow and pressure as required by FSDCoP, FSD Requirements and Circular Letters shall be supplied and installed.

The fixed fire pump for fire hydrant and hose reel system shall be actuated by the manual fire call point or other devices as specified and shall continue to run until stop manually with start/stop buttons. Should the duty pump fail to operate within fifteen (15) seconds, the standby pump shall be energised to serve as the duty pump.

The hydrant and hose reel systems shall be permanently primed with water. If jockey pump is provided, it shall be set to operate at 95% of the required system pressure and stop when the system pressure is restored to 100% level. Interlock shall be supplied and installed such that the jockey pump shall stop operation when the fire pump is put into operation.

The fire pumps for the street hydrant system shall be actuated by a flow switch or pressure switch in accordance with approved design. Should the duty pump fail to operate within fifteen (15) seconds, the standby pump shall be energised to serve as the duty pump. Jockey pumps shall be provided as necessary.

If any pump fails to operate, visual and audible warnings shall be activated.

Where the tanks are provided by the Building Contractor under the builder's works, coordination shall be required with the Building Contractor and the net effective water storage capacity shall be checked to ensure it is adequate to meet the fire service requirements.

8.1.2.9 CONTROLS

The control system, where applicable, shall comply with this General Specification, FSDCoP, FSD Requirements and Circular Letters.

To prevent unauthorised use of water, flow switch and/or pressure switch shall be installed in the system to give visual and audible warnings in the event that significant system flow or loss of pressure is detected during no fire alarm situation.

8.1.2.10 TEMPORARY WATER RELAYING FACILITIES

For construction of high-rise buildings or super high-rise buildings, early commissioning of the hydrant system shall be arranged and, where specified, provide temporary water relaying facilities, fire service equipment and water tanks at the Site during the construction period. The provisions shall be in accordance with FSD Circular Letter No. 4/96 and as approved by the FSD.

The Building Contractor will be responsible for providing temporary water relaying facilities unless otherwise specified. Where the temporary water relaying facilities is required under the Particular Specification, the temporary hydrant system, hose reels, portable hand operated approved appliances, water tanks, pumping system and other equipment complying with the requirements of FSD and WSD and other site safety requirements shall be provided in the construction period. All technical requirements in this General Specification shall be complied where relevant.

If temporary water supply is to be obtained from WSD, temporary water supply shall be obtained downstream of the water meter for the Building Contractor's construction supply. Temporary water relaying facilities shall be supplied off-tank during the construction period.

SUB-SECTION 8.1.3

AUTOMATIC SPRINKLER SYSTEM

8.1.3.1 GENERAL

Sprinkler system shall be installed in accordance with the following standards and requirements: -

(a) Loss Prevention Council Rules for Automatic Sprinkler Installations (including all the LPC Technical Bulletins, Notes, Commentary, and Recommendation) incorporating BS EN 12845:2015, FSD Circular Letters No. 4/2010, No. 2/2017, No. 5/2020 and, and all the subsequent amendments by the FSD;

(b) Latest Codes of Practice for Minimum Fire Service Installations and Equipment and Inspection and Testing of Installations and Equipment published by the Government of the HKSAR; and

(c) FSD Circular Letters and other requirements of the FSD.

8.1.3.2 DEFINITION OF TERMS

For the definitions of terms used for sprinkler systems, reference shall be made to the LPC Rules for Sprinkler Installations, FSDCoP and relevant FSD Requirements and Circular Letters and FSD Technical Guidance for Sprinkler Installations.

8.1.3.3 TYPES OF SYSTEMS

Types of sprinkler systems are as defined in the LPC Rules for Sprinkler Installations.

8.1.3.4 CLASSIFICATION OF FIRE HAZARD

The LPC Rules for Sprinkler Installations has defined various classes of fire hazard according to the occupancy of the building to be protected.

8.1.3.5 GRADING OF SPRINKLER SYSTEMS

Sprinkler systems are graded according to the number and type of water supplies available. Reference shall be made to the LPC Rules for Sprinkler Installations.

8.1.3.6 TYPE OF WATER

Unless otherwise specified, the sprinkler system shall be suitable for use with fresh water connected from the town mains.

8.1.3.7 BRANCH CONNECTION TO WATER SUPPLY SYSTEM

Whenever a direct feed town mains, gravity tank or other supply systems are used to supply the sprinkler system, no branch connection for any other purpose, hose reels included, is permitted.

8.1.3.8 ANTI-POLLUTION VALVE FOR DIRECT CONNECTION TO TOWN MAINS

For sprinkler systems without water storage tanks and supplied from a direct connection to town mains, an additional butterfly valve (anti-pollution valve), without stop screw and lock nut on handle and strapped in open position to the WSD Specification shall be fitted next/adjacent to the sprinkler inlet.

The anti-pollution valve shall be installed in accordance with the FSD Requirements and Circular Letters and the WSD's requirements.

8.1.3.9 SPRINKLERS

Sprinkler for general application shall be of LPCB approved conventional type or type approved by similar widely recognised independent regulatory body. Spray sprinkler shall be used only where specified and approved. The sprinkler shall not be altered in any respect nor have any type of ornamentation or coating applied after leaving the production factory. Where specified, quick response type sprinkler shall be approved by LPCB or approved by similar widely recognised independent regulatory body with the approval of the FSD. For sprinkler system for high hazard group, the sprinkler shall in addition provide appropriate water droplet sizes for the type of hazard and goods they protected.

Sprinkler shall be constructed with the appropriate characteristics, to suit each particular application. The sprinkler shall be of pendant, upright or side wall type to suit the installation requirements in accordance with the LPC Rules for Sprinkler Installations and FSD Requirements and Circular Letters. Each sprinkler may be defined by any of the following characteristics: -

(a) Nominal size of orifices;

(b) Type of heat-operated element;

(c) Operation temperature;

(d) Type of deflector.

Glass bulb sprinkler shall be constructed with heat sensitive quartzoid bulb with temperature rating of 68°C. Sprinklers installed in heated rooms, e.g. kitchen cooking area, autoclave room, boiler room etc. shall have a temperature rating of 93°C or as required by the FSD.

Sprinkler installed at the false ceiling shall be of flush pattern, pendant type and be supplied and installed with an adjustable screw type escutcheon and adaptor to be installed flush with the false ceiling with the yoke and heat sensitive element exposed

below the false ceiling line. Sprinkler heads shall be installed at the centre line of the ceiling tiles. The sprinkler head assembly including the yoke arm, escutcheon, adaptor and cover plate installed in exposed locations shall be chromium plated or finished to a polyester white colour or a colour to be approved by the Supervising Officer. The sprinkler head concealed inside false ceiling shall be of natural brass finish or of the same finish as the sprinklers in exposed locations.

Dry pendent sprinklers where specified for pre-action system shall be of adjustable standard or recessed type providing vertical adjustment needed for accurate fit to false ceiling level. The escutcheon shall match the other sprinklers.

Dry pendent sprinklers shall consist of a valve mechanism which utilises the centre strut in compression principle to seal water and air from the sprinkler pipe until the sprinkler is operated. Water shall then flow freely through the operated sprinkler and distributed by its deflector.

The sprinklers shall cover all areas in the sprinkler-protected building including staircases, common corridors and toilets except plant rooms/Dangerous Goods Stores/cold storage and other special areas that are provided with other fire service systems acceptable to the FSD.

8.1.3.10 SPRINKLER GUARDS

Sprinklers shall be protected by approved metal guards at locations where they are installed at a height less than 2 metres from ground level or any locations liable to accidental or mechanical damage or required by the FSD. Also, when sprinklers, other than concealed, recessed, or flush sprinklers, are installed in a position at risk of accidental mechanical damage, they shall be fitted with a suitable metal guard. Sprinkler guards shall be made from brass, wax coated or approved products having equivalent functions and performance for corrosion resistance. It shall be of size not more than 65 mm high.

8.1.3.11 SPACING AND LOCATION OF SPRINKLERS

Spacing and location of sprinklers shall be in accordance with the LPC Rules for Sprinkler Installations and FSD's Technical Guidance for Sprinkler Installations.

Sprinkler protection of concealed space is not required, if the maximum height of the concealed space at ceiling or floor is not more than 300mm in space and containing no other materials except: -

(a) Bare metal pipework;

(b) Metallic floor box;

(c) Cables (with voltage less than 250V, single phase) in metallic conduit or trunking; and

(d) Cables complying with FSD CL No. 2/2017 Minimum Fire Resisting Cable Requirements for Fire Services Installations.

The actual site conditions shall be checked before and during installation works to ensure that the sprinkler installation complies with the LPC Rules for Sprinkler Installations and FSD Technical Guidance for Sprinkler Installations. The Supervising Officer shall be informed in advance of any necessary change of pipe sizes or sprinkler layout in order to suit the finished architectural layout. Taking down and re-fixing works shall be carried out without charges if the site condition is not checked and the Supervising Officer is not informed in good time about such alterations.

Metal baffles of the correct size shall be supplied and installed between sprinklers wherever required by the LPC Rules for Sprinkler Installations.

8.1.3.12 SPARE SPRINKLERS

A cabinet containing a minimum number of spare sprinklers for each type of sprinklers shall be supplied and installed as recommended by the LPC Rules for Sprinkler Installations or as specified. Sprinkler spanners as supplied by the manufacturers of the sprinklers shall also be provided and kept in the cabinet. Where quick response sprinklers or fast response sprinklers are provided in the Installations, an adequate quantities of spare quick response / fast response sprinklers shall be supplied and maintained as recommended by the LPC Rules for Sprinkler Installations or as specified. Where both conventional sprinkler heads and quick response / fast response sprinkler heads are provided in an installation, the number of spare sprinklers for each type of sprinkler head shall be considered separately and each shall comply with the recommendation in the LPC Rules for Sprinkler Installations for any hazard class.

8.1.3.13 PIPEWORK INSTALLATION

Pipework installation for sprinkler systems shall be installed in accordance with the LPC Rules for Sprinkler Installations and as detailed in this General Specification. In case of conflict of the two requirements, the LPC Rules for Sprinkler Installations shall be adopted while any additional and more stringent requirements in this General Specification shall be included and provided.

Where the installation works require temporary suspension of parts of the Installations inside or outside the Site such as in landlord's area, consent shall be obtained from the landlord and relevant parties and notification shall be sent to FSD. All necessary temporary facilities, protection, and fire safety precautionary measures shall be provided in all affected areas to the satisfaction of the Supervising Officer, landlord/client/occupiers, and the FSD during the suspended period. The landlord/client/occupiers shall be advised to stay alert and to make corresponding management action. Draining the water in pipes of existing system inside or outside the Site shall be included, where required for the installation works, including its reinstatement and expenses for checking by landlord's maintenance contractor after lifting of the temporary suspension. The fire service specialist contractor shall, except if and so far as the Contract otherwise provides, or unless otherwise provided by the Building Contractor for the Installations, indemnify and keep indemnify the Employer against all losses and claims for injury or damage to any person or property whatsoever which may arise out of or in consequence of the temporary suspension of parts of the Installations for the execution of the Installations and against all claims, demands,

proceedings, damages, costs, charges and expenses whatsoever in respect thereof or in relation thereto.

8.1.3.14 PRESSURE GAUGES, VALVES AND ALARM DEVICES

Pressure gauges, various types of valve and alarm devices shall be installed in accordance with the LPC Rules and FSD's Technical Guidance for Sprinkler Installations.

8.1.3.15 CABINETS FOR CONTROL VALVE SETS AND SPRINKLER INLETS

Construction of the sprinkler inlet shall be the same as fire service inlet described in this General Specification. Cabinets for housing the sprinkler control valve sets and sprinkler inlets shall be constructed by the Building Contractor unless otherwise specified. All necessary information shall be furnished and proposed for the cabinet including dimensions and weights, based on BS 5041-4:1975, for approval in order to enable these cabinets to be constructed. Labelling and lettering shall be in accordance with FSDCoP, FSD Requirements and Circular Letters. All details shall be included in the builder's work drawings for construction by the Building Contractor.

8.1.3.16 TANKS AND PUMPS

Two sets of automatic pumps, one as duty and one as standby, each capable of delivering the required flow and pressure as required by the LPC Rules for Sprinkler Installations for the appropriate hazard class shall be supplied and installed.

A jockey pump shall be supplied and installed to maintain the required system pressure.

The sprinkler pumps and the jockey pump shall be housed in suitable dedicated pump room. The access to the pump room shall be via an exit, exit route and/or required staircase in compliance with the Means of Escape requirements in the Code of Practice for Fire Safety in Building. Access via a cat ladder is not acceptable. Such pump room shall be clearly marked in English and Chinese characters for its purpose and suitably locked to prevent unauthorised tampering of the pumps. A lockable access door shall be provided to the pump room. The door opening shall be of sufficient dimensions to permit easy access of personnel and the removal and replacement of equipment within the pump room.

The sprinkler duty and standby pumps and jockey pump shall be controlled by means of independent LPCB approved pressure switches suitable for starting pumps. Automatic changeover shall be supplied and installed such that the standby pump shall be put into operation, after the trunk mains pressure falls to 60% of the system pressure, in case there is a fault at the duty pump as sensed by the pressure switches at the common header. The duty sprinkler pump shall be set to operate when the system pressure has fallen by 200 kPa or dropped to a value less than 80% of the pressure attained when the pump is churning with the installation in the standby condition, whichever is the least reduction. The pump shall continue to run until stopped manually with start/stop buttons. In addition to pressure switches, the sprinkler pumps shall also be activated manually at the pump room and the fire alarm control and repeater panels for indicating purpose.

The jockey pump shall be set to operate at 95% of the system pressure and shall stop when the system pressure is restored to 100% level. The capacity of the jockey pump shall be so selected that it cannot support full flow of an operated sprinkler. Interlock shall be supplied and installed such that the operation of jockey pump shall cease to operate when the sprinkler pump is put into full operating conditions in response to a reduction in system pressure.

A pump output test facility shall be supplied and installed to permit a running pressure test of the pump at full load condition or at nominal rating as appropriate. The test facility shall include a LPCB approved direct reading flow meter suitable for sprinkler service. The waste water discharge pipe shall be connected, wherever practical, back to the sprinkler water tank.

Water supply equipment, such as pumps, pressure tanks and gravity tanks, shall not be housed in sections of premises in which there are hazardous processes or explosion hazards. The water supplies, pumps, stop valves and control valves sets shall be installed such that they are safety accessible even in a fire situation and the place shall be adequately ventilated; control valve set(s) shall be at a fire services access level and readily accessible when responding to a fire.

8.1.3.17 CONTROLS AND ALARM INDICATIONS

The control and alarm indication shall comply with this General Specification and the LPC Rules for Sprinkler Installations.

Tamper-proof electric switch or approved indication to indicate the correct operational mode of each stop valve in the sprinkler system shall be supplied and installed complying with the LPC Rules.

8.1.3.18 WATER FLOW ALARM SWITCHES

Water flow alarm switches as detailed in this General Specification and LPC Rules for Sprinkler Installations shall be utilised for sending a signal back to the fire alarm control and indicating panel to indicate which location is under operation with both visual indication and audible alarm. LPCB approved high sensitive water flow alarm switch capable of actuation by operation of one sprinkler head shall be used.

Where specified, LPCB approved automatic flow switch testing system shall be supplied and installed for sprinkler flow switches installed in a position difficult to be accessed or checked in routine inspection such as those inside false ceiling, at level higher than 2m above ground etc. The controlling test panels of the automatic flow switch testing system shall be wired and installed in sprinkler pump room or nearby plant room.

Where automatic flow switch testing system is not provided, adequate drain points shall be allowed in the Installations and connected to the nearest drain for routine testing of all flow switches in order to identify the operating conditions of sprinkler installation.

When the water supply is not by an automatic pump or pumps, a flow measuring device shall be permanently fixed and shall be capable of checking each water supply.

8.1.3.19 SUBSIDIARY STOP VALVES

Electric monitoring type subsidiary stop valves shall give visual signals back to the fire alarm control and remote indicating panel to identify the status of subsidiary stop valves at open/close state with security devices. The security devices with warning labels and serial numbers shall comply with the requirements of FSD Circular Letter No. 4/2010 and as approved by the Supervising Officer. Audible signal shall also be given when the valve is not in fully open position. The sprinkler subsidiary stop valves management system in accordance with the requirements of FSD Circular Letter No. 4/2010 shall also be adopted.

8.1.3.20 SPRINKLER CONTROL VALVE SETS

The control valve set comprising the associated pressure gauges, valves, alarm devices, water motor gongs, testing facilities, retarding chambers etc. shall be in accordance with the LPC Rules for Sprinkler Installations. Electric monitoring device shall be fitted at each valve to give signals back to the fire alarm control and indicating panel to indicate the open/close state of the valve with padlocking facilities. The padlocking facilities shall be to the requirements of FSD and as approved by the Supervising Officer. Audible signal shall also be given when the valve is not in fully open position. Drain connection to the system shall be led to conspicuous positions as approved by the Supervising Officer and comply with the requirements of the WSD. Sprinkler control valve set shall be of duplicate alarm valve arrangement or of alarm valve with bypass arrangement, and with alarm monitoring facilities.

8.1.3.21 DRY PIPE INSTALLATION

Dry pipe installations shall be supplied and installed where specified or where the conditions are such that a wet pipe system cannot be used. For example, wet pipe installation cannot be used in premises where the temperature is artificially maintained close to or below 0°C, such as in cold room, or in premises where the temperature is maintained or may be raised above 70°C such as in drying room, and where the pipework cannot be run outside the cold or hot areas.

The installation shall be pressurised with compressed air within the pressure range as recommended by the alarm valve manufacturer and shall not exceed 400 kPa. A drop of the pressure to a predetermined value shall activate the installation dry alarm valve and primes up the sprinkler piping installation. Each installation shall be served by an independent compressed air supply system.

In cold room, automatic means shall be supplied and installed to automatically shut down the air circulation fans of cooling system when the sprinkler system operates. Co-ordination with the parties for the installation of the cooling system shall be required. All necessary interfacing control, wirings, equipment and signals for shutting down the air circulation fans of the cooling system shall be supplied and installed. The installation shall be fitted with upright sprinklers if the pipework runs in the cold room.

The compressed air-supply pipework shall consist of copper pipe or pipe of other approved materials. The compressed air-supply pipework shall be fitted with pressure

relief valve, non-return valve, stop valve (normally open), suitably sized restrictor, and by-pass with stop valve (normally strapped and padlocked closed).

The compressed air-supply pressure-relief valve shall be set to relieve at a pressure of not more than 500 kPa in excess of the air pressure requirement of the installation dry alarm valve.

The compressed air-supply pipework shall be connected to the installation above the normal priming water level of the dry alarm valve.

With the installation valve primed in the ready position, it shall be possible to fully pressurise the installation in 1 hour, at any time.

Where recommended by the air compressor manufacturer, air compressors shall be equipped with automatic off-loading devices to depressurise the compressor prior to start up.

The compressed air-supplies to sprinkler installations in protecting the cold store shall be dried by passing through a suitable air dryer or freezer.

The restrictor in the compressed air-supply pipework shall be correctly sized to limit the mass flow of air from the air supply to the installation, so as to avoid delay of water discharge from the open sprinklers. Filter shall be supplied and installed at the upstream of the non-return valve and restrictor.

Restrictors shall be made from non-corrosive materials such as austenitic stainless steel or copper alloy having orifices with rounded edges.

Distribution and range pipes shall be of the terminal range configuration. Grid and loop configurations of pipework are not allowed.

A test facility shall be supplied and installed at the end of the hydraulically most remote range pipe on the installation, consisting of a 32 mm nominal diameter pipe and quick-acting test valve, with an outlet nozzle equivalent in size to the smallest sprinkler in the installation. The quick-acting test valve shall be located in an easily accessible position and shall be normally secured in the closed position with a suitable strap or chain. The end of the test line shall normally be capped or plugged.

Sprinkler installations in the dry-pipe mode shall either

(a) have an internal volume of air-filled pipe not exceeding: -

Light hazard	1.0 m^3
Ordinary hazard	2.5 m^3
High hazard	2.5 m^3

(b) discharge water from the testing facility within 60 seconds of activating the quick-acting test valve when the installation is in the normal stand-by condition.

The number of sprinklers on dry-pipe installations, including any tail-end extensions, shall comply with the LPC Rules for Sprinkler Installations.

8.1.3.22 PRE-ACTION INSTALLATION

8.1.3.22.1 Pre-action installation shall be supplied and installed where specified. Pre-action installation can be independent installations or subsidiary extensions from a wet pipe sprinkler installation with the pre-action control valve and associated water motor alarm gong located on the same floor protected by that pre-action sprinkler.

8.1.3.22.2 There are two types of pre-action systems as follows: -

(a) Type A pre-action installation

This is a normal dry pipe installation in which the control valve set is activated by an automatic fire detection system but not by the operation of sprinklers. The air/inert gas pressure in the installation shall be monitored at all times. At least one manually operated quick opening valve shall be installed in an appropriate position to the satisfaction of the Supervising Officer and the FSD to enable the pre-action valve to be activated in an emergency.

Type A pre-action installations shall only be installed in areas where considerable damage may occur if there is an accidental discharge of water, and as approved by the Supervising Officer.

(b) Type B pre-action installation

This is a normal dry pipe installation in which the control valve set is activated by an automatic fire detection system and/or by the operation of sprinklers. Independent of the response of the detectors, a pressure drop in the pipework shall result in the opening of the alarm valve.

Type B pre-action installations may be installed wherever a dry pipe system is called for and the spread of fire is expected to be rapid. They may also be used instead of ordinary dry pipe systems with or without an accelerator or exhauster.

8.1.3.22.3 Unless otherwise specified, Type A shall be used for pre-action installation.

8.1.3.22.4 Sprinklers shall be installed in upright position for either Type of pre-action installation unless otherwise recommended by the corresponding manufacturer of the installation and as approved by the Supervising Officer for the areas concerned.

8.1.3.22.5 The pre-action sprinkler installation pipework shall be normally charged with compressed air under pressure and monitored to give a warning

indication on reduction of the air pressure. Reduction of air pressure shall initiate the visual indication and audible alarm for a fault signal.

8.1.3.22.6 The maximum area controlled by a single wet alarm valve, including any sprinklers in a subsidiary extension, shall not exceed that governed in BS EN 12845:2015 and FSD Circular Letter No. 5/2020, and all the subsequent amendments of the FSD.

8.1.3.22.7 Where a sprinkler system includes more than one pre-action sprinkler installation, the following shall be implemented to cater for the possible simultaneous charging of the pre-action sprinkler installations: -

(a) The volume of stored water supplies shall be increased by the volume of the total pre-action installations.

(b) The time between multiple pre-action installations tripping and water discharging from any remote test valve on the installations under consideration shall not exceed 60 seconds.

8.1.3.22.8 The pre-action installation control panel shall incorporate the necessary relays, timers, switches, alarm and trouble lights essential to the operation of the system. The control panel shall employ printed circuit boards for the components and shall be completely factory-wired and ready for connection on Site. The control panel shall comply with this General Specification where relevant and the following: -

(a) The capacity of the stand-by battery power supply shall be capable of operating the pre-action system for at least 72 hours. At the end of the 72-hour stand-by period, the stand-by power supply shall still be capable of operating the pre-action control panel and solenoid valve or actuator to release the pre-action alarm valve; and

(b) The pre-action control panel shall initiate operation of the pre-action alarm valve immediately in the event of a fire alarm system fault (including a failure of the primary and stand-by power supplies) which may result in failure to execute the appropriate actions in the event of fire.

8.1.3.22.9 The pre-action control panel relays and circuitry operating the pre-action alarm valve solenoid valves or actuator mechanisms shall be duplicated and wired such that no single fault or failure shall render the installation inoperable.

Monitoring devices shall be supplied and installed to give: -

(a) indication that any stop valves down-stream of the installation control valve set are fully open;

(b) audible and visual warnings at the pre-action control panel that any monitored stop valve is not fully open;

(c) audible and visual warnings at the pre-action control panel that the cover to a condition indicator switch has been removed;

(d) audible and visual warnings at the pre-action control panel of short circuit or disconnection of the leads of any solenoid valve or actuator which is energised to open;

(e) audible and visual warnings at the pre-action control panel of short circuit or disconnection of the primary power supply, the secondary power supply or any battery charger associated with the operation of the pre-action system.

8.1.3.22.10 The fire detection system used to activate a pre-action sprinkler system shall comply with Modified BS 5839-1 where appropriate and the following: -

(a) Each room or compartment protected by sprinklers shall have sufficient fire detectors to initiate release of the pre-action installation without the operation of any detectors external to the room or compartment or located within equipment;

(b) Fire detection systems employing coincidence connection (requiring a response from two detectors to initiate operation of the pre-action alarm valve) may be used with Type A and Type B pre-action installations. Consideration shall be given to actuate the pre-action alarm valve on operation of a single fire detector where fast-developing fires may occur;

(c) Any two detectors of a group of detectors that may initiate the operation of the pre-action alarm valve shall be separately connected to independent wiring circuits (coincidence connection);

(d) Consideration shall be given to the nature of the occupancy, building height, sprinkler thermal sensitivity, air movement and the recommendations of the Modified BS 5839-1 for fire detection and fire alarm systems and the LPC Rules for Sprinkler Installations;

(e) Smoke detectors or equivalently sensitive detectors as approved by the Supervising Officer and acceptable to the FSD shall be used in pre-action installations.

8.1.3.23 RECYCLING SYSTEM

8.1.3.23.1 Whenever recycling system is adopted, the main system shall be in full compliance with this General Specification and the recycling system/installation shall be in full compliance with relevant sections of BS 5306-2:1990 (Incorporating Amendment No.1 and implementing Corrigendum No. 1). In addition, prior approval from both the Supervising Officer and FSD is required.

8.1.3.23.2 Recycling system shall be provided where specified and necessary for the following reasons: -

(a) to restrict water damage after a fire is extinguished;

(b) to avoid closure of the main installation stop valve if modifications are made to the installation pipework or if sprinkler heads are to be replaced; and

(c) to prevent water damage caused by accidental mechanical damage of the installation pipework or sprinklers.

8.1.3.23.3 The complete installation including equipment, components and wiring shall be LPCB approved or approved by similar widely recognised independent regulatory body and accepted by the FSD. The control panel, batteries and charger, sprinkler heads, flow control, related auxiliary valves and compressed air supply system shall be supplied from a proprietary manufacturer specialised in the manufacture of the system. The installation work shall also comply with the recommendations of the manufacturer.

The major components of each recycling installation shall consist of, but not limited to, the following: -

(a) Recycling heat detector;

(b) Fire resisting detector cable;

(c) Control panel;

(d) Batteries and charger;

(e) Electric alarm bell;

(f) Pipework and fittings;

(g) Sprinkler head;

(h) Flow control and other auxiliary valves; and

(i) Compressed air supply system including air compressor, piping and fittings.

8.1.3.23.4 All major components shall be LPCB approved or approved by similar widely recognised independent regulatory body as an integral part of the recycling installation. The complete recycling system shall be FSD approved or have been accepted by the FSD in past building projects.

8.1.3.23.5 Heat Detector

The heat detector shall be a heat sensitive, normally closed, electrical detector which shall operate at a fixed temperature. It shall be rate compensating and feature automatic recycling. Each detector shall be complete with a tell-tale of zinc alloy. The detector units shall be connected with fire resist cable to the control panel. When a detector is heated to the temperature set point, a mechanical switch shall open and break the series circuit interrupting the flow of current. When the temperature drops below the set point, the circuit is re-established. It shall be able to be mounted at any angle. The heat probe shall be of stainless steel and the top shall be colour coded for temperature set point and spacing. The detector trip temperature shall be factory set and shall not be adjustable in the field. The detector shall be capable of withstanding at least 815°C for short periods of time without damage. At sustained high ambient temperature above 420°C, the tell-tale tab shall drop away indicating possible detector damage. The conduit box attached to the detector shall be fire and explosive proof and constructed of copper-free aluminium with threaded conduit connections and adaptors provided for detector cables.

The detectors shall have a 60°C detection rating, spaced less than 12 m apart and less than 6 m from walls, which can monitor up to a maximum of 149 m^2 of area under optimum conditions of a smooth ceiling. Where approved by the Supervising Officer, exact requirements of the spacing, location, serving area, and provision of detectors shall be in accordance with the recommendation by the manufacturer of a proprietary recycling system acceptable to the FSD.

8.1.3.23.6 Fire Resisting Cable

The whole re-cycling pre-action system shall be wired with low smoke fire resistant cables to the requirements of BS 5839-1 for fire detection and fire alarm systems or other international standards acceptable to the Director of Fire Services. It shall be non-toxic, and no toxic or noxious fumes shall be emitted during a fire. It shall not allow a fire to propagate and no conduit shall be required. It shall be bent easily to match contours for easy installation. The cable shall be cut to length in field and may be spliced, but all splices shall be made in conduit boxes which shall be flameproof and water proof.

The binding tapes used with the cables shall be flame retardant.

The cables shall be installed in conduits, cable trays or other approved supports, and be properly fixed by approved fasteners or clamps specially constructed for the purpose, to the satisfaction of the Supervising Officer.

8.1.3.23.7 Mode of Operation

Water discharge cycling shall be controlled by heat detectors installed at the roof or ceiling which operate as an electrical interlock causing the water flow control valve to operate. A timer shall be supplied and

installed to delay closure of the flow control valve for a predetermined period of at least 5 minutes in each cycle after lowering of the temperature of the heat detectors.

The fire alarm bell shall continue to sound until the reset button is pushed. Should the temperature rise to the tripping point of any detector during any phase of the cycle, the system shall continue the water flow or immediately start the flow of water to suppress the fire.

8.1.3.23.8 Control Panel

The control panel shall be of FSD approved type and incorporate with all necessary relays, timers, key type switches, alarm and trouble lights essential to the operation of the system. The panel shall be completely proprietary product with factory-wired and ready for connection on Site.

The control panel shall control the re-cycling pre-action system and serve to operate as a cycling pre-action system with the electrical detection circuit in service or as a dry system without the electrical detection circuit in service. An ON/OFF indication light shall be incorporated to monitor the selection of the recycling ON/OFF switch. The control panel shall also incorporate a system tripped light and a low air pressure light. System operation or low air pressure shall activate the corresponding light and the audible trouble alarm and other alarms required which can be silenced by the ON/OFF switches.

Testing facilities shall be provided to simulate the opening of the detector circuit momentarily to cycle the system. A reset button on the panel shall reset the timer and alarm circuits after system operation.

The whole recycling installation shall be constructed as a fail-safe installation. If the detector circuit and/or pressurised air are unavailable for service, the system shall turn into an ordinary automatic dry pipe or wet pipe system. All alarms except the low air pressure alarm shall operate constantly unless shut off and cycling features are negated.

8.1.3.23.9 Flow Control Valve

The flow control valve shall be a quick opening, differential diaphragm valve with a spring loaded floating clapper. The flow control valve shall facilitate manual or automatic on/off control. It shall also be used to control water pressure or water flow rates. The flow control valve can be used as pressure reducing valve to limit or conserve water flow.

8.1.3.23.10 Sprinkler Head

Where there is a danger of freezing, sprinkler head shall be installed in the upright direction. Otherwise, it can be installed in the upright or pendant position.

The number of sprinkler head shall not exceed 1,000 per installation.

8.1.3.23.11 Compressed Air Supply

Each recycling installation shall be supplied and installed with an independent compressed air supply system.

The air supply system for each of the recycling installation shall consist of a compressor, pneumatic actuators, air maintenance devices, pressure monitoring valves, controls, wiring, copper pipework and fittings, and all other necessary accessories for the operation of the system. The compressor shall be operated by means of air pressure switches installed on the main pipe. On detecting air leakage reduced to a predetermined value, the compressor shall automatically cut-in, and shall cut-out after the air pressure has been built-up adequately. The air leakage will actuate the alarm system as mentioned earlier.

The compressed air system shall allow the recharging of the recycling installation manually after the sprinkler system has been operated and the actuated sprinkler heads are replaced.

The compressor of the compressed air system shall be an oil-free, permanently lubricated type. It shall be of direct driven type with no belts or gears, and shall be compatible with air maintenance devices and other system components for effective operation, with no special source of air required. The compressor shall be complete with thermal protection, air filters, safety relief valve and other protective provisions.

The air maintenance device shall be an automatic, field-adjustable air maintenance provision for the compressed air system. It shall be equipped with pressure switch, restrictor check valve, strainer, bypass valve etc. for the optimum operation of the system, and to enable the compressor to be started under load. The device shall provide a balancing means to minimise on-off cycling of the compressor and the need to rapidly relieve the system pressure to the actuation point.

8.1.3.24 DELUGE INSTALLATION

Deluge installation shall be supplied and installed where specified. The deluge system shall be designed under the Works to provide full protection in applying water over an entire area of protection. The deluge installation shall be fitted with open sprinklers and provided with devices for both manual release mode and automatic release mode. The automatic release shall be operated by a fire detection system in opening a deluge valve or energising multiple valve controls.

The design of such a system shall be subjected to consultation with and acceptance of the FSD.

The pipework sizing shall be checked and verified by hydraulic calculation and fully calculated results shall be submitted to the Supervising Officer for approval. The storage water tank requirements shall be calculated and checked for the deluge system. All calculations shall be included in the submission to the FSD for approval.

8.1.3.25 DRENCHER INSTALLATION

Drencher installation shall be supplied and installed where specified. Drencher system shall be designed to provide protection for openings, to separate an area of high fire risk, for exposure protection, to protect the marine filling station and to provide protection for the refuge floors to the approval of the FSD. The drencher installation shall meet with the relevant requirements in FSDCoP, FSD Circular Letters, Fire Safety Code, licensing requirements for Places of Public Entertainment, and other relevant codes and licensing requirements.

Drencher system shall be designed to protect the surface area with water flow rate of not less than 10.0 l/min/m^2 protected surface area at all points on the protected surface or at a flow rate agreed by the FSD. This shall be checked and verified by hydraulic calculation or computer simulation with on site acceptance tests. The system shall be designed to comply with Rules of the Fire Officers' Committee (Foreign) for the Installation of External Drenchers, FSDCoP, FSD Requirements and Circular Letters.

Drencher system shall be actuated by an automatic fire detection system or sprinklers installed in the same area. A manual release device/system with operating instructions shall also be supplied and installed near the deluge valve.

The sprinklers installed in the same area or pilot sprinklers, where provided, shall be used to actuate the drencher system. Where sprinklers are used to actuate the drencher system, a separate local sprinkler flow switch with test facilities shall be supplied and installed to the sprinklers installed in the same area as the drencher system, or to the pilot sprinkler system for actuating the drencher system. The location of the local sprinkler flow switch shall be selected such that actuation of the sprinklers in other area shall not cause the drencher system to operate.

The sprinklers for drencher actuation shall be of quick response type with a short Response Time Index (RTI) value suitable for the hazard to be protected. The RTI value shall be submitted for approval.

Where sprinkler system is not installed in the same area and where local sprinkler flow switch and pilot sprinkler system cannot be installed, heat detection system in coincidence connection shall be used to actuate the drencher system.

Smoke detection system could also be used where specified. Where the drencher system is used to separate an area of high fire risk for life safety protection or to protect a compartment forming part of an escape route as indicated or where specified, the drencher system shall be actuated by smoke detection system in coincidence connection.

Drencher system for refuge floor shall be actuated by heat detection system with coincidence connection where sprinkler system is not provided on the refuge floor.

For the detectors arranged with coincidence connection (cross-zone operation), the detectors shall be arranged each on either side of the drencher heads. The activation of one detector shall energise an alarm with visual and audible warnings on the control panel. The activation of any two detectors arranged in coincidence connection shall operate the drencher installation. Where required by the FSD and approved by the Supervising Officer, activation of the detectors provided solely for the drencher system

shall not activate the general fire alarm and shall not send the fire signal via the fire alarm direct link and alarm transmitter.

The drencher heads shall be designed to provide an even sideward and downward throw of water to protect the whole vertical surface. The number of drencher heads shall be calculated, the type of drencher heads, their separation and arrangement shall be selected to provide an even flow of water over the entire vertical surface of the openings protected by the drencher system. Due consideration shall be taken on the effect of wind and air movement in surrounding environment of the protected area in the design and selection of equipment for drencher system.

The sizing of pipework shall be checked and verified by hydraulic calculation and the fully calculated results shall be submitted to the Supervising Officer for approval. The size of the water storage tank shall be calculated and checked which shall be adequate for not less than 30 minutes of operation of all the drencher installations that are required to be operated simultaneously. All calculations shall be included in the submission to the Supervising Officer and FSD for approval.

For safety curtain provision in stage and auditorium, where specified, the drencher shall be designed to provide a protection of not less than the FRR required with the use of safety curtain. The water storage shall be enough for not less than the operation duration of the drencher system under the required FRR.

Where specified, foam drencher system shall be supplied and installed with quick response sprinkler heads for areas with special hazard.

8.1.3.26 OTHER AUTOMATIC FIXED INSTALLATIONS USING WATER

Other automatic fixed installations using water shall be designed, supplied and installed where specified. This includes water mist system, water spray system, foam water system etc. Water mist system shall comply with NFPA 750:2015. Water spray fixed systems for fire protection shall comply with NFPA 15:2017 and foam-water sprinkler and foam-water spray systems shall comply with NFPA 16:2015. All installation details and calculations shall be included in the submission to the Supervising Officer for approval. They shall also be of the design and construction to the acceptance of the FSD and the Supervising Officer.

SUB-SECTION 8.1.4

TANKS AND PUMPS

8.1.4.1 WATER SUPPLIES

Water supplies for the Installations shall be of types approved by the WSD and the FSD.

8.1.4.2 WATER TANKS

Water tanks forming part of the building construction will be provided by the Building Contractor unless otherwise specified.

Water tanks shall be constructed in compliance with FSDCoP, LPC Rules for Sprinkler Installations, FSD Requirements, FSD and Circular Letters, FSD Technical Guidance and the requirements of WSD, the HKSAR.

Puddle flanges for inlet and outlet pipes shall be supplied and installed by the Building Contractor. The puddle flanges for FSI shall be of ductile iron pipe to BS EN 545:2010 with puddle flange or cast iron to BS EN1561 with flanged type to BS EN 1092-2. All other piping connections and valves shall be supplied and installed except overflow, drains and inlet piping which will be supplied and installed by Building Contractor unless otherwise specified.

The construction drawings for water tanks shall be checked and verified for installation purposes. Where necessary, proposals for modification to the design shall be submitted and assist the supervision of the construction, in order to ensure their suitability and proper functioning.

Where an independent private water consumption meter is not provided by the Building Contractor for water supply to the water tanks of the Installations, private water check meter(s) shall be supplied and installed for the Installations and approval shall be obtained from the WSD.

8.1.4.3 WATER PUMPS

Water pumps for sprinkler systems shall comply with the LPC Rules for Sprinkler Installations. Sprinkler pumps shall be approved by LPCB or other similar widely recognised independent regulatory body acceptable by the Supervising Officer. For sprinkler pumps complying with other standards to the approval of the Supervising Officer, the operating characteristics and installation requirements shall still be following fully with the LPC Rules for Sprinkler Installations, to the acceptance of the FSD. Test certificate shall be submitted at the time of delivery.

Water pumps for hydrant/hose reel systems shall comply with FSDCoP, FSD Requirements and Circular Letters, and wherever applicable BS 5306-1:2006. The pumps shall be operated in accordance with this General Specification. Pumps shall be manufactured by a manufacturer possessing certified ISO 9001:2015 quality assurance system.

There shall be at least one standby pump in addition to the duty pumps for each pump set. In addition, there shall be at least one jockey pump installed for each sprinkler pump set.

8.1.4.4 PUMP OPERATION

Pumps with stable characteristics for the Installations shall be selected to suit the design requirements for capacity (flow rate) as specified and shall discharge at a pressure which shall produce running pressures within the statutory requirements at the location concerned. In addition, the required net positive suction head of the selected pumps shall be compatible with the available net positive suction head in the Installations. The design figures given on the Particular Specification and/or Drawings are indicative and for guidance purpose only. Pumps shall be selected to satisfy the actual requirements of the Installations, to the satisfaction and acceptance of the Supervising Officer. No adjustment in cost will be entertained if the actual required duty points (pressure and flow rate) are different from the specified figures. Close valve total pressure head shall not exceed 140% of the rated head.

A final accurate calculation of operating heads based upon the characteristics of the pipework systems including fittings, equipment and accessories as actually installed shall be carried out. Certified performance curves for the pumps shall be provided with the operating range clearly indicated.

The design speed for all fire service pump sets shall not exceed 50 rps and the output power of each driving motor shall be rated to give 20% for hydrant system and 10% for sprinkler system more power in addition to the hydraulic power required for the rated system flow.

Pumps shall be capable of running under conditions of zero or low “draw-off” continuously without overheating. This may be achieved either by pump design or by an automatic by-pass circuit arrangement. Details of this function shall be shown on the Installation Drawings. Overheat alarm devices may be supplied and installed if necessary but these shall not be arranged to shut down the pump automatically.

Pumps shall have acceptable low noise level and good energy efficiency to the approval of the Supervising Officer especially for the jockey pumps.

8.1.4.5 PUMP CONSTRUCTION

8.1.4.5.1 Pumps for fresh water pumping duties shall be of one of the following types: -

(a) End suction type, the pump set shall be installed with spacer type coupling so that the pump impeller can be dismantled from the motor side for servicing without disruption of the pipework nor dismounting the motor, or

(b) Horizontal or vertical spindle type centrifugal pump with end suction at the end or bottom.

8.1.4.5.2 Single stage pump shall be selected for system with high static pressure head. Multi-stage pump may be used only when suitable single stage pump is not available in the market and with substantiation submitted to and approved by the Supervising Officer.

8.1.4.5.3 The materials of construction and installation standard of the pumps shall be as follows or of better materials and approved by the Supervising Officer:

(a) Casing: Cast iron to BS EN 1561:2011, material designation EN-GJL-200;

(b) Impeller and guide rings: Stainless Steel to BS EN 10088-1:2014 No. 1.4401 ground and polished. Renewable guide rings shall be bronze and shall be provided in the casing, keyed to prevent rotation;

(c) Shaft: Stainless Steel to BS EN 10088-1:2014 No. 1.4401 ground and polished;

(d) Sleeves: Stainless Steel to BS EN 10088-1:2014 No. 1.4401 ground and polished;

(e) Casing rings: Stainless Steel to BS EN 10088-1:2014 No. 1.4401 ground and polished;

(f) Shaft nuts: Bronze or better materials;

(g) Mechanical Seal: Stainless Steel to BS EN 10088-1:2014 No. 1.4401 ground and polished. The Drain piping shall be connected to the nearest builder's drain for gland leakage. Mechanical seals shall be of leak free operation. The mechanical seal shall be the product of specialist proprietor and the materials used shall be suitable for the pumped liquid;

(h) Glands: Carbon steel or better material;

(i) Lantern rings: Stainless Steel to BS EN 10088-1:2014 No. 1.4401 ground and polished.

8.1.4.5.4 All connecting flanges of the pump shall be to BS EN 1092-1:2018, BS EN 1092-2:1997, BS EN 1092-3:2003, class PN16, or higher pressure rating as required. Taper pieces shall be provided where necessary. Shaft and Impeller(s) shall be statically and dynamically balanced after assembly. Impeller rings shall be of cast iron and renewable secured from relative movement by stainless steel end rotation ring.

8.1.4.6 PUMP SET INSTALLATION

The pump and motor shall be directly coupled and mounted on a substantial machined base plate of cast iron or of fabricated mild steel. Couplings shall be flexible of steel pin and synthetic rubber bushing type, accurately aligned, and fitted with guards.

Pumps shall be complete with all necessary water seal connections, vents, drains and priming plugs, and all installation materials including foundation bolts and anti-vibration mountings. Drain pipework shall be of copper and shall run to a nearby drain gully or as specified. Automatic priming equipment shall be included where necessary to ensure that the pumps are primed at all times.

Each pump set and the associated pipework shall be provided with automatic air valves, gate or butterfly valves, pressure gauges, strainers and check (non-return) valves etc. The drain vent shall be built-in complete with a drain plug except where the pump is inherently self-venting, the drain and drip connection valves and air cock shall be provided in accordance with this General Specification.

The exposed shafts, couplings and moving parts of pumps shall be provided with suitable galvanised iron mesh guards coated with primers and finishing paint and shall be stoutly constructed and easily removable complete with lifting handles.

Each pump shall be provided with pressure gauges installed to indicate the suction and discharge pressure. The pressure gauges shall be neatly mounted on a rigid wooden or metal board adjacent to the pump or rigidly fixed in-line with suction and discharge pipework. Suitable permanent labels in English and Chinese shall be affixed for each gauge to indicate its function. The pressure gauges shall be suitable for the system pressure ratings concerned and shall comply with this General Specification.

Duty/standby selector, manual start/stop buttons, voltmeters, ammeters, high/low level alarm, and associated indications shall be supplied and installed at the starter panel inside the pump room. Except the manual stop buttons, similar provisions shall also be supplied and installed at the main and/or repeating fire alarm control and indicating panels as specified in the Particular Specification. A lock-off type emergency stop shall be supplied and installed adjacent to each pump set. Visual and audible warnings shall be provided on the pump control panel indicating the pump is stopped and locked by the emergency stop and shall remain on until the emergency stop is reset.

Except for the proprietary package pump set and proprietary starter panel of FSD approved type and manufactured with ISO 9001:2015 quality assurance system, the starter panel shall be made from at least 1.6 mm thick steel plate with lockable door. The enclosure for the motor starter and its control and indicating panel shall have a degree of protection not less than IP 65 as specified in BS EN 60529:1992+A2:2013 or the whole enclosure for the motor starter and its control and indicating panel shall be properly and fully protected by a waterproof cabinet or waterproof enclosure of steel with the required IP rating, which would not affect the continuous and normal operation, control and viewing of any part of the panel. All the enclosures shall be finished in white colour internally and grey colour externally. All electrical live parts shall be properly covered and protected for the best electrical safety, to the full satisfaction of the Supervising Officer.

Means for starting the pumps manually shall be provided at the pump room adjacent to the pumps and on the fire alarm control and indicating panel.

8.1.4.7 MAINTENANCE FACILITIES

Pump installation shall be complete with adequate facilities for maintenance and future replacement of base plate. Lifting eyes shall normally be provided upon pumps, motors, and engines. Where there is a Building Contractor carrying out the building work for a particular project, the overhead run-ways, hoists and hoisting beam will be carried out in the building work by the Building Contractor. Details of any requirements for overhead run-ways, hoists etc., required for installation and maintenance shall be submitted in a good time to the Supervising Officer for approval, so that due consideration may be given before the Building Contractor commences work in the areas concerned. Where there is no Building Contractor, all facilities for maintenance shall be deemed to be included in the FS Installation.

8.1.4.8 MOTORS FOR PUMP DRIVES

Electric motor for pump drives shall be of the drip proof or totally enclosed fan-cooled (TEFC) squirrel cage induction motor to BS EN 60034-1:2010, BS EN IEC 60034-5:2020, BS EN 60034-6:1994, BS EN 60034-9:2005, BS EN 60034-12:2017, and BS EN 50347:2001 with Class F insulation. Drip proof motors shall be fitted internally with an anti-condensation heater of single phase pattern arranged so that the heater will be switched off automatically when the motor is started and switched on automatically after stopping. Totally enclosed fan-cooled motors shall be dust and moisture protected to not less than IP 54. In damp situations or in underground pump houses, motor terminal boxes shall be of weather-proof type. The power factor of the motor shall not be less than 0.85 lagging under all normal operating conditions. Noise level of all motors shall be in accordance with or better than the recommendation of BS EN 60034-9:2005 and shall comply with EPD's requirements. Motor and pump shall be properly balanced and aligned to avoid excessive vibration.

8.1.4.9 MOTOR STARTING

The method of motor starting shall be selected according to the characteristics of the pump and shall comply with the Electricity Supply Co.'s limitations on starting current. The type of starter shall be as follows: -

<u>Condition 1 : For supply arrangement from company's overhead line</u>

Up to 3.8 kW	Direct-on-line
3.8 kW to 22 kW	Star/delta
Above 22 kW	Automatic-transformer 60% tapping or star/delta

<u>Condition 2: For supply arrangement from company's non-overhead line system</u>

Up to 11 kW	Direct-on-line
11 kW to 25 kW	Star/delta
Above 25 kW	Automatic-transformer 65% tapping or star/delta

8.1.4.10 STARTERS

Starters shall be air break triple pole electromagnetic contactor type and shall comply with and be tested to BS EN IEC 60947-4-1:2019. Any no-volt release mechanism shall be of the automatic resetting type such that on the restoration of the supply the motor can re-start automatically. Magnetic and thermal overload trips shall not be allowed. A phase failure protective device shall be incorporated. Utilisation category shall be AC-3 of intermittent duty Class 0.1, 60% on-load factor. Each starter shall comprise on/off controls and indications.

Starters shall be supplied and installed complete with enclosures except where required to be mounted upon composite control panels and shall be in accordance with BS EN IEC 60947-4-1:2019. Enclosure shall provide protection of person against contact with live or moving parts inside the enclosure, protection against ingress of dust and liquid and protection against mechanical damage in accordance with BS EN 60947-1:2007+A2:2014, BS EN IEC 60947-4-1:2019.

Starters shall be capable of making and breaking currents without failure under the conditions specified in BS EN IEC 60947-4-1:2019 for the required Utilisation category and the number of operation cycle. The main contact of a starter shall be silver or silver-faced.

Starters shall comply with the requirements for performance under short-circuit conditions stipulated in BS EN IEC 60947-4-1:2019. Type of co-ordination shall be Type 1.

Star/delta and auto-transformer starters shall have approved timers for automatic transition, calibrated and adjustable.

All components shall be of non-hygroscopic, non-corroding material and tropicalised. Operating coils shall be wound on nylon or similar and vacuum impregnated with non-organic varnish or plastic encapsulated.

8.1.4.11 PUMP SET ISOLATION MOUNTINGS

Unless otherwise approved by the Supervising Officer, motor driven pump set shall be mounted upon a common base plate supported by approved spring-type isolation mountings on concrete plinth. Where package fire pump set is specified, the fire pump, motor, couplings, controls etc. shall be pre-assembled on the common base plate with spring type isolation mountings by manufacturer in a factory possessing ISO 9001:2015 quality assurance system. The bases of the pump set shall be mounted on the raised housekeeping plinth using appropriate anti vibration spring mountings that shall be individually selected according to load distribution and shall have an additional free travel equal to one half of the rated deflection.

8.1.4.12 JOCKEY PUMPS

Jockey pumps complete with TEFC driven motor for maintaining hydraulic pressure shall be of the multi-stage horizontal or vertical centrifugal type having construction generally in compliance with this General Specification with stainless steel shaft and

impellers. Alternatively, reciprocating pumps capable of performing the same duty may be acceptable. Reciprocating pumps shall be with stainless steel piston rod and piston, synthetic rubber seals and oil bath lubrication, mounted on a common base plate with the electric motor drive. Motor efficiency of jockey pumps shall comply with the Building Energy Code, except for pump motor which is a component of approved package equipment.

8.1.4.13 FACTORY TEST AND CERTIFICATION

Each of the sprinkler pumps to be used in a project shall either be on the approved listed of the LPCB and suitable for the purposes and requirements, or, before delivery, shall be factory tested and certified on the performance to the requirements. Original factory test certificates and records signed by the pump manufacturer showing the related pump pressure head, flow rate, pump input power and efficiency curves specifically for each of the pumps shall be submitted to the Supervising Officer for checking, acceptance and record. Where the manufacturer does not have appropriate pump test facilities, test shall be arranged to be carried out by an accredited laboratory, or internationally well recognised independent testing organisation or regulatory body acceptable to the Supervising Officer before delivery. On-site test will not be accepted as a substitute for the factory test or the test by the independent testing organisation or regulatory body. For pump test or certification approval test done by the independent testing or regulatory organisation or accredited laboratory, the original test certificates shall be endorsed by the independent testing or regulatory organisation or accredit laboratory and submitted to the Supervising Officer for checking, acceptance and record.

Package fire pump set shall be factory tested and certified with all test details same as that for sprinkler pump. Where specified, factory test and certification shall be provided for other pumps with the same requirements as sprinkler pump.

SUB-SECTION 8.1.5

GASEOUS EXTINGUISHING SYSTEM

8.1.5.1 GENERAL

The design of the gaseous extinguishing system to meet with the requirements in this General Specification and the design intent shown in the Particular Specification and Drawings shall be included.

Gaseous extinguishing systems shall be of the total flooding type with pressurised open-ended piping installation on the distribution side. The automatic gas release mechanism shall be operated by means of fire detection units at the protected compartment or manually by a pull handle or push button as described.

The gaseous extinguishing system shall comply with the standards published by National Fire Protection Association (NFPA), British Standards or other internationally recognised equivalent standards acceptable to the Supervising Officer and demonstrated to be equivalent in terms of the type of construction, functions, performance, general appearance and standard of quality of manufacture and approved by the Supervising Officer. All proprietary design details from the manufacturer shall be submitted to the Supervising Officer and the FSD for approval.

Gaseous extinguishing system shall use carbon dioxide, clean agents or other gases as approved or as specified in the Particular Specification.

Carbon dioxide system shall be designed and installed in accordance with BS 5306-4: 2001+A1:2012, or NFPA 12:2018, and shall only be used in normally unoccupied areas where egress of personnel can be accomplished in 30 seconds.

Other gaseous extinguishing systems shall use clean agents unless otherwise specified. The system shall be designed and installed in accordance with NFPA 2001: 2018, BS EN 15004-1:2019, 15004-2:2020, 15004-3:2008, 15004-4 to 6:2020, 15004-7 to 10:2017 or other recognised established system design manual published by the manufacturer and acceptable to the Supervising Officer. The system shall also comply with UL 2166:2017 and UL 2127:2017 as relevant.

Where the agent for the gaseous extinguishing system is not specified in the Particular Specification and Drawings, Dodecafluoro-2-methylpentan-3-one (FK-5-1-12), Heptafluoropropane (HFC-227ea) or other alternatives clean agents which shall fully comply with FSD and EPD's requirements for the gaseous extinguishing system shall be used, to the acceptance of the Supervising Officer. The alternatives clean agents proposed shall not be in the list of EPD's banning schedule of the Ozone Layer Protection (Products Containing Scheduled Substances) (Import Banning) Regulation.

For installation in areas with high ceiling height, low temperature or with limitation in the storage spaces for the clean agent cylinders making the use of FK-5-1-12 and HFC-227ea unsuitable, other clean agents such as Trifluoromethane (HFC-23), inert gas etc. may be proposed together with detailed manufacturer's design proposal and hydraulic flow calculations using the manufacturer's approved computer software with relevant manuals submitted for approval by the Supervising Officer. Additional submission, tests

and endorsement by the FSD may be required for the use of other clean agents. All the cost for such submissions and tests to the approval of the FSD and the Supervising Officer shall be included.

The gaseous extinguishing system shall be a proprietary product approved by the LPCB, UL, FM or VdS and has been accepted by the FSD for use in buildings in Hong Kong in past projects. All components of the installation shall be compatible with the design of the system. Any add-on device shall be approved by the system manufacturer and shall not affect the proper functioning of the system.

The system shall be designed in according to an engineered computer programme approved by a recognised approving organisation as listed in the FSD Circular Letters or accepted by the FSD, or alternatively, the system shall be of modular or pre-engineering type and installed in accordance with the manufacturer's specifications.

To ensure the adequate gaseous flooding concentration in system operation, the design shall critically review the actual volume of the protected space if the ceiling void and the space in the raised floor where extinguishing gas will enter through the inherent opening such as wire mesh type floor panel.

8.1.5.2 QUALITY OF EXTINGUISHING AGENTS

Carbon dioxide shall be free of water and other contaminants that might cause container corrosion or interfere with the free discharge through nozzle orifices. In general, carbon dioxide obtained by converting dry ice to liquid will not be acceptable. The vapour phase shall not be less than 99.5% purity with no detectable off-taste or odour. The water content of the liquid phase shall not be more than 0.01% by weight. Oil content shall not be more than 10 ppm by weight.

Clean agents shall comply with NFPA 2001:2018 or BS EN 15004-1:2019, BS EN 15004-2:2020, BS EN 15004-3:2008, BS EN 15004-4 to 6:2020 and BS EN 15004-7 to 10:2017, in particular, the acute toxicity, the ozone depletion potential and global warming potential.

All extinguishing agents shall be supplied from approved local or overseas agencies/suppliers authorised or recognised by the proprietary manufacturer. Documentary evidence shall be provided when required by the Supervising Officer. The Supervising Officer may also require the content and composition of the extinguishing agents to be tested and verified by the extinguishing agent's original manufacturer, re-charging suppliers/contractors or other test agents acceptable to the Supervising Officer before installation with no extra cost.

8.1.5.3 PERFORMANCE OF STANDARD TOTAL FLOODING INSTALLATION

Carbon dioxide total flooding systems shall be designed to achieve the necessary concentration, rate of application and duration to maintain the extinguishing concentration as specified in BS 5306-4:2001+A1:2012 or NFPA 12:2018 in accordance with the volume, hazard and environmental conditions of the protected enclosures. The rate of application shall comply with following requirements: -

(a) For surface fires, the design concentration shall be achieved within 1 minute; and

(b) For deep-seated fires, the design concentration shall be achieved within 7 minutes but the rate shall not be less than that required to develop a concentration of 30% in 2 minutes.

Clean agent gas flooding system shall be designed to achieve an acceptable concentration in the protected compartment as stipulated in NPFA 2001:2018 or any recognised system design manual from the manufacturer at room temperature. Discharge of gas shall be substantially completed within 10 seconds. Following discharge, the concentration of clean agent shall develop throughout the protected compartment to achieve final extinguishment of fire within 60 seconds.

8.1.5.4 RESPONSIBILITY FOR SYSTEM PERFORMANCE

The compartment to be protected and the location of the gas cylinders shall be as indicated on the Drawings or as approved. The layout of pipework and nozzles shown on the Drawing is indicative only. The complete system shall be designed in co-ordination with other services.

Notwithstanding the calculation has demonstrated to the satisfaction of the Supervising Officer that the system will perform to the standard required, the system shall perform in accordance with this General Specification and Particular Specification under test.

8.1.5.5 DESIGN CALCULATION

To justify the selection of components and pipe sizes for the system, the submission shall include the manufacturer's system design manual and calculation for the pre-engineered system; or either full mathematical calculation or computer modelling flow calculation for the engineered system. Where the computer programme does not show all the calculation steps, evidence shall be provided that the computer programme produces a design that will perform in accordance with this General Specification, Particular Specification and the relevant standards.

The calculation shall be based on the equipment offered. Valves, siphon tubes, distribution valves as well as bends and junctions shall be represented in the calculations as equivalent lengths of pipe. The actual size and location of pipes and nozzles and the number of nozzles shall be designed on the basis of the calculated flow rates and terminal pressures required to ensure successful operation. The calculation or computer programme shall provide all the information necessary to complete the installation including the total quantity of gas required to flood to the required concentration with allowance for losses, the flow rate, start and end pressure of each section of pipe and the orifice size for each nozzle.

The calculation shall show that the design concentration can be achieved and that the maximum allowable concentration shall not be exceeded at all conditions.

8.1.5.6 A COMPLETE WORKING SYSTEM

All the components necessary for full operation of the system in the automatic or manual mode shall be supplied and installed regardless of whether such components are specified or not.

8.1.5.7 GAS STORAGE PRESSURE

All the extinguishing agents shall be stored in rechargeable cylinders to hold the pressurised agents in liquid form at ambient temperature. Gas cylinders of commonly available sizes and types that can be recharged shall be selected. Each gas cylinder shall be sized to have spare capacity to hold at least 10% more gas extinguishing agent than the amount calculated in the design for fire suppression. The gas cylinder is however not charged with 10% more gas extinguishing agent than the requirement.

For high-pressure carbon dioxide system, it shall be pressurised to a corresponding nominal pressure of 5860 kPa at 21°C. The normal filling density shall not be in excess of 68%. For low-pressure carbon dioxide system, it shall be kept at the design pressure of 2068 kPa by refrigeration system. The refrigerant in the refrigeration system shall have zero ozone depletion potential. Appropriate alarm and pressure relief shall be supplied and installed to cater for possible failure of the refrigeration system.

Clean agent cylinders shall be charged in accordance with NFPA 2001:2018 or any recognised system design manual from the manufacturer.

Gas cylinders, distribution pipework, valves, nozzles and fittings shall be manufactured to standards designed to withstand the maximum pressure of stored agent allowing for variations in ambient temperature.

The gas cylinders shall be FSD approved and designed for the intended gas storage pressure and use. A copy of the approval of the gas cylinders by the FSD shall be submitted.

8.1.5.8 GAS CYLINDERS

Carbon dioxide cylinders shall be of seamless steel construction to BS EN ISO 9809-1:2019 and BS EN ISO 9809-3:2019 or API-ASME Code for Unfired Pressure Vessels for Petroleum Liquids and Gases. For low-pressure refrigerated system, it shall be in accordance with the manufacturer's design and approved by recognised bodies such as LPCB, UL, FM or approved by any similar widely recognised independent regulatory body acceptable by the Supervising Officer and the FSD.

Clean agent cylinders shall be constructed in accordance with NFPA 2001:2018.

Cylinders shall be securely mounted in a frame bolted to the wall and to be so arranged that the external parts may be readily inspected and avoid corrosion. Each cylinder shall be fitted with an automatic pressure release device for over pressure protection of the cylinder.

Each cylinder shall be complete with gas valve, actuator, pressure gauge, flexible hose, check valve and all other necessary accessories. Where the cylinder of a proprietary system accepted by the FSD is not fitted with a pressure gauge, the system pipework for each cylinder shall be supplied and installed with pressure gauge.

A device shall be supplied and installed for measuring the amount of liquid in the cylinder at any time. This shall be done by a method which does not require the cylinder to be detached from the manifold. If a weighing device of the type that requires suspension is proposed, means shall be supplied and installed above each cylinder for the attachment of the weighing device. The contents of the cylinders may alternatively be checked by the use of a liquid level indicator of a type approved by the Supervising Officer.

A low pressure supervisory switch for continuous monitoring of the pressure of the cylinder shall be provided and when the cylinder pressure drops below 70% of the storage pressure, the supervisory switch shall transmit an abnormal signal to the system control panel.

The liquid shall be discharged from the cylinder through a siphon tube. The pressure of the liquid stored in the cylinder shall be such that freezing cannot take place at the lowest possible ambient temperature.

Means shall be supplied and installed to prevent gas discharging into empty containers and to prevent loss if the gas is released when any of the cylinders is disconnected.

Gas cylinders shall be painted signal red as specified in BS 381C:1996 in accordance with the requirements of BS 5252:1976. The cylinder shall be free from all rust and corrosion before painting is applied. The type of extinguishing agent, the tare weight, gross weight, liquid level at 21°C and also the degree of super pressurisation (for clean agent) where applicable shall be clearly painted on each cylinder with white paint.

Gas cylinders shall be of rechargeable and re-usable types. If the discharge of gas will require the irreversible rupture of any component of the system such that they are not reusable, one spare set of such components for each installed cylinder shall be provided. They shall be stored in a labelled and locked cabinet inside the gas cylinder room. Three keys shall be provided.

The gas cylinder shall pass the pressure tests as required under Chapter 295 – Dangerous Goods Ordinance before filling with gas. Relevant test result shall be submitted to the FSD. A copy of approval document from the FSD shall be provided for the gas cylinders to the Supervising Officer at the delivery of the gas cylinders.

Only gaseous extinguishing system that can be recharged locally and that the refilling of gas after discharge can be accomplished within a short time shall be supplied. Details of the refilling arrangement including agency, address of local workshop, refilling time etc. shall be submitted together with the equipment submission to the Supervising Officer for approval. Equipment submission without details on the refilling arrangement shall not be approved.

Facilities to isolate or to lock the gas cylinders shall be provided during routine maintenance or inspection work on the gas cylinders and control system in order to

prevent accidental discharge of gas. The facilities shall give appropriate warning indication when it is switched to the 'isolated' mode.

8.1.5.9 FIRE DETECTION AND SYSTEM CONTROL - AUTOMATIC RELEASE

Fire detection in the protected area shall be by means of smoke or heat or multi-sensing detectors as specified. Sufficient detectors shall be designed and installed to give sufficient coverage in accordance with BS 5839-1 of the whole of the protected area and connected in cross-zones. The fire detection control panel and the detectors shall be compatible with each other and the fire detection system shall comply with this General Specification.

Activation of a detector on one zone shall cause alarm bells to sound. Activation of detectors on two zones shall cause a siren or an approved horn to sound and red or amber flashlights in the protected area to light warning that the extinguishing agent is about to be discharged if the system is in the automatic mode. These warning signals will also be activated by the operation of the manual release before the discharge.

The gas extinguishing control panel shall control and monitor the gas release system. It shall include an automatic/manual lock-off unit controlled by key switches at EACH entrance to the protected area. The operation of key switch at these locations shall be capable of switching the system from automatic mode to manual mode. The manual release mechanism will remain operative whether the system is in either mode. A time delay unit which is adjustable in the range of 15 to 30 seconds shall be supplied and installed. Relays shall be supplied and installed to shut down ventilation/air-conditioning control system, to close openings and to switch off equipment as necessary. These relays will operate immediately when two zones of the fire detection system are activated or when the manual release is operated. Release of the gas will follow after the pre-set time delay.

The gas extinguishing control panel shall comply with this General Specification where relevant and with battery backup. The battery supply shall be able to actuate the system at the end of the standby period.

8.1.5.10 MANUAL RELEASE

A manual release unit shall be supplied and installed in a suitable position outside each entrance to the protected compartment. The manual release unit shall consist of a pull handle or push button mounted in a box with "break glass" cover. The box shall be so designed that its glass front may be readily replaced and that its front cover can be opened with a key for the purpose of operating the switch without breaking the glass.

8.1.5.11 EMERGENCY RELEASE

An emergency release handle with direct mechanism shall be supplied and installed in an accessible position at or near the gas cylinders. The emergency release shall require no power supply to operate and it shall be supplied and installed with a removable pin to prevent accidental release of gas. Provision shall be made for operation of the emergency

release to activate the relays to cause simultaneous shutdown of ventilation, air-conditioning, equipment etc. and to sound the alarm.

8.1.5.12 GAS RELEASE MECHANISM

The operation of the gas release mechanism shall require minimum power from an external electrical, pneumatic or mechanical source and shall preferably be operated by a falling weight device. No springs shall be used in any position where their failure or fracture would prevent the correct operation of the gas release mechanism or cause the inadvertent release of the gas.

All release devices and mechanisms shall be designed for the working conditions they will encounter and shall not readily be rendered inoperative or susceptible to accidental operation. They shall have proper protection from mechanical, chemical or other damage that would render them inoperative.

8.1.5.13 GAS DISTRIBUTION SYSTEM

All pipework shall be non-combustible and able to withstand the expected pressures and temperatures without damage. Specification of materials and installation shall conform to the relevant international standards for the respective extinguishing agent used.

Pipes for high pressure open-ended carbon dioxide system shall be as follows: -

Up to and including 40 mm	:	Heavy galvanised steel pipe to BS EN 10255:2004 / ISO 65:1981 butt welded or products having equivalent functions or performance
50 mm and up to and including 150 mm	:	Electric resistance and induction welded carbon steel pipe to BS EN 10217-1:2019 with wall thickness not lower than ASME B36.10M-2018 Schedule No. 80 pipe and with steel grade P265TR1 or ASTM A106/A106M:2019 Grade A hot finished or cold Schedule 80

Pipes for clean agent system shall be as follows: -

Pipes to be used shall conform to the following relevant standards or NFPA 2001:2018 or approved products having equivalent functions and performance or that recommended by the manufacturer for an approved proprietary system for a particular gas extinguishing system in accordance with the pipe size and pressure of the system. Special attention shall be paid, in particular, to the maximum allowable pressure for pipes and the minimum piping requirements.

ISO 65:1981 (BS EN 10255:2004), heavy grade	Screwed and socketed steel tubes and tubular and for plain end steel tubes suitable for welding or for screwing to ISO 7-1:1994 (BS EN 10226-1:2004) pipe threads

BS EN 10217-1:2019 with wall thickness not lower than ASME B36.10M-2004 Schedule No. 80 pipe and with steel grade P265TR1	Carbon steel pipes and tubes with specified room temperature properties for pressure purposes
or,	
ASTM A106/A106M:2018, grade A hot finished or cold schedule 80	Seamless carbon steel for high temperature service
ASME B31.1:2019	Power piping
ASTM A53/A53M:2020	Specification for welded & seamless pipe

Pipe fittings to be used shall conform to the following relevant standards or NFPA 2001:2018 or approved products having equivalent functions and performance or that recommended by the manufacturer for an approved proprietary system for a particular gas extinguishing system in accordance with the pipe size and pressure of the system. Special attention shall be paid, in particular, to the maximum allowable pressure for pipes and the minimum piping requirements.

BS 1640-3:1968	Steel butt-welding pipe fittings for the petroleum industry: wrought carbon and ferrite alloy steel fittings
BS EN 10253-2:2007 where applicable	Butt-welding pipe fittings. Non-alloy and ferritic alloy steels with specific inspection requirements
BS EN 10241:2000	Steel threaded pipe fittings
BS 143 & 1256:2000	Malleable cast iron and cast copper alloy threaded pipe fittings
BS EN 10242:1995 where applicable	Threaded pipe fittings in malleable cast iron
BS EN 1759-1:2004	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, class-designated. Steel flanges, NPS 1/2 to 24
ASME B31.1:2020	Power piping
ANSI/ASME B1.20.1:2013(R2018)	Standard for pipe threads, general purpose
ASTM A53/A53M:2020	Specification for welded & seamless pipe

Other standards adopted for proprietary systems that have been accepted by the FSD can also be used when approved by the Supervising Officer.

Pipes up to 100 mm shall be screwed and socketed, pipework over 100 mm shall use screwed flanges.

Threaded steel pipework and fittings shall be free of burrs and rust and shall be galvanised inside and outside. Screwed threads shall conform to the dimensions specified in BS EN 10226-1:2004. Screwed joints shall be made with P.T.F.E. tape or approved products having equivalent functions and performance but chemically inert to the extinguishing agent used. Compressed fibre gaskets free of asbestos shall be used for flange joints. Pipework shall be painted signal red as specified and illustrated in BS 381C:1996 in accordance with the requirements of BS 5252:1976. Brass fittings shall be left unpainted.

Pipework supports shall be arranged as near as possible to joints and changes of direction and each support shall take its share of the load. The maximum space between supports to take into the total mass of pipe and extinguishing agent shall be as follows: -

Table 8.1.5.13 Minimum spacing of pipework supports for gaseous extinguishing system

Pipe size (mm)	15	20	25	32	40	50	80	100	150	200
Span (m)	1.5	1.8	2.1	2.4	2.7	3.0	3.6	4.2	5.2	5.8

Additional supports shall be supplied and installed where there are extra loads such as valves, where required by the Supervising Officer and where recommended by the manufacturer.

Clean agent discharge nozzles shall be of robust construction and designed for use with the expected working pressure and temperature without deformation. The discharge nozzle shall be made of brass or stainless steel capable of being installed in the upright or pendent positions. Corner (90 degree), sidewall (180 degree) or centre (360 degree) of room placement shall be able to be accommodated. If the discharge nozzles are required to be placed in a back to back pattern, they shall be in full compliance with the guidelines and requirements of the manufacturer's manual. Part number, orifice diameter and direction arrow shall be etched prominently on the nozzle to ensure that the nozzle is placed in the proper orientation. The limitations mentioned by the manufacturer and/or detailed in the installation and maintenance manual shall be strictly followed for all piping drops to the nozzles.

Flexible hose connections shall be selected, inspected and tested only by an engineer or technician suitably trained and shall be designed for service at the pressures and temperatures involved.

To prevent entrapment in pipework, a suitable excess pressure relief valve shall be supplied and installed at any section of high pressure piping blocked by valves at both ends and shall operate at the following pressures: -

Carbon dioxide high pressure system : 15 MPa ± 5%

Clean agent extinguishing system : 2 times the maximum system pressure

Valves shall be capable of being opened when subjected to the maximum operating pressure and shall be so equipped that they can be opened manually. Valves for carbon dioxide system constantly under pressure shall be designed for a working pressure of 19 MPa. Valves for other clean agents shall be designed for maximum working pressure plus a 50% safety factor.

Manifolds shall be tested for duration of minimum 5 minutes at the manufacturer's works to the following minimum pressure: -

Carbon dioxide high pressure system:	:	19 MPa
Clean agent extinguishing system:	:	2 times the maximum system pressure

Pipework shall be earthed to prevent building up of electrostatic charge.

Gas nozzles shall be of approved type and appropriately spaced in accordance with the manufacturer's design manuals. Gas nozzles shall be supplied and installed in all voids and spaces to be protected by gas flooding in accordance with manufacturer's recommendation and as approved by the Supervising Officer and the FSD. Calculation or manufacturer's manual shall be submitted to substantiate the nozzle spacing.

8.1.5.14 GAS DISCHARGE SYSTEM TO BE SECURELY FIXED AND GUARDED

The gas discharge system including cylinders, pipework and nozzles shall be securely fixed to the structure with correctly spaced saddles or brackets in according with the FSD Requirements and Circular Letters. All components shall remain in place when subjected to the pressures and forces produced during discharge. Fixings shall allow for movement due to thermal expansion.

The system shall be guarded so that the operation of any moving parts shall not be obstructed.

8.1.5.15 INDICATOR LIGHTS, WARNING NOTICES AND LABELS

All compartments protected by a gas extinguishing system shall have a warning notice fixed on each entrance door to the compartment. Configuration, lettering, colour and size of the notice shall be in accordance with the FSD Requirements and Circular Letters for the respective gas extinguishing system. The notice shall be made of sheet metal plate not less than 1.6 mm thick or of material approved by the Supervising Officer.

For a total flooding system, protecting a normally occupied area, which is designed to operate automatically when unoccupied but to be in the manual mode when occupied, the following warning lights shall be installed together with explanatory/warning notices in English and Chinese. Such notices shall be clearly legible and painted or engraved on sheet metal plate or on substantial durable material approved by the Supervising Officer. Warning lights and notices for systems other than as described above, e.g. local application systems or systems designed to be in the automatic mode when the area is occupied, shall be equally informative and suitably substantial and shall be arranged and worded either as specified or as agreed with the Supervising Officer.

Inside the protected area, a flashing red light to indicate gas release imminent with a notice which shall read: -

"WARNING - *** gas release imminent. Leave the room at once."

Outside each entrance to the protected area: -

(a) a green light to show that the system is on manual control with automatic control locked off, with a notice which shall read: -

"Safe to enter. *** fire extinguishing system on manual control. When room vacated, switch to automatic control".

(b) an amber light to show that the system is on automatic control, with a notice which shall read: -

"Not safe to enter. *** fire extinguishing system on automatic control. Switch to manual control before entering".

(c) a red light to show that the system has operated, with a notice which shall read: -

"DANGER - Do not enter. *** gas discharged".
*** denotes the extinguishing agent.

The manual/automatic lock off key switches, the manual release units and the emergency release handle shall all be labelled in English and Chinese so that it is clear what their purpose is and how to operate them.

8.1.5.16 SYSTEM ODORISER

Odorisers or oil of wintergreen where specified shall be capable of automatically treating the gas after releasing from the cylinder and shall be of citrus/distinctive odour type, so that hazardous atmosphere can be recognised at once. Where odorisers or oil of wintergreen are installed, a suitable notice to the effect that anyone detecting the citrus/distinctive odour shall leave the area immediately and report the occurrence to a responsible person. The notice shall be worded in English and Chinese.

8.1.5.17 ROOM CONDITION

Co-ordination with relevant parties to check the exhaust requirements for the room is required after the discharge of gas extinguishing agent and additional facilities requirement shall be submitted if the exhaust provisions are not adequate to meet with the relevant safety standards or that recommended by the manufacturer. Where specified, exhaust facilities and fans recommended by the manufacturer shall be supplied and installed for removing the gas after discharge. Unless otherwise specified, approved dampers, curtains and other approved products having equivalent functions and performance shall be supplied and installed to shut off all room openings/door louvres/air ducts as shown on the Drawings during the discharge of gas.

Calculation shall be checked and provided to show that the rooms designed with gaseous extinguishing system can maintain the design concentration for the period required in the NFPA Standard. Where necessary, test shall be conducted such as door fan pressurisation and depressurisation test to establish the data on room leakage rate. Any works leading to a high leakage rate not complying with the requirements of the FSD shall be reported to the Supervising Officer when such works are provided by others.

On-site full discharge test shall be allowed after completion of the Installations when required by the FSD and in accordance with the FSD's requirements to confirm the design conditions can be met. The gas cylinders shall be refilled after the discharge test.

8.1.5.18 OTHER AUTOMATIC FIXED INSTALLATIONS OTHER THAN WATER

Other automatic fixed installations other than water shall be designed, supplied and installed where specified. Details shall be submitted to the Supervising Officer for approval.

SUB-SECTION 8.1.6

MANUAL AND AUTOMATIC FIRE ALARM SYSTEM

8.1.6.1 GENERAL

Performance at fire and reliability are two key requirements in the selection of equipment. Highly reliable approved manual and automatic fire alarm systems shall be designed, supplied and installed. Substantiation on a good record of reliability shall be obtained from the suppliers and submitted to the Supervising Officer. System that has a poor false fire alarm record or has failed to provide the required record when asked will not be accepted for the Installations. Only equipment that suits the operating environment shall be selected and used.

Manual and automatic fire alarm initiating devices shall be appropriately sited to avoid factors that can generate false fire alarms/unwanted fire alarms.

At locations where the relative humidity is higher than 95% continuous non-condensing such as in non-air-conditioned space, detectors of harsh type or of appropriate design specially made for harsh environment and high humidity application up to relative humidity 99% continuous non-condensing shall be used.

At dusty or windy environment, appropriate filtering and shielding devices shall be added to the detectors. At external area or covered area that can be subject to rainwater at wind condition, waterproof equipment shall be used. Appropriate type of surge protective device shall be supplied and installed in the electrical and control circuits for suppression of over-voltage surges arising from lightning strikes and switching transient.

Manual and automatic fire alarm system shall be of analogue addressable type except for system with manual fire alarm only.

The rate of false fire alarms, excluding false fire alarms arising from malicious actions by humans and false fire alarms with good intent involving genuine belief of a fire, shall not be more than one false fire alarm per 100 fire alarm initiating devices per annum for all the Installations in a building, and shall not be more than one false fire alarm per 80 automatic detectors per annum for the automatic fire alarm system. The false fire alarms shall be limited in the process of equipment selection, choosing suppliers, types and brands, whole system integration, installation, siting, testing, commissioning, cleaning/maintenance, and verification of manufacturer's test records and quality control standards. Only brands and models of equipment and materials that have good track record or job reference of meeting the above requirement on the rate of false fire alarms shall be selected.

All equipment/devices such as fire manual call points, heat/fire/flame/beam/multi-sensors detectors, detectors with integration devices, alarm bells, etc. shall be: -

(a) FSD approved type; or

(b) Listed by the Product Certification Body as recognised by FSD and conform to all relevant local requirements of FSD.

8.1.6.2 MANUAL CALL POINT

Manual call point shall be of "break-glass" or "resettable" type complying with BS EN 54-11: 2001 or other standards acceptable to FSD. The method of operation of all manual call points in a system shall be that of type A as specified in BS EN 54-11:2001. Electrical contacts shall operate automatically upon breaking of the frangible element at the front of the unit, or pressing resettable button at the front of the unit. The cover shall be locked in position with a special key and the frangible element shall be clipped firmly into place.

The unit shall be of pleasing appearance and styling, constructed of non-combustible and corrosion resistant materials, and finish enamelled red. The words: "Fire: Break Glass 火警鐘掣" or "Press Here 按下報警" shall be suitably engraved, embossed or printed in English and Chinese on the front.

Contacts shall be of silver or approved non-deteriorating alloy of normally-open or normally-closed type to suit the alarm system. A concealed "test" device shall be included. The voltage and current ratings of the contacts shall be marked in the unit or clearly indicated in the corresponding installation instruction sheet, to the approval of the Supervising Officer.

Call points shall be of flush semi-recessed mounting or surface mounting type as specified and suitable for direct connection to the wiring system of the type specified therein without the addition of unsightly surface boxes, glands, adapters etc. Where necessary, specials boxes shall be supplied and installed for installation of the call points in a conduit system. Boxes recessed in concrete or plaster shall be of galvanised steel.

Terminals for external conductors shall be provided in the unit for connection of at least two conductors of size not less than 1.5 mm^2 each. When the call point is intended for use at voltage in excess of extra low voltage, it shall have suitable means for providing earth continuity between external circuits connected to it.

Call point located at outdoors or at a location subject to possible rainwater due to occasional strong winds and other intermittent factors shall be of waterproof type to IP66 as the minimum. Waterproof call point shall be provided at all locations with risk of water damage even when the risk is not high. The corresponding conduit to the call point shall run through an additional box installed below the call point to prevent the possibility of water running inside the conduit enter the call point directly.

Where the call point is located in hazardous area, explosive zone and dangerous good store, the call point shall also comply with this General Specification.

Generally, manual call points shall be fixed at a height of 0.9 - 1.2 m above finished floor level unless otherwise required to comply with the universal accessibility best practices. The fixing heights of all manual call points shall be to the acceptance of the FSD and the Supervising Officer. They shall be surface mounted, or semi-recessed, in order to present a side profile area of not less than 750 mm^2.

Manual call points shall be provided at all escape routes and each hose reel point and, in particular, adjacent to all storey exits (or the entrance lobby in lieu if such lobby leads only to the storey exits) within a distance of not more than 2 m and adjacent to all staircase exits to open air on G/F or place of ultimate safety. For exit opening 12 m in

width or more, two manual call points shall be provided before such exit (or before the entrance lobby in lieu if such lobby leads only to the exit) and within a distance of 2 m from each end of the opening. Additional call points shall be provided where specified in the Particular Specification or Drawings.

Manual call points shall be of addressable type or integrated with appropriate interfacing module when analogue addressable manual and automatic fire alarm system is provided. The interfacing module shall be compatible with the manual call points and the analogue addressable manual and automatic fire alarm system.

8.1.6.3 HEAT DETECTOR

Heat detector shall be of point-type complying with BS EN 54-5:2017+A1:2018 or other standards acceptable to FSD.

Heat detector shall be of Class A1/A2 complying with BS EN 54-5:2017+A1:2018 with combined fixed temperature and rate-of-temperature-rise, except as specified or where necessary to suit the actual environment of the space being protected. Class A1R, BR or CR heat detector as appropriate to suit the operating environment shall be provided for pantry, domestic kitchen and specified space where rapid increases in temperature can be experienced under normal operating condition. Class A1S, BS, CS, DS, ES, FS or GS heat detector, depending on the maximum application temperature, shall be provided for boiler room, commercial kitchen and specified space where under normal operating condition, high ambient temperature and rapid changes in ambient temperature may be experienced.

Heat detector shall function correctly at ambient temperature between -20ºC to the maximum application temperature specified in BS EN 54-5:2017+A1:2018 for respective class. Heat detector shall be designed to assume minimum protection rating of IP 43 or equivalent standards. It shall be suitable for stable operation in the Hong Kong climate where high humidity condition may exist at location without constant air-conditioning. Manufacturer's printed catalogue or other certification shall be provided for proving that the heat detector in either air-conditioned space or non-air-conditioned space is suitable for operation under relative humidity up to 95% continuous non-condensing. In rooms or spaces where the relative humidity is usually high, such as boiler room and plant rooms, and other areas specified by the Supervising Officer, the heat detector shall be suitable for operation under relative humidity up to 99% continuous non-condensing.

Heat detector shall be of analogue addressable type. Heat detector unit shall be of flush or surface mounting type as specified in the Particular Specification. Heat detector unit in suspended ceilings shall be flush mounted and shall, in the case of modular constructed ceilings, be co-ordinated into the ceiling layout.

Installation of heat detector shall be in accordance with the Modified BS 5839-1. Heat detector shall be mounted not less than 500 mm away from any walls or partitions and not less than 25 mm or more than 150 mm below the ceiling or roof. In open areas under flat horizontal ceilings, the horizontal distance between any point in the area and the nearest point-type heat detector shall not exceed 5.3 m.

Where the type of detector is not specified, heat detector shall be used in electrical/switch room, utility/plant room, kitchen, non-air-conditioned space/area/void, basement, car parks, semi-open/open area, cold store, lift shaft, riser ducts etc. except in areas where smoke or multi-sensors detectors are required to satisfy FSD Requirements and Circular Letters such as installation for sleeping risk, for smoke management, for ventilation/air-conditioning control system, etc.

8.1.6.4 SMOKE DETECTOR

Point-type smoke detectors include ionisation smoke detector, optical (photoelectric) smoke detector, multi-sensors detector, duct type smoke detector and other point-type smoke sensing devices as approved by the Supervising Officer or other standards acceptable to FSD.

Smoke detector shall be of proprietary design to avoid false fire alarms. Smoke detectors that have good track record or job reference on no false fire alarm shall be supplied and installed.

Smoke detector shall function correctly at continuous ambient temperature between 0ºC and 48ºC, relative humidity up to 99% continuous non-condensing in non-air-conditioned space and relatively humidity up to 95% continuous non-condensing in air-conditioned space unless otherwise specified. Where smoke detector is installed in low temperature zone with temperature less than 10ºC continuous or in high temperature zone with temperature higher than 40ºC continuous, smoke detector designed for a wider operating temperature range shall be provided. Smoke detector shall be suitable for stable operation in the Hong Kong climate where high humidity condition may exist at location without constant air-conditioning. Manufacturer's printed catalogue or other certification on the maximum and minimum application temperature and humidity range of the smoke detector shall be submitted. Smoke detector shall have minimum protection rating of IP 43 or equivalent standards.

Smoke detector shall be housed in a corrosion-proof plug-in unit designed to mount pendent, surface or semi-recessed as specified. Removal of the unit from its base shall cause a fault alarm signal to be given. Sensitivity shall be adjustable by means of a pre-set control only accessible by use of a special tool or in the central fire alarm control system.

Smoke detector shall be of analogue addressable type. The system shall have automatic drift compensation provision and remote adjustable sensitivity setting to cater for different environment.

Smoke detector shall be provided with built-in wind-shield to ensure that air currents of up to 10 m/s do not affect the proper operation of the detector. A built-in wire mesh shall be incorporated to prevent entry of insects into the interior. Static shielding shall be built in and included to protect against the operation interference of electrical noise.

Smoke detector installed inside lift shaft and outdoors shall be completed with extra wind-shield to cater for higher air current and shall also be of harsh type with anti-condensation facilities or built-in heaters designed for higher temperature fluctuation, relative humidity and dirt accumulation.

The electronic circuitry shall be of solid-state type, operating at extra low voltage DC. The quiescent current consumption of the unit shall be minimal and shall not exceed 650 μA at 24V. The circuitry shall be protected against electromagnetic interference. The internal electronic circuitry shall be of highest possible reliability and protected against voltage spikes and surges. The smoke detector shall be capable of operating satisfactorily under variation of ±25% minimum in supply voltage.

Smoke detector shall have normal working life (mean failure time) of not less than 10 years. Documentary evidence shall be submitted from the manufacturer or from an independent organisations accredited under the Hong Kong Laboratory Accreditation Scheme (HOKLAS) by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation body with mutual recognition agreement with HKAS, approved by the Supervising Officer certifying the normal life span of the detector.

Installation of smoke detector shall be in accordance with the Modified BS 5839-1. A low-profile design smoke detector that protrudes no more than 60 mm from the ceiling shall be used in all air-conditioned areas with false ceiling. Point-type smoke detector shall be mounted not less than 500 mm away from any walls or partitions and not less than 25 mm or more than 600 mm below the roof or ceiling. In open area under flat horizontal ceiling, the horizontal distance between any point in the area and the nearest detector shall not exceed 7.5 m.

Use of smoke detector in area vulnerable to false fire alarm shall be avoided where possible if it shall comply with the FSD Requirements and Circular Letters. Heat detectors will be preferred in such case if it will comply with the requirements.

Smoke detector where specified and without the type stated shall be multi-sensors type detector except in area having high risk of fast growing fire with colourless smoke. Ionisation smoke detector or optical smoke detector shall only be used where specified or at the approval of the Supervising Officer or as required by the FSD. However, where ionisation smoke detector is the most suitable detector for a particular application, the consideration on performance at fire shall take priority over the reliability factor and ionisation smoke detector will be the choice in such case.

Smoke detector installed in cold store and in non-air-conditioned space/area/void including basement, plant room, car park, open area, concealed/false ceiling, raised floor, external area, lift shaft, and riser ducts shall be of approved harsh type designed to stand for extreme or hostile environmental conditions. Smoke detector of harsh type shall also be provided in dusty area and in area where the relative humidity is likely to exceed 95% non-condensing.

Where there is no smoke or heat point-type detector suitable for the environmental condition of a particular application, special detection system or other systems approved by the Supervising Officer shall be used.

For smoke detector installed in the air duct, duct type smoke detector with probe units of approved type shall be provided.

Where there are two or more smoke detectors installed in a zone or fire compartment, the smoke detectors shall be wired in cross-zoned operation (coincidence connection) unless otherwise specified. The activation of any one smoke detector shall initiate a fire alarm with audible alarm and visual indication on the control panel only and shall at the

same time activate a time delay unit which is adjustable in the range from 0 second to 5 minutes or as approved by the Supervising Officer. If the alarm still exists at the end of the time delay period and/or the second smoke detector in the coincidence connection is activated, the building fire alarm shall be activated and the fire signal shall be sent via the fire alarm direct link and the alarm transmitter as appropriate. The setting of the time delay period shall be agreed by the FSD.

Smoke detectors installed solely as automatic actuating device for drencher system, fire shutter, fire door, and fire/smoke curtain provided for the purpose of fire compartmentation shall be connected in cross-zoned operation and shall only be operated with fire alarm when any two detectors in coincidence connection are activated. Activation of one detector shall give visual and audible alarm indication on the control panel only. Transmission delay unit shall be provided so that operation of two detectors in coincidence operation shall not send the fire signal to the FSD until after a pre-determined time delay. The setting of the time delay period shall be agreed by the FSD. When required by the FSD, activation of detectors provided solely as automatic actuating device for the above systems shall not activate the building fire alarm and shall not send the fire signal to the FSD via the alarm transmitter and fire alarm direct link.

Different types of smoke detectors shall also comply with the requirements specified hereunder.

8.1.6.5 IONISATION SMOKE DETECTOR

Ionisation smoke detector shall comply with BS EN 54-7:2018 or other standards acceptable to FSD.

Where ionisation smoke detector of harsh type is specified, the ionisation smoke detector shall be specially designed to function correctly at extreme or hostile environmental conditions including large accumulation of dirt/dust, high wind speed, extreme temperature and high humidity (up to 99% relative humidity), and approved by the Supervising Officer. Anti-condensation facilities shall be included in the detector of harsh type as necessary to cope with high humidity.

Ionisation smoke detector shall be of the type responding to both visible and invisible products of combustion. Detector shall have not less than two ionisation chambers, one for detection and one for reference. Detector having only one ionisation chamber will not be accepted. Radiation level from the radioactive isotopes shall be within the safety limit of less than 0.1 mr/h at a distance of 100 mm. The combined radiation activity of each ionisation smoke detector shall not exceed 555 kBq in commercial/industrial buildings and 370 kBq in residential building.

The total Americium 241 radiation level of all the ionisation smoke detectors installed in building shall be submitted to Hong Kong Radiation Board for approval on behalf of the Employer as necessary before the completion of the Installations and the commencement of the Maintenance Period. Arrangements shall be made for inspection of the Installations by the authorised representative(s) of the Hong Kong Radiation Board when required.

The total radioactivity from all the detectors installed in building shall be limited to below 20 MBq and detectors with low radioactivity approved by the Supervising Officer shall be used to meet with this requirement.

In the case that ionisation smoke detector with lowest practical radioactivity is used and the total radioactivity from all detectors in building still exceeds 20MBq, submission shall be made to the Hong Kong Radiation Board for obtaining the licence on behalf of the users before the completion of the Installations and the commencement of the Maintenance Period, unless the building is exempted from such licensing requirement as informed by the Hong Kong Radiation Board or the Supervising Officer.

Ionisation smoke detector shall have built-in signal integration feature to avoid false fire alarm caused by transient interference and be characterised by a reversible response time delay from 15 to 30 seconds depending on the concentration of smoke continuously present before an alarm is initiated. Upon clearance of the transient interference within the time delay, the ionisation smoke detector shall resume its quiescent state without any alarm initiation.

8.1.6.6 OPTICAL SMOKE DETECTOR

Optical (or photoelectric) smoke detector shall comply with BS EN 54-7:2018 or other standards acceptable to FSD.

The optical smoke detector shall respond to the product of combustion based on photo detection of light scattered in a forward direction by smoke particles. The detection chamber shall consist of a horizontal optical bench housing an infra-red emitter and sensor arranged radically to detect forward scattered light. The sensor shall be of silicon DIN photo diode or better design. The emitter shall be infra-red light emitting diode. The sampling and confirmation frequency shall not be less than once every 10 seconds and 2 seconds respectively. At least three consecutive sensed alarm signals shall be needed to trigger detector alarm. The detector shall have built-in devices or labyrinth arrangement to prevent false fire alarm due to an exterior high-energy light sources.

8.1.6.7 MULTI-SENSORS DETECTOR

Multi-sensors detector shall comprise a combination of heat sensor, optical/ionisation smoke sensor, flame sensor, carbon monoxide sensor, ultraviolet/infrared sensors, and/or other sensors as recommended by the manufacturer to suit a particular fire risk and growth of fire. Multi-sensors detector shall comprise at least one smoke sensor and one heat sensor. Unless otherwise specified, the smoke sensor shall be optical smoke sensor type. The heat sensor shall be combined fixed temperature and rate-of-temperature-rise type.

Multi-sensors detector shall conform to the appropriate standards for type of combination of sensors such as BS EN 54-29:2015 for combination of smoke and heat sensors, BS EN 54-30:2015 for combination of carbon monoxide and heat sensors and BS EN 54-31:2014+A1:2016 for smoke, carbon monoxide and optionally heat sensors, or other standards acceptable to FSD for other combinations of the above-mentioned sensing elements. Only multi-sensors detector suitable for the required application, environmental condition, fire growth characteristic, fire risk and hazard shall be selected

and used. Performance data, equipment catalogue, technical details, software algorithm, test report and certificate shall be submitted to the Supervising Officer for approval. Information proving suitability of multi-sensors detector for a particular application and hazard shall be submitted for approval.

In addition, the multi-sensors detectors shall comply with the following and other prevailing requirements of FSD:

(a) Failure of the carbon monoxide (CO) detection element of the multi-sensor smoke detector shall not adversely affect its normal function and performance as a smoke detector;

(b) Fault signal shall be triggered in case of the fault of other detection elements for heat, CO etc.;

(c) In the FSD's compliance inspections, field test method for ordinary smoke detectors shall be adopted to test the multi-sensor detectors if the multi-sensors detectors are designated as smoke detectors in the application;

(d) The smoke sensing function of a normal multi-sensor detector shall not be disabled through any programming or similar process at the AFA control panel;

(e) A symbol specifically to indicate multi-sensor detectors used either as smoke or heat on the layout plans shall be included in the legend, for example "H_M" or "S_M" in a circle represent multi-sensor detector as heat detector and smoke detector respectively. Appropriate corresponding field test methods shall be adopted to verify its purposed normal function;

(f) The spacing limitation and design criteria for smoke or heat detector prescribed by Modified BS 5839-1 shall be complied with for the application of multi-sensor detector as smoke or heat detector respectively;

(g) Only either "smoke detector" or "heat detector" shall be specified in the fire service notes of the general building plan. The term "multi-sensor detector" shall not be used.

Multi-sensors detector shall process inputs from more than one sensor using software algorithm that equate signals into pre-determined responses to react to defined environmental condition. One sensor can "check" with the other to confirm or deny the existence of a fire.

Multi-sensors detector shall have no more than four sensors. Through integration of signals from different sensors by software algorithm, multi-sensors detector shall be capable of providing reasonable response both for the fast growing fire and the slow developing smouldering fire. Multi-sensors detector shall be analogue addressable type. Except for smoke sensing function, individual sensor can be programmed to be disabled for some periods of time when required and approved by the Supervising Officer.

The design operating life of multi-sensors detector shall be at least 10 years. Documentary evidence from the manufacturer to demonstrate the operating life of multi-sensors detector shall be submitted.

8.1.6.8 PROBE UNIT

Duct type smoke detector with probe unit shall be provided for smoke detector installed for the air duct. Probe unit for air duct insertion mounting shall be of robust corrosion-proof construction and capable of accurately sampling the air flowing in the duct over a wide range of velocities. Insertion of the probe shall cause negligible air flow head loss. Probe unit shall be designed to suit the type of smoke detector installed. Probe unit shall be installed in the centre of a straight section of air duct that has a length at least 6 times its width. The probe unit shall be supplied and installed with filter and the filter element shall be designed such that it can be removed for routine cleaning without the need of removing the probe unit and it does not cause the detection system to raise a false fire alarm.

Where duct type smoke detector is provided to air ducts in area vulnerable to false fire alarm for ventilation/air-conditioning control system, two duct type smoke detectors fed by the same or separated probe units shall be provided and connected in coincidence (cross-zoned) operation as agreed by the FSD and approved by the Supervising Officer. Activation of one detector shall give visual and audible alarm indication on the control panel only, and the ventilation/air-conditioning control system and building fire alarm shall only be actuated when two detectors in coincidence connection are activated.

8.1.6.9 INTRINSICALLY SAFE DEVICE

Manual call point, heat detector, smoke detector, multi-sensors detector and other detectors installed in hazardous areas including explosive gas and dust environment shall be intrinsically safe type or comply with BS EN 60079-14:2014 or BS EN 50281-1-2 or other international standard acceptable to FSD and the Supervising Officer as appropriate as required by the FSD Requirements and Circular Letters.

Intrinsically safe heat detector shall be supplied and installed in Cat 2, Cat 5 and appropriate categories of dangerous good stores, fuel oil tank rooms etc.

The intrinsically safe devices shall be factory certified to Ex ia IIC T5 complying with marking Ex ia IIC T5 to IEC 60079 or approved products having equivalent or better functions and performance for use with all listed gases. The certification shall cover the entire system and components and shall be approved by an independent organisations accredited under the Hong Kong Laboratory Accreditation Scheme (HOKLAS) by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation body with mutual recognition agreement with HKAS, approved by the Supervising Officer. Intrinsically safe devices shall also comply with BS EN IEC 60079-0:2018, BS EN 60079-11:2012 (Incorporating corrigenda January 2012 and November 2014) and IEC 60079 where relevant.

The operation of intrinsically safe manual call points, heat and smoke detectors shall be as specified in this General Specification. Remote red LED indicator shall be provided and factory certified for use with the detector. Each intrinsically safe circuit shall be

restricted to a single zone and connected as a radial connection from the automatic fire alarm panel. Each circuit shall be provided with a "translator" and a safety barrier. The "translator" shall translate the system voltage to a level compatible with the intrinsically safe requirements and to boost the current pulses returned by the manual call points and detectors back to the panel. The "translator" shall be installed outside the hazardous area and within the safe area. Certification of the "translator" is not necessary.

A safety barrier shall be supplied and installed at the boundary of the hazardous and safe areas to stop the transmission of transient and fault interference from the system circuit into the intrinsically safe circuit. Unless otherwise specified or approved, the safety barrier shall be of single channel 28 V/300 Ohm type. The safety barrier shall be completed to a high integrity safety earth by duplicate (two) copper cables, each of cross sectional area of 4 mm^2 or greater. The impedance of the earth connection from the connection point to the main power system earth shall be less than one ohm. The safety barrier shall be certified to Ex ia IIC.

Each safety barrier shall not be connected to more than one intrinsically safe circuit in the hazardous area. The circuit shall not be connected to any other electrical circuit. The circuit in the hazardous area shall be installed in separate conduit and wiring system. The circuit shall be capable of withstanding a 500 V rms A.C. test voltage for at least 1 minute. The manual call points, detectors and LED indicators shall be installed in such a way that all terminals and connections are protected to at least IP 20 when they are mounted on the bases.

8.1.6.10 ALARM BELL

Alarm bells shall be of minimum 150 mm diameter gong suitable for 24 V DC operation. They shall comply with BS EN 54-3:2014+A1:2019 or other standards acceptable to FSD. Each alarm bell shall be capable of producing a minimum sound level of 80 dB(A) at 3 m. The bell shall consist of a micro motor as the driving unit offering high performance and reliability together with low current consumption and low starting voltage characteristics. The bells shall be painted red and labelled "FIRE ALARM 火警警鐘" in both English and Chinese.

The alarm bells shall produce an alarm sound level complying with Modified BS 5839-1 when the doors of the rooms are closed and with all the windows fully opened. For domestic building, the alarm sound level of any alarm bell shall not be less than 60dB(A), and not less than 5dB(A) above any background noise likely to persist for a period longer than 30s when the building is in use, whichever is the greater. For other types of buildings, the alarm sound level of any alarm bell shall not be less than 65 dB(A), and not less than 5dB(A) above any noise likely to persist for a period longer than 30s, whichever is the greater except in areas not required by the FSD. The locations of all sound measurements shall be taken at 3m from the inside of the main entrance door with all the windows fully opened and all the doors closed. A higher alarm sound level of minimum 75 dB(A) is required for sleeping accommodation. High power alarm bells shall not be used. The alarm sound level at all accessible locations shall not exceed 120 dB(A).

The alarm bells shall be sited and distributed throughout the buildings to produce the alarm sound level. The alarm bells where shown in the Drawings are the minimum requirements only. Adequate and additional alarm bells shall be provided to meet with

the sound level requirement. Before installation, calculation on the alarm sound level shall be submitted to the Supervising Officer for approval. The alarm bell sound level at different locations shall be tested and verified on completion of installation work.

The alarm bells shall be zoned such that only alarm bells in the pre-determined zones shall sound. The zoning of alarm bell shall be in accordance with the FSD Requirements and Circular Letters and to the approval of the FSD and shall be submitted to the Supervising Officer for approval. In general, zoning of fire alarm is for the phased evacuation in large building and in premises supervised by trained staff. It depends on many factors including type and height of building, provision of sprinkler system, presence of refuge floors, and separation between occupancies. For large building, details of the proposed alarm zoning shall be submitted for approval by the FSD and the Supervising Officer when such are not indicated on the Drawings.

Alarm bell shall be suitable for use in addressable system when used with analogue addressable manual and automatic fire alarm system.

Where specified, alarm bell / alarm sounder shall be capable of generating two different alarm tones, one intermittent tone for alert and one continuous tone for evacuation, that can be programmed, either on a zoned basis or common system basis.

8.1.6.11 VISUAL ALARM UNIT

Visual alarm unit shall be supplied and installed in places within buildings that are accessible to the public and where manual fire alarm system is provided. Visual alarm signal shall be in the form of flashing light conforming to NFPA 72:2019, or in accordance with Section 17 of Modified BS 5839-1 and as approved by the Supervising Officer. The strobe light shall consist of a xenon flash tube, LED or similar and associated lens/reflectors system. Unless otherwise approved by the Supervising Officer, the flashing light shall be red.

The strobe shall be designed for one flash per second with continuously applied minimum voltage and providing a light output of not less than the requirements in NFPA 72:2019 or as approved. The light output shall also not be so high as to cause difficulty in vision due to glare. The strobe shall have no measurable in-rush current in excess of the operating peak current. Visual alarm unit of appropriate light intensity shall be selected and positioned such that at least one of them can be seen at any part of the building accessible to the public. The minimum rating of a visual alarm unit shall be 15 cd minimum.

The number of visual alarm units and their positions if shown on the Drawings are indicative only. Adequate number of visual alarm units shall be supplied and installed to comply with FSD Requirements and Circular Letters including FSD Circular Letter No. 2/2012, and approved by the Supervising Officer. There shall be at least one visual alarm unit above or at a position as close as practical to every hose reel point and alarm point. Every compartment shall in any case be provided with at least one visual alarm unit. Where the number of visual alarm unit can be reduced by using unit of higher light intensity and accepted by the FSD, details shall be submitted for approval by the Supervising Officer. In general, the distance between two visual alarm units shall not be more than 60m.

The unit shall be mounted at a height not less than 2.1m above the floor but not closer than 150mm to the ceiling.

The unit shall be suitable for surface or semi-flush mounting and labelled "FIRE ALARM 火警" in both English and Chinese. The height of English letters and Chinese characters shall not be less than 10 mm and 15 mm respectively. They can be indicated on separate plate affixed nearby or engraved on the light cover.

Where more than one visual alarm units are supplied and installed in a room or in a common compartment, they shall be arranged to operate in synchronisation.

Back up emergency power supply and battery supply of adequate rating and capacity shall be supplied and installed for the visual alarm units similar to the fire alarm bells, to the satisfaction of the Supervising Officer and to the acceptance of the FSD.

8.1.6.12 ALARM INDICATOR LAMP FOR DETECTOR

Detector shall have a built-in alarm indicator lamp to be easily visible for identification of the detector giving off the alarm until the alarm condition is reset. The alarm indication shall be by means of a red LED or LED which emitting red light during alarm state.

Unless otherwise accepted by the Supervising Officer, the LED indication shall be designed for 360^{o} viewing or with two built-in LED indicators for each detector so positioned that at least one LED indicator can be seen from any angle. Remote LED indication may be added to substitute one of the built-in indicators when approved.

The indicator lamp shall be visible from a distance at least 6m directly below the indicator in an ambient light intensity up to 500 lux.

Detector installed in inaccessible area such as inside false ceiling, ceiling void, floor void and in concealed space etc. shall have remote alarm indicator lamp connected and mounted at ceiling level directly below or near to the concealed detectors with lamp plate for identification. The remote alarm indicator lamps shall be conspicuous from any position in the nearby area. The remote indicating lamp plates shall be clearly labelled with words "Fire 火警" and location of detectors shall be represented by graphic symbol. The wording and graphic symbol shall comply with details as stipulated in FSD Circular Letter No. 6/2021.

Where detectors are installed inside plant rooms, electrical equipment rooms, store rooms, dangerous good stores etc. which are unoccupied and normally kept locked, similar remote indicator lamps shall be supplied and installed above the doors outside the rooms to show the alarm status. If there is more than one detector inside the room, the indicator lamps can be connected to a common remote indicator lamp mounted above the door outside the room.

8.1.6.13 MOUNTING BASE

Detachable detector shall be provided unless otherwise specified. For detector installed at easily accessible height in public circulation area, detachable detector shall not be used without the approval of the Supervising Officer and shall be provided with means to guard against theft when required.

Smoke detectors (other than those installed in concealed space and ceiling void) installed in guestrooms of guesthouses or the like, bedrooms of dormitories, student hostels and other accommodations as specified or as required by the FSD shall be provided with integrated and proprietary made sounder bases. The installation of smoke detector with integrated sounder base shall comply with Modified BS 5839-1 whereas the sounder base shall be certified in compliance with BS EN 54-3:2014+A1:2019 or approved by FSD. Upon actuation of any of such smoke detector, its integrated sounder base shall sound in addition to the sounding of the general building fire alarm. The sound level shall be measured right below the sounder base(s) and 1m above finished floor level with all the guestroom/bedroom windows fully opened and doors closed. In the absence of general building fire alarm, the minimum sound level achieved shall satisfy the relevant requirements that stipulated in FSDCoP.

The mounting bases of all detectors shall be designed to enable detectors to be plugged in with a simple clockwise motion without significant insertion force. Where detectors are mounted at level above 4 m, they shall be capable of being removed and re-fixed from below by means of an extended arm special tool. Removal of individual detector from the mounting base shall not affect the operation of other alarm devices in the system.

A remote monitoring system shall be provided for detachable detector to detect the removal of the head from the mounting base to give a fault signal.

The mounting base shall be able to accommodate different types of detectors of the same series from the same manufacturer and products from compatible suppliers. Any type of detector heads of the same series including heat, smoke, multi-sensors, fire, etc. shall be interchangeable and fit into a common mounting base. Unless otherwise specified or approved, all types of detectors (except the intrinsically safe detectors and the detectors for gas flooding system) supplied in a building shall be of the same series from one manufacturer.

8.1.6.14 TEST FACILITIES

The end of line tester for each circuit of a conventional fire alarm system shall be located at high level or concealed inside ceiling void but shall be easily accessible. The tester shall be flush mounted type with stainless steel plate surface marked with engraved characters indicating the function.

Provision shall be made so that individual detector can be tested without either sounding an alarm or requiring the complete system to be disabled to prevent such an alarm.

8.1.6.15 INTELLIGENT ADDRESSABLE DEVICE

8.1.6.15.1 General

All devices in the addressable fire alarm system shall be of analogue addressable type, and of type approved by the Supervising Officer, including the detectors, manual call points, flow switches, pressure sensors etc. where appropriate.

Each device/detector shall be addressable via a mechanism approved by the Supervising Officer. The address of each unit shall be easily set and changed. The allowable address shall be adequate to cater for the whole fire alarm system with ample spare capacity for future expansion. Dip switch type address setting mechanism is generally not preferred. Unless otherwise approved by the Supervising Officer, the address setting mechanism shall be attached to the base/device/detector so that the device/detector head can be changed and replaced without the need to re-program the address. The device/detector shall constantly verify against the database in the addressable fire alarm control and indicating panel via an addressable detection cable loop.

All the necessary tools, kits, electronic and computerised devices/instruments shall be supplied for initial setting, adjustment and subsequent resetting, retesting and re-commissioning of all the addressable detectors/ components and the whole fire alarm addressable system after any detectors are replaced or any part of the addressable system are modified. All relevant instructions and manuals giving clear guidelines on how to use the tools, kits, and electronic/computerised devices/instruments, and adequate training, shall be provided to the operation and maintenance personnel to enable them to use such tools, kits and devices/instruments readily for works on the addressable system. All hardware and software licensing agreements and any future software upgrading for such tools, kits and devices / instruments if required are wholly allowed for and granted when they are handed over, together with other spares and tools to the satisfaction of the Supervising Officer.

Addressable devices shall provide information for continuous monitoring and control of detector status and annunciate the need for immediate service. The decision on the control actions shall however be from the fire alarm control system and not on individual detector. Connection wires for the addressable devices shall be of approved type by the Supervising Officer. Unless otherwise specified or approved by the Supervising Officer for use of 2-wire cable, twisted pairs in concealed conduits for point-to-point connection shall be used.

Detector shall be fully compensated for temperature, humidity and barometric changes in the surroundings. All electronic components shall be hermetically sealed to prevent their operation from being impaired by dust, dirt, humidity, corrosion or mechanical shock. All circuitry shall be protected against typical electrical transients and electromagnetic interference according to BS EN 61000-4-1 / BS EN IEC 61000-4-3 / EN

IEC 61000-6-3 / BS EN 50130-4 or other standard accepted by the Supervising Officer. Built-in testing facility shall be provided.

One LED indicator designed for 360º viewing or two built-in LED indicators shall be provided for each detector unless otherwise accepted by the Supervising Officer and they shall be so positioned that at least one LED can be seen from any angle. Remote LED indicator may be added to substitute one of the built-in LED indication requirement when approved. The detector shall have provisions to drive remote visual alarm indicator. Remote indicator shall be compatible with the detector so that the operation of the indicator shall not affect the brightness of the detector's built-in LED.

8.1.6.15.2 Addressable Heat Detector

Addressable heat detector shall continuously measure the temperature of air and generate a proportional analogue output.

The detector shall employ two matched thermal sensing elements in a bridge configuration to give a response which depends both on temperature and the rate of change of temperature. The reference and sensing thermal sensors shall be fabricated under identical conditions to ensure good matching and excellent tracking with both temperature and ageing.

8.1.6.15.3 Addressable Smoke Detector

Addressable smoke detector shall continuously measure the products of combustion in the air and generate a proportional analogue output.

The measuring chamber shall be so designed to create a very low background signal in clean air condition. A specially designed device shall be incorporated to control dust settlement on non-critical surfaces so that high dust level in the surroundings can be tolerated.

8.1.6.15.4 Addressable manual call point

The addressable manual call point shall be of a type approved by the Supervising Officer or other standards acceptable to the FSD.

8.1.6.15.5 The addressable detectors (heat, smoke or others) shall be provided with the following features as a minimum: -

(a) Remote adjustment of detector sensitivity to suit the occupancy and/or the environment of a detector at any time;

(b) Sensor monitoring with automatic compensation of sensor alarm threshold due to aging, humidity and accumulation of dirt and dust with time (automatic drift compensation);

(c) Adjustable time lag from the time of reaching alarm threshold to the time of issuing or communicating a fire alarm (pre-alarm, alarm verification);

(d) Different alarm levels are provided such as detection level, maintenance or regular servicing level, fire alarm level etc. to give an early warning for maintenance to avoid false fire alarm (multi-sensitivity levels, day/night adjustment, and maintenance alert);

(e) Alarm condition simulation for testing purpose; and

(f) Loop monitoring for error such as short circuit, open circuit, detector removed and detector communication failure (auto detector test, circuitry test).

8.1.6.16 ADDRESSABLE INTERFACE MODULE

8.1.6.16.1 General

Various modules shall be provided for the addressable automatic fire alarm system for the required functions, interfacing with non-addressable devices and other services. Modules shall be mounted into junction boxes for ease of installation. The addresses of these modules shall be easily set, seen and changed.

The module shall have a conspicuously located LED, which blinks or does not blink, upon being scanned by the panel. Upon determination of an alarm condition, the LED shall be latched on and blink or not blink as assigned.

8.1.6.16.2 Monitor Module

Monitor module shall allow the panel to interface with and monitor individual non-addressable monitoring alarms such as a non-addressable manual call point, sensors, detectors, water flow switches, sprinkler supervisory devices etc.

The module shall provide addressable inputs for all N.O. or N.C. contact for continuous monitoring. In addition to the supervised state of the monitored device, the measurement of the supervision shall be sent to the addressable automatic fire alarm control and indicating panel.

The monitor module shall also be provided with a supervised initiating circuit. An open-circuit or short-circuit fault shall be indicated at the fire alarm control and indicating panel.

Facilities shall be provided for carrying testing at the monitor module during maintenance and diagnostics.

8.1.6.16.3 Control Module

Control module shall supervise and monitor wiring to appliances of small connected load like alarm bells, flashing light units, indicator units, and interface relays. Upon command from the addressable automatic fire alarm control and indicating panel, the module shall disconnect the supervision and connect the external power supply to the device and a signal shall then be sent to the panel to indicate that the command was executed. The external power shall be isolated, so a trouble condition at the power supply shall not interfere with the rest of the system.

The connected alarm load shall be closely monitored for any open and short circuit conditions. The output circuit connected to the loading shall be short circuit protected.

8.1.6.16.4 Fault Isolator Module

The non-addressable fault isolator module shall detect and isolate a short-circuited segment of a fault-tolerant loop whilst allowing the rest of the addressing circuit to function normally.

At least one fault isolator module shall be provided for every 20 intelligent addressable devices, i.e. detectors, manual call points, monitor modules and control modules to limit the number of devices lost in the event of a short circuit.

8.1.6.16.5 Facilities for interfacing with any other systems as shown on the Drawings or as specified in the Particular Specification.

8.1.6.17 SPECIAL DETECTION SYSTEM

Special detection systems, including optical light beam smoke detection system (complying with BS EN 54-12:2015 or other standards acceptable to FSD), VESDA (very early smoke detection alarm system), line-type heat detection system, flame detection system (complying with BS EN 54-10:2002 or other standards acceptable to FSD), aspirating smoke detection system (complying with BS EN 54-20:2006 or other standards acceptable to FSD), carbon monoxide detection system, gas detection system, infrared detection system, ultraviolet detection system, video smoke detection system, dust detection system etc. shall be provided where specified or where required to meet with the requirements for a particular application. The detection system shall be of a type acceptable to the FSD and approved by the Supervising Officer. Selection of special detection system shall be to suit a particular application, environmental condition and fire hazard. Detailed performance data, equipment catalogue, description, technical information, test report and certificate shall be submitted to the Supervising Officer for approval. Information justifying the suitability of the special detection system shall be submitted for approval.

SUB-SECTION 8.1.7

AUDIO/VISUAL ADVISORY SYSTEM

8.1.7.1 GENERAL

The audio/visual advisory system and the selection of proper, correct and compatible equipment and components shall be designed, supplied and installed to achieve the performance specified. Detailed design layouts as well as full technical information and calculations for the system shall be submitted to the Supervising Officer and the FSD for their approval prior to ordering and installation.

All equipment and components offered shall be proven proprietary products with good and reliable quality for accomplishing the safe evacuation of occupants in the premises during a fire risk condition and to the acceptance of the Supervising Officer and the FSD. They shall be operated at not more than 90% of the manufacturer's specified ratings. They shall be fully tropicalised and suitable for continuous operation with optimum performance in ambient temperature between 0ºC and 40ºC and with relative humidity up to 99% continuous non-condensing as normal condition, and also in fire conditions.

In selecting makes and types of equipment, servicing facilities and replacement spare parts shall be made available locally for future maintenance of the system.

In the event that these requirements cannot be met due to the use of improper, incorrect or incompatible components, all such components shall be replaced and the whole system shall be redesigned to the satisfaction of the Supervising Officer at no extra cost.

The audio/visual advisory system shall comprise coloured lights, flashing lights, illuminated and coloured signs, directional signs, low-level directional signs, microphones, amplifiers, recorders and players, EEPROM and other associated built-in recording and play back components/devices, loudspeakers and other accessories for providing indication to the exit routes and exits and for delivering verbal or direct transmission of emergency messages to the occupants.

Audio/visual advisory system shall be supplied and installed to all areas and places controlled and classified under Places of Public Entertainment Ordinance, Cap 172 and to other areas as required in FSD Requirements and Circular Letters.

8.1.7.2 AUDIO SYSTEM

8.1.7.2.1 General

The audio system shall be designed and installed in accordance with the FSD Requirements and Circular Letters and BS 5839-8:2013. The system shall also comply with this General Specification, the General Requirements for Electronic Contracts issued by the EMSD, the General Technical Specification for Public Address System issued by the EMSD, BS EN 50849:2017 and BS EN 60268 or technical specification for voice alarm control and indicating equipment under BS EN54-16:2008.

The design of the system shall be such that special attention is paid to the following points: -

(a) System reliability and fail-safe;

(b) System damage caused by defective appliances and components;

(c) System feedback of sound level of operation for audio signals;

(d) Adequate output levels; and

(e) Variable input levels.

The audio system shall be designed to ensure matching between amplifier and load. The variation in available power shall not exceed 3 dB between the outlet nearest to the amplifier and any other outlet in the system. Suitable and acceptable repeaters and signal conditioner shall be installed as necessary to maintain the sound power level. A load variation of 50% shall not affect the quality of sound or cause the output voltage at any outlet to vary by more than 6 dB.

The audio system shall be provided with pre-amplifier and amplifier of sufficient power to drive all the loudspeakers and other equipment in the system. Each pre-amplifier and amplifier shall have a 100% standby unit, so arranged that if any one unit failed, the corresponding standby unit shall take up the duty for the respective operation automatically within fifteen (15) seconds. The system shall be so wired and arranged as to achieve this function.

8.1.7.2.2 Desktop Microphone

Desktop microphone shall be single zone type complete with condenser microphone on gooseneck for use with the amplifier. It shall complete with a minimum of 1m length cable and a plug.

8.1.7.2.3 Amplifier

Amplifier shall be fully transistorised solid state device. They shall have sufficient power with at least 10% spare capacity to drive all the speakers within the broadcasting zone.

The rated power output of each amplifier shall have a regulation from no load to full load of 2 dB. The amplifier shall have an audio response level to within +2 dB from 50 Hz to 14 kHz at full output, and the total harmonic distortion shall not exceed 1% at full load.

The noise level of each amplifier shall be at least 40 dB below maximum output with all inputs and outputs correctly terminated. Sensitivity shall be such that full output can be obtained from a 2 mV microphone or equivalent input.

Amplifier shall maintain a damping factor of not less than three over the frequency range of 100 to 5,000 Hz. Amplifier shall have a low hum level and low over-shoot or ringing when a square wave generator is connected to the input level within the working range. The variable tone control shall provide attenuating of the high frequencies, i.e. 0 - 20 dB at 8 kHz.

Amplifier shall be of constant voltage output type not requiring dummy load to maintain matching of the amplifier output. The output shall be provided with an overload protection device to prevent damage to the output stage from overload or a short circuit on the speaker lines.

The signal incoming leads shall terminate at the rear of the amplifier through suitable screened type plug mountings. Where more than one input is required, a screwdriver adjustment shall be provided at the rear for each additional input for preset balancing of the inputs. Input sockets and output terminals shall be well separated and in separate cut-outs in order to prevent coupling between the amplifier input and output.

Preamplifier shall be provided with connection to power amplifier, microphone, recorder and other associated built-in recording and play back components/devices, and other audio equipment. It shall have built in On/Off switch, headphone outlet and volume control for each channel. An LED VU meter shall be provided to indicate the output level.

For single broadcasting zone, the power amplifier shall be completed with mixer. Power amplifier shall be capable of connecting with microphone, recorder, built-in recording and play back components and devices, and other audio equipment. Each power amplifier shall have built in On/Off switch, headphone outlet, volume control for each channel and matching transformers with tapping to enable loudspeakers to be driven at 100V, 70V or 50V up to 8Ω. An LED VU meter shall be provided to indicate the output level. The power output shall be adequate for the connected loudspeakers in the broadcasting zone.

For multiple broadcasting zones, each zone shall be provided with a power amplifier channel.

Power amplifier shall be provided with input transformers for audio inputs from the preamplifier and built-in loudspeaker matching transformer. It shall have built in On/Off switch, headphone outlet and an LED VU meter showing the output level. The power output shall be adequate for the number of connected loudspeakers within the zone.

8.1.7.2.4 Loudspeaker

Loudspeaker shall provide a crisp, clear audio reproduction for voice and alarm tone signalling, designed for fast and easy surface/flush installation on ceiling or wall. It shall be constructed of sheet steel or high impact ABS plastic in white colour or as specified matching the false ceiling or wall finishes. The back of the loudspeaker shall have an enclosure to prevent ingress of dirt to the speaker zone. Loudspeaker installed on false

ceiling shall be suitable for flush mounting with the body fully recessed into the false ceiling.

Loudspeaker installed in plant room or any other places without false ceiling shall complete with surface mounting boxes which include knock-out for surface conduit installation.

Loudspeaker shall be equipped with tapped transformer suitable for the system operating voltage and having individual optional attenuator. The optional attenuator shall be integrated with the speaker unit and shall comprise carbon type volume controls with adjustment.

Loudspeaker shall have a maximum output rating of at least 1 Watt and a frequency response of within +3 and -7 dB from 100 to 10,000 Hz with respect to 1 kHz.

The layout of the loudspeakers as shown on the Drawings is for the indication of the areas where the audio announcement is required to be provided. The audio system shall be designed and co-ordinated with the Building Contractor and other sub-contractors of the Building Contractor for the exact quantity and positioning of the loudspeakers.

Where the loudspeakers specified are provided by others, co-ordination s with relevant parties on the installation of the loudspeakers for completion of the audio system shall be required. Compatible equipment for operating the loudspeakers without affecting other systems connected to the loudspeakers shall be provided.

8.1.7.2.5 Recording and Play Back Devices/Decks

The recording and play back components, devices and decks shall be of proprietary products with proven quality capable of recording and play back music and audio messages. The equipment shall be of adequate capacity for recording and playing back not less than 120 minutes of high quality music and audio messages. Details shall be proposed to the Supervising Officer for approval. The recording and play back system shall also be to the acceptance of the FSD.

8.1.7.2.6 Control and Monitoring

A wall mounted panel for the control and monitoring of the audio system shall be provided as specified.

The monitoring and control system shall be backed up by battery and charger. Except for the proprietary control panel of FSD approved type and manufactured with ISO 9001:2015 quality assurance system, the housing of panel and front panel shall be constructed from 1.6 mm thick stainless steel sheet to BS EN 10088-1:2014 No. 1.4401 with engraved labels and lettering.

8.1.7.2.7 Audio Alarm Messages

Audio alarm message in Cantonese and English shall be announced repeatedly with the audio alarm bell signal in sequence. The message shall be as required by the FSD and will be similar to the following: -

"This is a fire alarm message. Please keep calm. Follow the flashing lights to the nearest exit. Do not use the lift", and in equivalent Cantonese as:

"這是一個火警警報, 請保持冷靜, 依閃燈指示, 由就近出路牌方向離開, 切勿使用升降機。 "

The message shall be audible in all areas within the specified zone of the building including toilets, stores, staircases etc. The signal to noise ratio shall not be less than 40 dB when the loudspeaker output level in the area concerned is not less than 20 dB above the background noise level normally expected in the respective area during fire situations. The variation in sound power level between the outlet nearest to and farthest from the amplifier shall not exceed 3 dB.

8.1.7.3 VISUAL SYSTEM

Visual system shall consist of a system of coloured and flashing lights that may be incorporated into the illuminated exit signs and related directional signs, and may be supplemented by additional signs and low-level directional signs to assist building occupants and public visitors to escape quickly during fire. The system shall be approved by the Supervising Officer and shall comply with FSDCoP, relevant FSD Requirements and Circular Letters, BS ISO 3864-1:2011, BS 5499-4:2013, BS EN 60598-1:2015+A1:2018, BS EN 60598-2-22:2014 (Incorporating corrigendum June 2014), BS 5266-1:2016, BS EN 50172:2004 and BS EN 1838:2013 unless otherwise specified. Design and construction details of visual system shall be submitted for approval.

(a) The design of illuminated exit signs and related directional signs shall conform to this General Specification. A flashing light control gear shall be integrated with each sign as required. An independent circuit including a separate set of lamp-holder, wiring and protective gear shall be provided for each lamp element. In normal situation, the lamp elements shall be in the ON condition and they can be changed to flashing mode in emergency. Where separate set of flashing lights or signs is proposed, they shall be submitted to the Supervising Officer for approval.

(b) The evacuation routes may be supplemented by low-level directional signs of non-flashing photo-luminous type, or other signs to the approval of the Supervising Officer.

Construction of signs in visual system, the luminance output, and the words, colour and size of signs used in the system shall comply with this General Specification and to the approval of the Supervising Officer. The signs and associated flashing lights shall be of design easily visible, conspicuous and legible in fire and smoke conditions.

The sign in visual system shall be safe in construction and use. It shall not create any harmful effect and not generate any additional risk and liability to the building occupants, workers and public visitors during the whole period of use.

The construction details, finishes, appearance and performance data of the signs shall be submitted to the Supervising Officer for approval before fabrication. The appearance and details of the signs shall be modified to the satisfaction of the Supervising Officer.

The average luminance of visual system shall not decrease by more than 30% of its initial design value throughout its rated life in continuous operation when operated at ambient temperature between 5ºC and 40ºC.

The battery, battery charger, wiring, testing facilities, automatic changeover switch, accessories and related provisions of illuminated signs shall comply with relevant requirements of emergency lighting installation and the requirements specified in this General Specification, BS 5266-1:2016, BS EN 50172:2004 and BS EN 1838:2013. The battery shall be of capacity adequate to maintain light output of all lamps as well as the flashing lights for a period of not less than the period specified for emergency lighting installation during emergency in this General Specification and in any case shall be not less than 2 hours after mains failure.

8.1.7.4 OPERATION OF THE SYSTEM

The audio/visual advisory system shall interconnect with the fire alarm system of the building. When the fire alarm is activated, the following operations shall be performed automatically: -

(a) The flashing light control gear of all the illuminated directional signs and exit signs which are incorporated with flashing lights within the fire alarm zone shall operate. The lamp elements shall be switched on and off continuously at a duration of 1 to 2 seconds. The flashing rate shall be continuously adjustable between 30 to 60 times per minute. All the lamp elements in the directional sign shall be lighted up and turned off simultaneously to produce the maximum visual effect. The process shall continue until the fire alarm is reset. Then the lamp elements shall be switched back to the normal ON condition automatically and shall be switched to the flashing mode again on receiving any further fire alarm signal.

(b) The alarm bells and flashing light units within the alarm zone shall operate. After 10 seconds, the alarm bells shall stop while the flashing light units shall continue to flash. Then the pre-recorded audio alarm messages shall announce within the alarm zone to alert the occupants and direct them to evacuate immediately following the directional and exit signs. The alarm bells and the audio alarm messages shall repeat in sequence continuously until the fire alarm has been reset at the fire alarm panel.

8.1.7.5 CONTROL SYSTEM

The complete audio/visual system shall be equipped with all the necessary circuits and components for the proper control and operation of various functions, the indications of the health status of the system, and any fault diagnosis. The circuits and components shall be in printed circuit modular board design. The components shall include the following items and any other items necessary for the proper control and operation of the system to the satisfaction of the FSD: -

(a) microphone control panel;

(b) speaker zone switch bank and annunciator module;

(c) tape transfer, power supervisor and remote transmission module;

(d) automatic timer sequencer which shall be a multi-function assembly to provide pre-recorded messages, timing sequences, transfer function plus supervisory signal to amplifiers;

(e) alarm failure transfer units which shall transfer audio output from main duty amplifiers to standby amplifiers upon detecting the absence of a supervisory signal;

(f) general alarm and all call module;

(g) alarm input transfer module for controlling the amplifiers.

The microphone control panel shall contain dual pre-amplifiers continuously supervised. It shall have the ability to transfer to the standby pre-amplifier upon failure of the duty unit. A noise reduction hand microphone having a UL listed or other standards accepted by FSD and the Supervising Officer and supervised coil cord shall be provided. Provision for automatic alarm zone override of speaker switching shall also be included to ensure proper alarm zoning if the selector switches are left in an incorrect mode.

The speaker zone selector switch bank shall control the audio dispersion throughout the protected premises. Each switch shall permit the transfer of its zone of speakers into either all call, page and fire operation modes. Failure of any zone shall be indicated by the corresponding amber LED. Indicators for alarm and switch bank trouble shall also be supplied and installed.

Tape transfer, power supervisor and remote transmission module shall supervise the remote rack equipment, provide output and supervision of the remote transmitting function, and control the sequencing of evacuation tape messages and the selection of tape track.

The system shall not cause any interference with all electrical or electronic system, the telephone system, radio paging system, audible paging and other communication system and vice versa, whether they are in operation or not.

The operation of all controls shall be automatic and as simple as possible. The operating procedures shall be provided to give concise and clear indications. Where it is

considered necessary, these indications shall be accompanied by the connection diagram which shall show the various operation alternatives available to each equipment.

All equipment shall be mounted in well ventilated but water protected stainless steel enclosure and equipment rack. Where permanently fixed in position, the top and undersides of the equipment shall be readily accessible by means of removable panels. The metal enclosures shall be secured and have sufficient space for cable routing and bending. Except for the proprietary equipment enclosure that have been accepted by the FSD and manufactured with ISO 9001:2015 quality assurance system, the housing shall be constructed from BS EN 10088-1:2014 No. 1.4401 stainless steel of 1.6 mm thick minimum, well ventilated but shall be free from any dust and be vermin and corrosion proof. All operating controls and equipment shall be adequately labelled to assist ease of operation and maintenance of the system.

8.1.7.6 WIRING INSTALLATIONS

The wiring installation for the audio/visual advisory system shall be supplied and installed except the power supply to the exit signs, the directional signs, the amplifiers and the monitoring and control panel as indicated on the Drawings.

The power supply cables to the audio/visual advisory systems shall be fire resisting cables which shall comply with the relevant Clauses and Appendices of the FSDCoP, relevant FSD Circular Letters and this General Specification.

The wiring to the loudspeakers and the directional signs shall be installed in concealed conduits, and the wiring shall be so arranged that any damage to the wiring for any one loudspeaker or directional sign shall not affect the proper operation of all other loudspeakers nor directional signs. All cables shall run continuously from the originating point to termination and no joint or connector shall be permitted. The amplifier output circuits to the loudspeakers shall use twin cables with low power loss and protected against interference. Care shall be taken to ensure that each loudspeaker is correctly phased.

SUB-SECTION 8.1.8

FIRE ALARM CONTROL SYSTEM

8.1.8.1 GENERAL

The fire alarm control system and all necessary controls for the whole Installations including equipment for fire control centre shall be provided. Design of fire alarm control system shall also be included. There shall be at least one fire alarm control and indicating panel in the system with additional repeater panels installed at appropriate locations and as required.

Fire alarm control and indicating panel shall comply with BS EN 54-2:1997+A1:2006 (Incorporating corrigenda January 2007 and July 2009), shall be listed by the Product Certification Bodies in accordance with FSD Circular Letters Nos. 3/2020, 6/2021 or of FSD approved type and acceptable by the Supervising Officer. The fire alarm control and indicating panel shall be constructed of, or enclosed with cabinet, at least 1.6 mm stainless steel plate to BS EN 10088-1:2014 Grade 1.4401, except for the proprietary control panel that has been accepted by the FSD and manufactured with ISO 9001:2015 quality assurance system or equivalent. A glazed lockable door shall be supplied and installed to restrict access to the control switches but allowing a full view of the visual indications. The panel shall afford a degree of protection to at least IP 52 under BS EN 60529:1992+A2:2013. The fire alarm control system shall be conventional hard wire type or a type approved by the FSD, and approved by the Supervising Officer.

BACnet interface shall be added for fire alarm control and indicating panel to allow communication between all fire service devices and iBMS for remote monitoring and analysis of fire/fault alarms.

The system shall have devices to detect and raise fire alarm for open or short circuited condition of the system. Where a residual current device is required in order to comply with the statutory requirements for Electrical Installation, a fault on any circuit or equipment shall not result in isolation of the supply to the fire alarm control system. The system loop design shall be such that the actuation of any detection device or when there is any fault in the loop shall not cause the loop to be disabled for the alarm and trouble signals to be followed.

Layout, design and construction of all the fire alarm control and indication panels and repeater panels shall be submitted for approval.

All wirings in the panels shall be neatly arranged and grouped together. Proper labels shall be supplied and installed.

Surge arresters for the fire alarm control system shall be supplied and installed to prevent false fire alarms and malfunctioning of the fire alarm control system due to power and lightning surge.

Where time related system, transmission delay unit and/or similar features are needed for the fire detection system, they shall be submitted to the FSD for approval in accordance with FSD Circular Letter No. 4/2001. The time delay shall be adjustable

from 0 to 5 minutes or such longer period as agreed by the FSD and approved by the Supervising Officer. The final setting of the time delay shall be agreed with the FSD.

Where specified, time related system shall be provided to automatic fire alarm system with alarm signals for fire detection system.

Where automatic fire alarm system is provided, fire alarm control system and associated fire alarm control and indicating panels shall be analogue addressable type.

To cater for maintenance and future alteration of fire alarm control system, approved addressable system from manufacturer who can provide relevant programming information, manuals, details, keys, hardware locks, training and passwords shall be supplied and installed. Addressable system from manufacturer who cannot provide/release the programming information, hardware locks and password information shall not be selected to the Supervising Officer, future users and maintenance bodies. The programming information will be limited to those that are required for routine maintenance, diagnosis and repair works, and for future upgrading and modification works such as relocation, change, deletion, addition etc. This requirement shall be confirmed with the manufacturer before placing order.

All the components/devices in the system manufactured by different firms shall be compatible. Confirmation or certificate on the compatibility from each source or manufacturer to guarantee that the various items are totally compatible shall be obtained for approval by the Supervising Officer. In this respect, a certificate from one source will not be accepted. Fire alarm control system with all the components/devices supplied by one manufacturer shall be used when confirmation is not available.

The connection and service for linking with the FSD's approved centre and the associated communication line (e.g. telephone point, dedicated telephone line etc.) installation/connection/hiring fee for the whole Maintenance Period shall be at no extra cost.

8.1.8.2 CONVENTIONAL FIRE ALARM CONTROL AND INDICATING PANEL

8.1.8.2.1 General

Conventional fire alarm control and indicating panel shall be supplied and installed to monitor centrally the manual fire alarm system, fire hydrant and hose reel installation, VAC control system and other Fire Service Installations and equipment. The panel shall be equipped to suit the manual fire alarm system. Fire alarm signals may originate from manual call points, flow switches, pressure switches, gaseous flooding system alarm contacts etc. as applicable. The connection of these devices in zone (alarm circuits) shall be as specified.

The panel shall include the following minimum provisions: -

(a) Service Features

- Relays, terminal strips, wiring, labels etc. for the proper operation of the whole system including alarm bells;

- Auxiliary relay or additional relay contacts for automatic starting of water pumps and other devices as specified;

- Test facilities for each alarm zone.

(b) User Control Switches

- System isolation key switch;

- Zone isolating key switch;

- Alarm silencing switch with warning buzzer and indication;

- Buzzer mute;

- Sound alarm switch for all indicator circuits and internal buzzer;

- System reset switch after clearance of an alarm or fault condition;

- Lamp test switch;

- Pump start switch;

- Key switches for isolating signals to the VAC control system, to the fire shutters and to the lift controls with visual warning indication;

- Other necessary controls for fire hydrant/hose reel system and sprinkler system as required by the FSD.

(c) Visual Indicators

- "Supply On" visual indicator, green;

- "System On" visual indicator, green;

- "System or Device Isolated" visual indicator, amber with buzzer;

- "Fire" alarm visual indicator for each zone, red;

- "Zone Fault" visual indicator, amber;

- "System Fault" visual indicator, amber;

- "Battery" condition (full/charging/low) visual indicator, green/amber/red respectively;

- "Battery Charger Fault" visual indicator, red;

- "Zone Disable" visual indicator, amber;

- "Tank Low Level" and "Tank High Level" visual indicators, amber;

- "Pump Running" visual indicator, green;

- "Pump fault" visual indicator, red;

- "Essential Power On" or emergency generator running visual indication, amber;

- Subsidiary sprinkler stop valves status visual indication, red (light up when valve closed);

- Sprinkler control valve set status monitoring, amber;

- Sprinkler flow switches activation visual indication, red;

- Fire alarm direct link fault/isolation indication, red;

- Emergency generator manual mode visual indicator, amber;

- Emergency generator fail to start visual indicator, red;

- Emergency generator fuel tank low level visual indicator, red;

- Other necessary indications for fire hydrant/hose reel system, sprinkler system etc. as required by the FSD.

8.1.8.2.2 Performance Requirements

All visual indications shall be provided with twin indication LED lamps of approved size, brightness and colour. All visual indications and labelling shall be easily seen at 2 m away from the panel.

Upon operation of one or more triggering devices, the control panel shall generate a fire alarm indication by: -

(a) At least one internal alarm sounder in or near the indicating equipment;

(b) At least one external alarm sounder;

(c) A visible indication for each zone in which a triggering device operates;

(d) Where specified, a signal transmitted to the FSD through the fire alarm direct link and the Computerised Fire Alarm Transmission System.

Fire alarm control system shall be arranged for continuous monitoring of all alarm circuits, including the wiring and the alarm signalling devices connected thereto.

Faults to be detected shall include open-circuits, short-circuits, and removal of signalling devices.

Indicator lamps shall be of a voltage rating 20% higher than the applied voltage, and shall be of extra low voltage type. Where A.C. mains operation is required, indicator lamps shall be operated at extra low voltage via a step-down transformer and be suitably rated for long life and reliability.

Alarm bell circuits shall be interleaved and separately fused at the control equipment.

Relays shall be of the potted type or similarly protected against dust and shall have solenoids with varnish-impregnated or plastic encapsulated windings.

Contacts shall be of silver and adequately rated. Additional contacts shall be supplied and installed as required for the operation of auxiliary controls.

The control equipment shall incorporate battery charger set with appropriate voltage regulators suitable for the rating of the interconnected triggering devices and the equipment shall incorporate overload cut-out or limiting devices to protect the external circuit against excessive current.

8.1.8.3 AUTOMATIC FIRE ALARM CONTROL AND INDICATING PANEL

8.1.8.3.1 General

In addition to the conventional fire alarm control and indicating panel, automatic fire alarm control and indicating panel shall be provided for system containing automatic fire alarm system. All control functions of the conventional fire alarm control and indicating panel may also be incorporated and integrated with the automatic fire alarm control and indicating panel as one panel when provided.

The automatic fire alarm control and indicating panel shall comply with the requirements as stipulated in Modified BS 5839-1, shall be listed by the Product Certification Bodies in accordance with FSD Circular Letters Nos. 1/2007, 2/2012, 3/2020 or of FSD approved type and acceptable by the Supervising Officer and shall be microprocessor based. Fire alarm signals may originate from heat detector, smoke detector, multi-sensors detector and/or other automatic fire detection devices as applicable.

At least one automatic fire alarm control and indicating panel shall be supplied and installed to monitor centrally the automatic fire alarm system and the like. For addressable fire alarm system, addressable fire alarm control and indicating panel shall be supplied and installed as the automatic fire alarm control and indicating panel.

The panel shall be able to transmit fire alarm signals to the FSD Computerised Fire Alarm Transmission System without any external connection module.

The panel shall allow detectors in any individual zone and sounders to be tested during commissioning or maintenance by a single person, i.e. one-man test facility.

8.1.8.3.2 The panel shall contain the following minimum provisions: -

(a) Service Features

- At least two alarm circuits;
- At least two pairs of auxiliary contacts;
- Comprehensive fault monitoring devices;
- One-man test facility;
- Integral power supply;
- Back up batteries shall be of sealed lead acid type or of a type with equivalent or better functions and environmental performance approved by the Supervising Officer. For batteries built in and integrated with proprietary panels, or for individual battery with power capacity each exceeding 50 Ah, other types of battery will only be accepted subject to the approval of the Supervising Officer.

(b) User Control Switches / Push Buttons

- Zone isolation switch with visual indication;
- Alarm silence switch with visual indication;
- System reset;
- Lamp test.

(c) Visual Indicators

- Mains on, green;

- System isolated, amber;
- System fault, amber;
- Zone fire alarm visual indicator using twin LED, red;
- Zone fault/isolated LEDs indications, amber;
- Status of equipment controlled by detectors e.g. 'closed' status of fire shutter, amber.

8.1.8.3.3 The control equipment shall incorporate battery charger set with appropriate voltage regulators.

8.1.8.4 AUTOMATIC SPRINKLER SYSTEM ALARM CONTROL AND INDICATING PANEL

The panel for automatic sprinkler system shall comply with the LPC Rules for Sprinkler Installations. At least one automatic sprinkler system alarm control and indicating panel shall be supplied and installed for the sprinkler installation. It can be combined and integrated with the automatic fire alarm control and indicating panel or conventional fire alarm control and indicating panel where allowed and accepted by the FSD.

8.1.8.5 ADDRESSABLE FIRE ALARM CONTROL AND INDICATING PANEL

8.1.8.5.1 Where addressable fire alarm system is provided, addressable fire alarm control and indication panel shall be supplied and installed. The addressable fire alarm control and indicating panel shall be analogue addressable intelligent type with its own microprocessor and memory. The panel shall comply with the requirements as stipulated in Modified BS 5839-1, shall be listed by the Product Certification Bodies in accordance with FSD Circular Letter No. 3/2020, 6/2021 or of FSD approved type and acceptable by the Supervising Officer and shall be microprocessor based. All detectors, sensing devices and control devices connected to the addressable panel and automatic fire alarm system shall be of compatible addressable types acceptable to the Supervising Officer.

8.1.8.5.2 In addition to the intelligent functions, LED indicating lights and LCD panel together with audible alarm shall be included in the panel to provide alarm/detection zoning requirements as specified and in accordance with the FSDCoP, FSD Requirements and Circular Letters as well as the following monitoring signals, where applicable: -

(a) Status of micro-switch for each sprinkler subsidiary stop valve;

(b) 'Closed' status of each fire resistant shutters operated by smoke detector;

(c) Running of each sprinkler pump;

(d) Running of sprinkler jockey pump;

(e) Fault/loss of power supply to sprinkler/jockey pumps;

(f) Sprinkler tank overflow alarm;

(g) Sprinkler tank low level alarm;

(h) Running of each fixed fire pump;

(i) Fault/loss of power supply to fixed fire pumps;

(j) Fire service tank overflow alarm;

(k) Fire service tank low level alarm;

(l) Running of each intermediate booster pump;

(m) Fault/loss of power supply to intermediate booster pumps;

(n) Running of each transfer pump;

(o) Fault/loss of power supply to transfer pumps;

(p) Transfer tank overflow alarm;

(q) Transfer tank low level alarm;

(r) Running of each foam system water pump;

(s) Fault/loss of power supply to foam system water pumps;

(t) Foam system water tank overflow alarm;

(u) Foam system water tank low level alarm;

(v) System fault;

(w) Circuit fault;

(x) Status of power supply including normal supply, essential power on, emergency generator manual mode, emergency generator fail to start and fuel tank low level;

(y) Line normal and line fault/isolation of fire alarm direct link;

(z) 4 nos. spare allowed on each panel for additional alarm points.

8.1.8.5.3 The following control functions in the form of push button or key switch integrated as part of the panel shall be supplied and installed, where applicable: -

(a) Manual starting of each fixed fire pump;

(b) Manual starting of each intermediate booster pump;

(c) Manual starting of each sprinkler pump;

(d) Manual starting of each transfer pump;

(e) Manual starting of each foam system water pump;

(f) Alarm test and lamp test facilities;

(g) Key switch for system isolation with visual indicator;

(h) Key switch for stopping transmission of fire signal to ventilation control system and Lift Installation with visual indicators;

(i) Alarm and buzzer mute;

(j) All the control and indicating functions of conventional fire alarm control and indicating panel and automatic fire alarm control and indicating panel as appropriate.

8.1.8.5.4 The panel shall drive four wire loops of addressable analogue fire/smoke sensing, signalling, monitoring and communication devices or better design and approved. The panel shall have output ports for the connection of external printer and monitor, and allow for expansion of the system. The loop shall be self-powered for all sensing, signalling, monitoring and communication functions. Upon a communication failure anywhere on the loop or power failure, a failure alarm shall be reported. Each loop shall have a minimum of 30% spare for intelligent sensors/detectors and 20% for addressable modules. The addressable panel shall have a minimum of 10% spare to cater for future expansion and modification.

8.1.8.5.5 The panel shall process all analogue values for normal, trouble, pre-alarm and alarm thresholds. Thresholds and sensor values shall be displayable, modifiable and reportable in decimal values.

8.1.8.5.6 The panel shall be able to connect to intelligent addressable sensors and conventional alarm initiating circuits as specified. Independent modules for alarm zones (e.g. break glass zone, detector zone, sprinkler flow switch zone) and trouble zones (e.g. subsidiary valve shut off) shall be provided on a floor-by-floor or zone-by-zone basis.

8.1.8.5.7 The panel shall include backup batteries and battery charger and provide power necessary for the devices connected to it and lodged in the panel.

8.1.8.5.8 Except for approved proprietary panel manufactured with ISO 9001:2015 quality assurance system, the panel shall be made of minimum 1.6 mm thick stainless steel to BS EN 10088-1:2014 No. 1.4401 or other approved material by the Supervising Officer. Access to the panel switches and all panel electronics shall be via key locks; no other tools shall be required. Visual indicators for the panel status shall be visible. Push buttons for pumps shall be accessible without opening the key locked cover.

8.1.8.5.9 All hardware and software which define the panel configuration and operation shall be supplied and installed. Memory data shall be contained in non-volatile memory. Memory data shall not be lost after long power failure.

8.1.8.5.10 The pre-alarm and alarm thresholds of detectors connected to the system shall be adjustable through the panel. In addition, the panel shall be able to provide time related features and transmission delay unit for alarm verification with field adjustable time from 0 to 5 minutes.

8.1.8.5.11 The system shall have drift compensation provision to distinguish long term change due to dirt accumulation from the short term variation due to fire, have fire detection algorithms and signal integration capability so as to avoid false fire alarms caused by transient interference and adjustable sensitivity setting to cater for different environment. The system shall have self-diagnostic function to detect every deviation from the normal operating condition or automatically emit service signal if a detector is contaminated (automatic detector maintenance alert function). The system shall have features to allow output of alarm be delayed for immediate on-site investigation, to allow individual detector zone, individual sensor in multi-sensors detector, individual detector etc. be individually disabled, and to have user programmable output while programme edit does not interfere normal operation. The system shall also have all the features for addressable system as specified in this General Specification.

8.1.8.5.12 A maintenance system or tool kits for scanning and reporting of situations and conditions of all devices, modules and control loops connected to the panel shall be provided. The scanning report can be either printed by event printer or exported in an electronic format to be opened by commonly used computer software available in the market. Such system or tool kits can be either built-in type or external type and shall be submitted to the Supervising Officer for approval before placing order.

8.1.8.5.13 Location, type, address and condition of each device in the system shall be displayed through a built-in LCD panel automatically in case of alarm or trouble. The display on the LCD panel shall be in a user friendly format. It shall also be time stamped.

8.1.8.5.14 All other changes of status shall also be displayed in the LCD panel giving at least the following information

(a) Condition of point;

(b) Type of point (smoke/heat detector/sprinkler flow switch/break glass unit etc.);

(c) Location of point plus numerical system address;

(d) All other points appearing on the panel.

8.1.8.5.15 Individual red alarm and common yellow trouble LEDs shall be supplied and installed for each initiating and for each indicating zone. Devices on intelligent loop circuits shall be identified by display of their addresses, locations and types, and by their conditions (Alarm, Pre-alarm, Fault) on the built-in LCD panel. In addition, the conditions shall be displayed on the appropriate intelligent loop interface board.

8.1.8.5.16 Individual zone disconnect switches/facilities shall be supplied and installed, which shall prevent operation of the zone for alarm but allow the remainder of the panel to operate normally. While the disconnect switch is activated, a trouble condition shall be indicated on the zone as well as an indication of "Disconnect". Devices on intelligent loop circuits shall be capable of being disabled by authorised personnel from the panel.

8.1.8.5.17 It shall be possible to command test, reset, and alarm silence from the panel.

8.1.8.5.18 If communications with the central processing unit board inside the panel is interrupted for any reasons, the following critical control actions shall still occur at the panel. Upon determination of an alarm condition, the panel shall: -

(a) Activate the fire alarm signalling devices;

(b) Release fire shutters as specified;

(c) Capture the lifts and return them to the home landing as specified;

(d) Raise alarms in accordance with FSD Requirements and Circular Letters;

(e) Initiate the alarm transmitter to the Fire Services Department Computerised Fire Alarm Transmission System via telephone line;

(f) Activate various fire service water pumps and other fire fighting systems as specified;

(g) Stop ventilation system as specified;

(h) Display the sensor or module address and condition.

8.1.8.5.19 The panel switches/facilities shall allow authorised personnel to accomplish the following: -

(a) Initiate a general alarm condition;

(b) Silence the local buzzer;

(c) Silence the alarm signals;

(d) Activate and reset the alarm transmitter to the FSD Computerised Fire Alarm Transmission System via telephone line;

(e) Reset all zones after all initiating devices have been returned to normal;

(f) Perform a complete system test with a visual indication of numbers of all detectors in normal working condition;

(g) Test all panel LEDs for proper operation without causing a change in the condition on any zone;

(h) Eliminate a device mismatch condition by changing the device type. The panel shall always operate with thresholds unique to the device type, and shall do so whether or not the mismatch has been eliminated.

8.1.8.5.20 An event printer shall be supplied, installed and connected to the panel. The event printer shall be integrated into and form part of the panel, unless a separate wall mounted event printer is accepted by the Supervising Officer. It shall be activated either by a fire alarm condition or by commands entered through the panel for the printing of system data essential for preventive maintenance. The print out for each alarm or trouble signal shall at least provide the following information:-

(a) Condition of point;

(b) Type of point;

(c) Location of point plus numerical system address.

8.1.8.5.21 The printer shall be capable of printing a minimum of twenty four characters per line and the minimum operating speed shall be 2 lines per second.

8.1.8.5.22 Operation of the printer shall not inhibit, delay or affect the functioning of the alarm and control system in anyway.

8.1.8.5.23 Where a separate event printer is provided and accepted by the Supervising Officer, a wall mounted stand/rack near the panel shall be supplied and installed to the approval of the Supervising Officer for housing the printer. Details of the stand shall be submitted for approval.

8.1.8.6 ALARM REPEATER PANEL

Alarm repeater panels having indicators for each zone of the fire alarm system shall be supplied and installed at locations as specified. They shall be provided with their own backup battery and charger set. The panel layout and configuration shall be submitted for approval.

8.1.8.7 COMPONENTS AND EQUIPMENT COMPATIBILITY

All the devices, components and equipment used in the system shall be suitable for humid tropical working conditions. They shall be fully compatible with one another within the whole system. The whole system shall comply with BS EN 54-13 or other standards accepted by FSD and the Supervising Officer.

Special attention is drawn to the compatibility between automatic detectors and control and indicating equipment and information on the detectors and their required electrical interface with the control and indicating equipment shall be supplied. All the components in such a system shall preferably be from one principal system manufacturer forming one compatible system approved by the relevant widely recognised independent regulatory body.

8.1.8.8 ALARM TRANSMITTER

The alarm transmitter shall be compatible with the FSD Computerised Fire Alarm Transmission System.

Applications to the appropriate agencies shall be initiated within 3 months after commencement of the Contract to allow the fire alarm direct link to be completed, connected and tested at least one month before statutory inspections by the FSD. A copy of the application document shall be submitted to the Supervising Officer for record. Co-ordination shall be carried out closely to monitor the completion status of the fire alarm direct link and associated telephone line before the fire service inspection by the FSD.

The required telephone point for connection of the fire alarm direct link shall be applied at no extra cost. The works shall co-ordinate with relevant parties and the power supply point for the fire alarm control and indicating panel and fire alarm direct link shall be arranged as necessary. All conduit works for the fire alarm direct link and associated telephone point shall be included. In addition, the initial, rental and maintenance charges for the leased line for fire alarm direct link and associated telephone point shall also be included from completion to the end of the Maintenance Period.

If the fire alarm direct link cannot be completed by the date of fire service inspection by the FSD, all necessary manpower and telephone equipment shall be provided at no extra cost , solely for the purpose for a 24-hour/day full attendant service to substitute the fire alarm direct link up to the date of the completion of the fire alarm direct link and to the satisfaction of the Supervising Officer.

Key switch or keypad control shall be provided for the temporary isolation or suspension of fire alarm direct link with visual warning indication during routine testing of the Installations.

8.1.8.9 CONTROL FOR AUXILIARY SYSTEMS

Control for the operation of auxiliary systems, including intermediate booster pump, audio/visual advisory system, fire damper release mechanism, door release mechanism, smoke extract fan, ventilation system, public address system, fireman's lift control etc., where specified, shall comply with the requirements of the FSD and all associated electrical control wiring and connections shall be carried out. Relevant visual and audible alarm indications shall be provided on the fire alarm control and indicating panel.

8.1.8.10 BATTERY AND CHARGER

All equipment in the fire alarm control system shall be backed up by storage battery and battery charger set. The storage battery and battery charger set shall be a solid-state secondary D.C. power supply unit operating in parallel with a storage battery bank. The rated capacity of the battery system shall be adequately allowed to supply a constant voltage and current for the combined standing load and alarm load in all situations.

The storage battery and battery charger set shall be capable of maintaining the system in normal operation for a period at least 24 hours without recharging and thereafter shall remain capable of operating in the maximum "alarm" condition for at least 30 minutes for all connected units and/or capable of actuating the Installations as required.

If the system is connected by an alternative standby supply such as an automatically started emergency generator designed for 6 hours standby capacity, the capacity of the storage battery and charger unit may be proportionally reduced, that is, the system shall be capable of maintaining the system in normal operation for 18 hours and thereafter capable of operating in the maximum "alarm" condition for at least 30 minutes and capable of actuating the Installations as required.

The charger unit shall be able to recharge and restoring the battery bank back to its constant potential voltage setting in not more than 12 hours after fully discharged.

Calculation shall be submitted to demonstrate that the capacity of the battery and charger unit is able to cope with the power demand of the whole system. In any case, the ampere-hour rating of the battery shall not be less than 10 Ah, except for batteries provided and built in by the panel manufacturer in the proprietary made panels, with relevant test records and certificates on the battery performance and capacity of each panel to be submitted to the Supervising Officer for approval.

The battery shall be of sufficient voltage to transmit signals to the FSD Computerised Fire Alarm Transmission System via the alarm transmitter unit and the telephone line.

The charger unit shall consist of a rectifier bridge which has the A.C. mains input supplied via an isolation transformer and has the ripples of its D.C. output smoothed out by a D.C. filter before supplying the connected load under normal operation or the battery

after discharging in A.C. mains failure. The charging process shall be automatically controlled and switched by a control logic unit made up of printed circuit boards.

The battery charger set shall be manufactured to conform to the current editions of the relevant standards as indicated below: -

BS EN 61204-6:2001	Low voltage power supplies, D.C. output. Requirements for low-voltage power supplies of assessed performance
IEC 61204 Edition 1.1:2001	Low-voltage power supply devices, D.C. output – Performance characteristics
BS 7430: 2011+A1:2015	Code of practice for protective earthing of electrical installations or other standards accepted by FSD

Back up batteries shall be of sealed lead acid type or of a type with equivalent or better functions and environmental performance approved by the Supervising Officer. For batteries built in and integrated with proprietary panels, or for individual battery with power capacity each exceeding 50 Ah, other types of battery will only be accepted subject to the approval of the Supervising Officer. The battery shall have a proven life expectancy of at least 4 years. It shall not have any memory effect as to affect its usable life or performance. The nickel-metal hydride battery shall comply with BS EN 61951-2:2017 where applicable. The battery charger unit shall be compatible with the batteries used.

The battery and charger set shall be designed and manufactured by a reputable manufacturer which has continuously manufactured battery and charger set to work in conjunction with a wide range of applications for at least 5 years and their manufacturing facility shall have a local agent to provide full technical support which includes adequate spare holding and technical expertise in testing, commissioning and trouble-shooting.

The following technical requirements shall apply: -

Input Voltage	:	220V A.C. plus or minus 6%
Frequency	:	50 Hz , plus or minus 2%.
Output Ripple Voltage	:	±5 of D.C. output
Output Voltage	:	To suit the offered fire alarm panel.
Output Current	:	To suit the fire alarm system
Overcurrent Protection	:	Mains fuse, charger fuse, battery fuse against overload and short circuit conditions.
Control	:	Fully automatic
Instrument	:	D.C. output voltmeter, D.C. output ammeter
Indication	:	Mains and charger healthy, Battery low-volt

Except for the approved proprietary unit manufactured with ISO 9001:2015 quality assurance system, the battery and charger set shall be housed in an industrial grade cabinet constructed from stainless steel to BS EN 10088-1:2014 1 No. 1.4401 or other approved material of minimum 1.6 mm thick side and back plate and 1.6 mm thick hinged front door with key lock. Adequate ventilation inside the cabinet shall be provided. Protection class of the cabinet shall not be less than IP 32 for indoors and weatherproof for outdoor application. If material other than No. 1.4401 stainless steel is approved to be used, the entire enclosure surface shall be applied with chemical rust inhibitor, rust resisting primer coat and top coat to give maximum corrosion protection, to the satisfaction of the Supervising Officer.

The logic printed circuit board, together with the isolation transformer and fused mains input terminals, shall be factory assembled on a plate located at the rear of the case. The power transistors shall be mounted on heat sinks, separated from the printed circuit board, on the back plate. The instruments and LED indicators shall be mounted on the front door of the cabinet. A lower ventilated compartment inside the cabinet shall provide adequate space for accommodation of the storage battery bank and ventilation.

The following technical information shall be submitted to the Supervising Officer for approval prior to the ordering of equipment: -

(a) Technical catalogues and specification, calculation sheet for charger and battery capacity;

(b) Power supply unit circuit diagram;

(c) Control circuit diagram;

(d) Power supply unit front plate layout; and

(e) Power supply unit console details.

The battery and charger set including the printed circuit board shall be factory assembled and tested prior to delivery on Site according to the manufacturer's testing manual. The delivery of battery and charger set to Site shall be accompanied by the original factory test certificate. A statement or certificate shall be produced by the battery and charger set manufacturer for the proof of the life expectancy of the power supply unit.

8.1.8.11 AUXILIARY BATTERY

Where battery operation of auxiliary control systems is required, a separate sealed lead acid type battery (or better functions and environmental performance approved by the Supervising Officer) and charger set for these systems shall be supplied and installed and suitably labelled for indication. Other types of battery will be accepted subject to the approval of the Supervising Officer. The main fire alarm system shall not be connected directly to any auxiliary circuits, other than those essential to the detection and alarm system as specified.

8.1.8.12 TRAINING FOR ADDRESSABLE SYSTEM

Adequate and separate training courses to not less than eight persons nominated by the Supervising Officer shall be provided to enable them to understand and familiarise with the use, maintenance, programming and re-programming of the addressable system. Details and the proposed training programme shall be submitted to the Supervising Officer for approval. The training shall be conducted during normal working hours by approved trainers of the manufacturer unless otherwise approved by the Supervising Officer. The training shall be so designed that after completion of the course, the trained persons shall be able to carry out all the functions as defined in their corresponding level of access.

8.1.8.13 FIRE ALARM MANAGEMENT SYSTEM

Fire alarm management system shall be supplied and installed for large or complex Installations and where specified. Fire alarm management system shall be a cloud-based system comprising a computer system, fire event notification software, web gateways and interface communications media for indication and monitoring of the operational status of fire service equipment and fire alarms. The system shall be used to facilitate the management and maintenance of the Installations including but not limited to self-diagnosis for healthiness of the Installations, record of the planned maintenance schedule, fire event notification and asset management. The system shall not interfere with the operation of the fire alarm control system. When the system is down or has faults, the fire alarm control system shall still perform without any interruption. The system shall be compatible with the fire alarm control system.

Fire alarm management system can be part of an integrated system for indication and monitoring of all building services systems in a building. Facilities shall be built-in for easy monitoring and access of the fire alarm management system from a remote site through the Internet. A cloud-based mobile application for event notifications shall be provided and shall be compatible with the fire alarm control system and the fire alarm management system. The mobile application shall provide one-way communication remote monitoring of the real time fire signals of the fire alarm control system.

Where specified, web cameras shall be provided to key locations of fire service equipment including fire service pump room, fire control room or fire control centre, near the automatic detectors and hose reels etc. The web cameras connected to the fire alarm management system shall provide good quality high-resolution colour images for remote monitoring of the environment of the room and condition of fire service equipment, and for quick initial checking/ confirmation of the fire alarm when received. Web cameras in public areas shall be concealed and complete with protective housing as approved.

Details and associated software of the fire alarm management system shall be submitted to the Supervising Officer for approval.

SUB-SECTION 8.1.9

ELECTRICAL INSTALLATION

8.1.9.1 GENERAL

The electrical installation under the fire service installation works shall include all switchgear, trunking, conduits and wiring works commencing from the electricity supply points provided by others as specified in the Particular Specification or Drawings. The Installations shall also include the interconnecting wiring works with other specified services, e.g. lift control, signage, fire damper/shutter, smoke control, ventilation/air-conditioning control system, central control and monitoring, direct telephone link etc.

Where control panels, electrical switches or isolators are installed in an environment with high humidity such as plant rooms or control rooms without the provision of air-conditioning or have a risk of condensation, in order to prevent the condensation seeping into the panels, switches or isolators, a space or gap of 10 mm shall be provided between the wall and the back side of such equipment.

8.1.9.2 GENERAL ELECTRICAL REQUIREMENTS

The electrical equipment, installation materials, cables, wiring, and installation practice, shall be to the standard called for in the relevant sections of this General Specification.

Registered Electrical Workers of the appropriate grades shall be employed in accordance with the Electricity Ordinance to carry out the electrical works for the Installations. All relevant certificates/test reports shall be duly signed by the Registered Electrical Contractor and the Registered Electrical Workers and submitted to the Supervising Officer for record.

All electrical equipment shall be rated for continuous duties at designed capacity and operating conditions. The circuits and equipment of the electrical installation shall be selected in such a manner that they are not susceptible to external electrical and magnetic interference which includes, but not limited to, supply interruption or voltage dip as well as supply harmonics on their normal operations and performance. On the other hand, they shall not cause interference, harmonics or other adverse effects to the normal and essential electrical supply systems as well as to other electrical equipment.

8.1.9.3 ELECTRICITY SUPPLY

The electricity supply shall be 380 Volt 3 phase 50 Hz or 220 Volt single phase 50 Hz. All equipment and installations shall be suitable to operate with this main supply conditions. All equipment and installations shall be sized with continuous ratings at the designed duties and operating conditions with optimum performances and efficiencies, and with minimum acceptable temperature rises.

To cope with the possible interruption of the electrical power supply and/or the fluctuation of frequency or voltage value outside the acceptable range specified above,

all equipment and installations shall be able to ride through and function properly on any unavoidable disturbance to the European Standard EN 50160:2010+A1:2015.

All equipment and installations shall also comply with Semiconductor Equipment and Materials International (SEMI) F47, IEC 61000-4-11+AMD1: 2017:2004 and IEC 61000-4-34:2005+AMD1:2009 on voltage dip ride-through capability.

8.1.9.4 WIRING SYSTEMS

Wiring shall be laid in concealed steel conduit or in steel trunking inside a fire rated enclosures/rooms/ducts unless otherwise specified. They shall be grouped and installed together in a neat and tidy manner. Concealed PVC conduits shall only be accepted subject to the full compliance with the conditions stipulated in this General Specification Clause 8.1.9.6, to the approval and satisfaction of the Supervising Officer.

8.1.9.5 CONDUCTOR SIZES

Conductor sizes for alarm circuit wiring to automatic detectors and addressable fire alarm and control system shall be in accordance with the Modified BS 5839-1 and achieve satisfactory operation of the system. However, the conductor size shall not be less than 1.0 mm^2 in any case. The wiring system shall also be capable of being installed, and subsequently maintained, easily and without damage.

Conductor sizes for other application shall be strictly as required by this General Specification.

8.1.9.6 CONDUIT AND TRUNKING SYSTEMS

Surface mounted conduit and trunking if specified or allowed to be used shall be of steel complying with relevant Clauses of this General Specification. Where concealed PVC conduits are specified in the Particular Specification or on the Drawings, they shall only be accepted subject to the full compliance with the Part 7 of this General Specification and other conditions and criteria (if any) required or imposed by, and to the acceptance of the Supervising Officer and FSD.

In general, conduits shall be concealed, except in protected rooms having approved FRR such as in fire control room, pump room and sprinkler control valve cabinet/room, or unless otherwise specified. Conduit and trunking shall be completely separated from those of other services, and used exclusively and solely for the purpose with no wiring of other services present. Trunking shall only be used in fire rated protected enclosures/ducts/rooms having approved FRR.

Flexible conduits shall be used for the final connection from rigid conduits/boxes or trunkings to equipment. Each flexible conduit shall not be longer than 2 m in length. Suitable adaptors shall be installed at both ends of the flexible conduit. The adaptor shall be constructed from brass. Each adaptor shall comprise two parts, an inner core which screws into the bore of the conduit together with a ferrule which caps off the end of the conduit, so that the adaptor can provide an extremely strong joint. The core shall lock

against the outer ferrule and also isolate any sharp cut edges in the conduit which can damage cables on insertion or in use.

Conduit and trunking shall be routed and installed in such a way as to give maximum protection against mechanical damage. Where it is unavoidable to run conduits across other services conduits, water pipes, air conditioning ducts etc., they shall be installed first and fixed closest to the structure.

Galvanised iron draw-wires of adequate size shall be provided in all empty conduits.

8.1.9.7 EARTHING

Proper earthing shall be supplied and installed for the electrical and electronic equipment as well as bonding of all exposed conductive parts of the Installations to the main earthing system as specified in this General Specification. All conductive moving parts such as hinged door of panel, battery and charger cabinet etc. shall be properly and sufficiently bonded by suitably sized flexible insulated cables to the fixed conductive part of the panel.

8.1.9.8 IDENTIFICATION OF CONDUCTORS, CABLES AND CABLE DUCTS

Identification colour codes of conductors and cables on LV power circuits shall be in accordance with the current requirements and all subsequent amendments stipulated in the Code of Practice for the Electricity (Wiring) Regulations issued by the EMSD and as specified in this General Specification. ELV alarm circuit wiring identification shall follow BS 7671:2008+A3:2015 and Modified BS 5839-1 with red colour for the line conductors. Colour tracers may be used, in addition, to distinguish cables one from another.

All surface conduits, cable ducts and cable trays, exposed fire resistant cables, exposed low smoke zero halogen cables, exposed armoured cables, exposed MICC cables etc. forming part of the Installations, shall be colour coded in red in such a way as to permit ready identification. Banding by means of paint will be acceptable only where this can be carried out permanently and effectively. Durable high quality red plastic self-adhesive tape may be used for armoured and MICC cables. Colour bands shall be applied at intervals not exceeding three metres.

Suitable identification plates shall be supplied and installed on all electrical equipment giving voltage, current, wattage or other ratings and manufacturer's name, trademarks or other descriptive markings by which the organisation responsible for the product may be identified.

Each disconnecting means required for all electrical equipment and each electrical source of supply shall be legibly marked to indicate its purpose unless so located and arranged that the purpose is clearly self-evident.

All markings and identifications shall be of sufficient durability to withstand the environmental effects.

8.1.9.9 FIRE RESISTANT CABLES

Unless otherwise specified or approved by the Supervising Officer, fire resistant cables used for the Installations shall be in full compliance with the requirements of relevant Clauses and Appendix of the FSDCoP, relevant FSD's Circular Letters and amendments. Fire resistant cables shall also be of low smoke zero halogen type complying with the following standards unless they comply with BS 7629-1:2015, BS 7846:2015 (Cat. F2 for cables of overall diameter not exceeding 20 mm or Cat. F30 for cables of overall diameter exceeding 20mm) or BS EN 60702-1:2002+A1:2015:

(a) BS EN 61034-1:2005+A1:2014 & BS 61034-2:2005 + A1:2013; and

(b) BS EN 60754-1:2014 (with less than 0.5% halogen acid content) or BS EN 60754-2:2014 (with pH level for the gases evolved not less than 4.3).

Fire resistant cables shall be listed under LPCB, BASEC (British Approvals Service for Electrical Cables) or similar widely recognised independent regulatory body as approved by the Supervising Officer.

Where mineral insulated copper cables are specified, the cables shall comply with BS EN 60702-1:2002+A1:2015.

8.1.9.10 MOTOR STARTER AND CONTROL AND INDICATING PANEL

Except for type tested starter panel complying with BS EN 60439-1 Form 3B Standard, or manufactured by a manufacturer certified by ISO 9001 quality system, the enclosure for the motor starter and its control and indicating panel shall be constructed from at least 1.6 mm thick steel plate with lockable door. The enclosure for the motor starter and its control and indicating panel shall have a degree of protection not less than IP 65 as specified in BS EN 60529:1992+A2:2013 or the whole enclosure for the motor starter and its control and indicating panel shall be properly and fully protected by a waterproof cabinet or waterproof enclosure of steel with the required IP rating, which would not affect the continuous and normal operation, control and viewing of any part of the panel. All the enclosures shall be finished in light grey colour externally. All electrical live parts shall be properly covered and protected for the best electrical safety, to the full satisfaction of the Supervising Officer.

Control cables inside panel shall be neatly laid out and securely fastened. They shall be terminated in connection blocks where a schedule ferrule numbering system shall be provided. The numbering system shall be clearly indicated on the as-built schematic diagram attached to the back of the panel front door.

Where the motor starter forms a part of a motor control cubicle or cubicle switchboard, the requirements in this clause shall be applied to the cubicle sections where the motor starter and its control and indicating panel are installed. The overall protection for the motor starter shall not affect the operation of the fire pumps.

8.1.9.11 CABLES AND WIRING USED FOR FIRE SERVICE INSTALLATION

Fire resistant cables shall comply with this General Specification for all installations listed in Table 8.1.9.11 below for different parts of the Installations or cables having equivalent or better performance to the approval of the Supervising Officer. Generally, concealed conduit shall be used for wiring outside plant room. In case the use of concealed conduit is not practicable, armoured fire resistant cable shall be used. The cable support shall be non-combustible and that the overall wiring and circuit integrity shall not be reduced below that afforded by any of the cables it supported. The fire resistant integrity of any cable support shall also be not less than that equivalent to the cables it supported.

Table 8.1.9.11 indicates the minimum requirements only. Where other cable standards and requirements are specified for any part of the Installations and/or required by the FSD, the most stringent standards and requirements shall be followed.

Table 8.1.9.11 Installations to use Fire Resistant Cables

Type of Fire Service Installation or location, where specified	**System/Equipment requiring the use of Fire Resistant Cables**
Audio/visual advisory system	The power supply/signalling cables to speakers and flashing directional signs from control panel/console and AV equipment.
Automatic fixed installations using water	The power supply cable from main/sub-main switchboards to electric motor of pumps including transfer and intermediate pumps.
Automatic fixed installations other than water	The power supply cable from main control panels to fire extinguishing agent actuating devices.
Emergency generator/Main backup power source	All outgoing power supply cables from emergency generators and other main backup power sources to main switchboards and to main essential power supply boards.
General emergency lighting except those for cinemas, theatres and scheduled premises	The power supply cable from main switchboards, sub-main boards, central battery supply or other power sources to emergency lighting fittings except for self-contained emergency lighting fittings.
General emergency lighting for cinemas, theatres and other scheduled premises	The power supply cable from main switchboards, sub-main boards, central battery supply or other power sources to emergency lighting fittings. Remark: Other latest licensing requirement as stipulated in PPA 104/104A shall be followed.
Exit sign	Same as general emergency lighting.

Fire alarm system	The power supply/signalling cables to manual call points, alarm bells, visual alarm signal units and other field devices from fire alarm control and indication panels.
Fire detection system	The power supply/signalling cables to audio/visual alarm/detection devices from fire alarm control and indication panels.
Fire hydrant/hose reel system	The power supply cable from main/sub-main switchboards to electric motor of fixed fire pumps and intermediate booster pumps.
Fireman's lift	The power supply cable from main/sub-main switchboards to traction motors/car lighting/power circuit of lift.
Fixed foam system	The power supply cable from main/sub-main switchboards to electric motor of pumps.
Pressurisation of staircases system	The power supply cable from main/sub-main switchboards to electric motor of fans and the control cable.
Ring main system with fixed pumps	The power supply cable from main/sub-main switchboards to electric motor of pumps
Sprinkler system	The power supply cable from main/sub-main switchboards to electric motor of pumps.
Pre-action Recycling Sprinkler system	Heat detector circuit cables from and to the control panel.
Smoke extraction system	The power supply cable from main/sub-main switchboards to electric motor of fans and the control cable.
Water spray system	The power supply cable from main/sub-main switchboards to electric motor of pumps.
Street Fire Hydrant System	The power supply cable from main/sub-main switchboards to electric motor of pumps.
Power circuits not covered in other items in this table	Cables from main switchboards to control panels/consoles of various Fire Service Installations, unless otherwise specified.
Hazardous areas/ Dangerous goods stores	Cables/wirings within the compartment (depend on the hazard zone)

Except for the hazardous areas, the following are acceptable methods alternative to the use of fire resistant cable for installation work list at Table 8.1.9.11: -

(a) Cables running in trunkings or on cable trays inside plant room/switch room/fire control centre of approved fire resistance rating where termination of cables at both ends are located;

(b) Cables running inside concealed steel conduits embedded in concrete to a depth of at least 12mm;

(c) Cables running inside underground cable ducts or concrete cable trenches of approved fire rating;

(d) Cables embedded in the soil to a depth of at least 300 mm;

(e) Cables running within fire resistant cable ducts/enclosures which are not used by other services and with a fire resistance rating not less than that of the corresponding building compartment.

Cables installed using any one of the alternative methods (a), (b), (c), (d) and (e) shall also comply with the following: -

- Where cables run within cable ducts/conduits, they shall not be mixed with other services;

- Power cables connecting centrally supplied emergency luminaires shall be fire resistant cable and fully segregated from the general distribution system;

- Power cables to the fireman's lift, emergency generator installation, smoke extraction system, and pressurisation of staircases system shall be fire resistant cables;

- Cables to the detection units of pre-action recycling sprinkler system shall be fire resistant cables;

- Power cables from essential power supply switchboards to all kinds of pumps in the Installations as defined in this General Specification including sprinkler pumps, fixed fire pumps, drencher pumps, street hydrant pumps, jockey pumps, intermediate booster pumps, foam pumps, ring main fixed pumps, transfer pumps etc. shall be fire resistant cables;

- For cases other than (ii) to (v) above, the cables running inside concealed steel conduits or not shall comply with relevant Clauses of this General Specification.

8.1.9.12 ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS

The electrical equipment shall depend on the classification of the hazardous areas into zone 0, zone 1 and zone 2 in IEC 60079. Intrinsically safe equipment and materials

complying with marking Ex ia IIC T5 or Ex d IIC T5 to IEC 60079 or approved products having equivalent or better functions and performance shall be used for all zone 0 and zone 1 hazardous areas. Flameproof protective equipment and explosive proof equipment specially approved by a recognised regulatory or approval body for use in zone 0 may be used with the approval of the Supervising Officer for zone 0 and zone 1 hazardous areas. For zone 2 hazardous areas, spark-proof enclosure or intrinsically safe equipment complying with marking Ex ib or Ex e in IEC 60079 or approved products having equivalent or better functions and performance shall be used unless otherwise specified.

Wirings in zone 0 and zone 1 hazardous areas shall be of mineral insulated metal sheathed cable to BS EN 60702 -1:2002+A1:2015 with compatible and explosive proof terminating glands or approved products having equivalent or better functions and performance. Wirings in zone 2 hazardous areas shall be in concealed conduits or of fire resistant cables of appropriate type. Terminations of cables shall use sealing fittings, ground continuity connection or explosive proof seal whichever is appropriate.

All electrical and electronic equipment used in hazardous areas including automatic detectors shall be approved by the Supervising Officer and certified by a widely recognised independent regulatory body. The equipment shall bear marking “Ex ia”, “Ex d” etc. or have relevant approval documents issued by a widely recognised independent regulatory body. Intrinsically safe electrical and electronic equipment shall also comply with BS EN 60079-11:2012 (Incorporating corrigenda January 2012 and November 2014) where relevant.

8.1.9.13 SURGE PROTECTION DEVICE

Surge protection device shall be supplied and installed to the electrical supply connecting to the manual and automatic fire alarm installation and other controls in the Installations. The surge protection device shall incorporate both high energy clamping devices and special filtering circuitry to reduce any electrical surge appearing in the connected electrical system and earth circuit to an acceptable level without causing any damage or malfunctioning to the connected electrical and electronic equipment in the Installations.

Surge protection device shall be able to give protective performance in all modes, including Phase and Neutral, Phase and Earth, and Neutral and Earth as required. Surge protection device shall be able to withstand repeated electrical surges appeared in the electrical system without undue degradation of its surge protection performance under healthy condition.

Surge protection device shall be manufactured with ISO 9001 or manufactured by a manufacturer certified by ISO 9001 quality system and it shall be able to meet performance requirements stipulated in this General Specification.

8.1.9.14 LAMPS

All maintained type emergency lightings shall be in accordance with the energy efficiency requirements of the Building Energy Code. LED lamps of approved type, size, brightness and colour shall be used for all exit signs for energy saving purpose.

All lamps for the visual indications on the control and indication panels and repeater panels shall be LED lamps of approved type, size, brightness and colour unless otherwise specified or approved by the Supervising Officer.

All LED lamps used shall comply with this General Specification.

SUB-SECTION 8.1.10

PORTABLE HAND-OPERATED APPROVED APPLIANCES

8.1.10.1 GENERAL

Portable hand-operated approved appliances include fire extinguishers, fixed sprayer units, fire blankets, sand buckets and any other fire service equipment that are used as an independent mean for the purpose of extinguishing, attacking, preventing or limiting a fire. It shall also include the fixed automatically operated approved appliances installed in a room. Only portable appliances in the list approved by the Director of Fire Services will be accepted. All mounting fixtures and labour for installing the appliances shall be provided. Inspection, repair and maintenance of the portable appliances throughout the contract period shall be carried out by a Registered Fire Service Installation Contractor in Class 3 registered with the FSD. Portable hand-operated approved appliances shall comply with FSDCoP and Fire Protection Notice No. 11 and where applicable BS 5306-3:2017.

Portable hand-operated appliances approved by the FSD and the Supervising Officer and in accordance with (i) the type(s) of occupancy or risk in individual area(s) such as Dangerous Goods Stores, LPG Stores, plant rooms and various licensed premises and (ii) the Laws of the Hong Kong Special Administrative Region shall be supplied and installed.

Supply, fixing and installation of the portable hand-operated approved appliances including the wall mounting brackets shall be included in the Installations.

Where there are several fixed automatically operated appliances of similar types in a compartment, unless otherwise not required by the FSD, all necessary controls shall be included such that the operation of any one unit will cause all similar units within the compartment to operate simultaneously.

Where portable hand-operated approved appliance is installed in public areas, details of the fixing and builder's work requirements shall be submitted for approval with particular attention to the requirements for preventing the appliance from being stolen. Remote monitoring unit and remote alarm panel shall be supplied and installed where specified which shall be energised when the appliance is lifted up or removed. The unit shall also monitor the condition of the portable hand-operated approved appliance. Portable hand-operated approved appliance located outdoor shall be installed inside a cabinet to the approval of the Supervising Officer. Where the portable hand-operated approved appliance is installed outdoor, details of the cabinet for housing the appliance shall be submitted to the Supervising Officer for approval. The cabinet shall be of robust and weather-proof design to the acceptance of the FSD and the Supervising Officer. Its design and construction shall ensure the ready access and taking out from the cabinet, and replacing back after use, the portable appliance easily under all circumstances. Suitably sized and easily identifiable labels/wordings shall be fixed or engraved permanently on the cabinet to enable users to locate the portable appliance readily, to the satisfaction of the FSD and Supervising Officer.

8.1.10.2 FIRE BLANKETS AND SAND BUCKETS

Fire blankets and sand buckets shall conform to the requirements of the FSD. Buckets shall have a capacity not less than 10 litres and shall be made of galvanised steel and painted red. Fire blankets shall comply with BS 7944:1999 and shall be of FSD approved heavy duty and reusable type.

8.1.10.3 FIRE EXTINGUISHERS

Fire extinguishers shall be rechargeable hand-operated extinguishers complying with FSDCoP and of appropriate type to BS EN 3-7:2004+A1:2007, NFPA 10:2018, ISO 7165:2017, BS 5306-3:2017 and BS 7863:2009 for water, foam, dry powder, carbon dioxide, Novec 1230, FM200 or other approved agent type with a capacity as specified. Foam and powder type extinguishers shall be cartridge operated with a replaceable gas cartridge fitted into the extinguisher. Inverted type fire extinguishers requiring turning upside down before use are not acceptable. All fire extinguishers shall be properly labelled with appropriate instructions of use, indication date of last inspection and with maintenance labels in accordance with FSDCoP.

Fire extinguishers shall be manufactured and tested to recognised international standards. Batch-approval certificate, batch-approval certification mark, or other evidence showing that the extinguisher has been batch-approved by recognised bodies or organisation acceptable shall be submitted to the Supervising Officer after manufacture. Extinguisher without batch-approval certificate/mark or other approval documents will not be accepted.

Where the type of fire extinguisher is not indicated, the appropriate type of fire extinguisher suitable for the hazard and the occupancy in individual area shall be submitted to the FSD and the Supervising Officer for approval.

8.1.10.4 FIXED SPRAYER UNITS

Fixed sprayer units shall be of self-contained automatically operated clean agent or dry powder type fitted with a sprinkler head or other actuation device complying with UL, FM, NFPA, BS or other relevant international standards and approved by FSD. The activation temperature rating of the actuation device shall meet with the protection requirements stipulated by and to the acceptance of FSD. For rooms fitted with clean agent automatic extinguishers, identification symbols prescribed by the FSD shall be supplied and installed and fixed to each entrance door. The fixed sprayer unit shall be properly labelled with maintenance label in accordance with FSDCoP. The last inspection dates of the fixed sprayer units shall be indicated.

Subsequent to more stringent controls on ozone depleting agents used for fire extinguishing systems in Hong Kong under the Ozone Layer Protection Ordinance (Cap. 403), some fire extinguishing agents such as HCFC Blend A (NAFS-III) and HCFC-124 (FE-241) fixed sprayer units are dispensing, and the FK-5-1-12 (Novec 1230) or HFC-227ea (FM200 / FE-227) type fixed sprayer unit is accepted as an alternative. The approved fixed sprayer units can be found on Government Gazette or the FSD website. Protected volume and particular risk to be protected for each type of approved fixed sprayer unit shall be referred to Government Gazette.

8.1.10.5 REMOTE MONITORING UNIT

8.1.10.5.1 The remote monitoring unit shall be specifically designed for security control and monitoring of portable hand-operated approved appliance (portable appliance). It shall have a bracket for hanging the portable appliance. Local audio alarm shall be provided, in addition to remote monitoring and alarm.

8.1.10.5.2 The remote monitoring unit shall be addressable type to monitor the presence of a portable appliance and to check that it shall maintain a correct installed weight.

8.1.10.5.3 Each remote monitoring unit shall be a standalone installation to be mounted on wall and shall be battery powered. The battery shall be of adequate capacity for its continuous operation for at least 6 months. The microprocessor of the unit shall constantly check on the battery capacity. Long before the battery is exhausted, the unit shall start to give a warning bleep for battery replacement alert.

8.1.10.5.4 Each unit shall be adjustable to take virtually any make, type and size of portable appliance. The hanging strap shall be multi-punched for all popular brackets and can be drilled to take non-standard fittings. Its steel chassis plate shall be designed and constructed to spread the load when fixing to plasterboard and other weak structures. Its cover shall be interlocked to prevent tampering but enable easy battery replacement and set up with a special tool to be supplied with the unit.

8.1.10.5.5 Theft control

The theft control unit shall constantly check the weight of the portable appliance hanging on it. As soon as the portable appliance is removed, a high pitched integral sounder shall be activated locally to give a continuous warning for 30 seconds even if the appliance is returned immediately. At the same time, a remote alarm shall be triggered on a remote alarm panel to be supplied and installed in a remote location as specified. The location of those theft control unit(s), the alarms of which are triggered, shall be identifiable with LED indicator(s) or the like and approved on the remote alarm panel.

After 30 seconds, the warning sound shall reduce to an intermittent alarm. If after a further 90 seconds, the portable appliance is still not returned then a quad bleep shall be heard periodically. The same alarms shall be repeated on the remote alarm panel at the same time, with the location(s) of the unit(s) with alarm to be identifiable with LED indicator(s) or the like and approved.

8.1.10.5.6 Condition control

If the portable appliance under monitoring is in a discharged or partly discharged condition (i.e. 15% reduction in gross weight or more), the unit shall quad bleep periodically until the portable appliance has been recharged correctly and replaced. The same alarm shall be repeated in the

remote alarm panel, with the location(s) of the unit(s) with alarm to be identifiable with LED indictor(s) or the like and approved on the remote alarm panel.

If the portable appliance has been overfilled (i.e. 15% increase in gross weight) and replaced after use, the unit shall again give an intermittent alarm for 5 seconds and then 2 seconds off in between to warn that the portable appliance is in a dangerous condition. A reassurance bleep shall be given when the appliance is correctly replaced and charged to its original installed weight. All alarm signals shall be repeated in the remote alarm panel, with the location(s) of the unit(s) with alarm to be identifiable with LED indicator(s) or the like and approved.

8.1.10.5.7 Remote Alarm Panel

A remote alarm panel shall be provided in a location as specified on the Drawings or as directed by the Supervising Officer for remote monitoring of the conditions of the remote alarm units and the associated portable appliances. The remote alarm panel shall be of construction and design similar to addressable fire alarm control and indicating panel as specified in this General Specification, to the acceptance of the Supervising Officer. All indicators on the panel shall be of LED type or the equivalent and approved to indicate the conditions of the remote alarm units and the portable appliances hanging on them, and the specific location(s) where alarm or warning has been triggered, besides the audible alarms. All wiring in between the remote alarm units and remote alarm panel shall be supplied and installed in concealed conduits and trunking specifically for the purpose.

The panel shall be constructed of, or enclosed with cabinet of at least 1.6 mm stainless steel plate to BS EN 10088-1:2014 No. 1.4401, except for proprietary panel that has been accepted by the FSD and manufactured with ISO 9001:2015 quality assurance system or equivalent.

The design and layout of the remote alarm panel shall be submitted to the Supervising Officer for approval before order and manufacturing.

SUB-SECTION 8.1.11

EMERGENCY LIGHTING, EXIT SIGN AND EMERGENCY GENERATOR

8.1.11.1 EMERGENCY LIGHTING

8.1.11.1.1 General

Emergency lighting shall be provided for the purpose of fire escape in the event of mains power failure.

Emergency lighting for fire escape purpose shall comply with BS5266-1:2016, BS EN 50172:2004, BS EN 1838:2013, BS EN 60598-1: 2015+A1:2018, BS EN 60598-2-22:2014 (Incorporating corrigendum June 2014) and the requirements of the FSD and Buildings Department, and shall be backed up by emergency power supply.

Emergency power supply shall be fed from an emergency generator. If the building is not equipped with an emergency generator, the emergency lighting shall be provided with secondary battery supply.

In the event of power failure, the emergency lighting shall be activated within 5 seconds or within such shorter time specified elsewhere in this General Specification, Particular Specification or as required by FSD upon mains power failure in ALL types of buildings. To meet this requirement, emergency lighting shall be provided with secondary battery supply, uninterrupted power supply, or an approved source of backup power supply accepted by the Supervising Officer even when they are connected to the emergency generator.

Secondary source of power supply obtained before electrical mains switch is not accepted to be the source of emergency power supply for emergency lighting and so secondary battery supply shall be provided.

In places of public entertainment such as theatres, cinemas etc., other locations such as fire exit staircases, main fire exit routes etc., as required by the FSD, and where specified in the Particular Specification, emergency lighting shall be backed up by both emergency generator and secondary battery supply.

Where an emergency generator is provided in a building for the Installations, all emergency lighting systems with or without battery system shall be connected to and backed up by the emergency generator for fire fighting purpose.

Battery emergency lighting system shall be in the form of centrally supplied emergency luminaires or self-contained emergency luminaires or their combination.

The operation of non-maintained type emergency lighting system shall not be affected by lighting switch. During power supply failure, any emergency lighting system shall be switched on automatically without switching by lighting switches or other control devices.

Unless otherwise specified or approved by the Supervising Officer, the provision of emergency lighting shall be as follows: -

(a) Battery emergency lighting system, i.e. emergency lighting backed up by battery system, shall be selected and provided where possible. The system shall in addition be backed up by emergency generator for fire fighting purpose when it is available in the building;

(b) Self-contained emergency luminaires backed up by emergency generator for fire fighting purpose (when available) shall be provided to fire exit staircases, main switch rooms, security control rooms, fire control rooms, emergency generator rooms, major mechanical plant rooms, building management rooms, switch rooms and control rooms served for essential operation, unless otherwise approved by the Supervising Officer, and locations as required by the FSD;

(c) Centrally supplied emergency luminaires backed up by emergency generator for fire fighting purpose (when available) shall be provided to all other areas and divided in zones due to its advantage in centralised testing and inspection unless otherwise specified. The number of emergency luminaires served by one centrally supplied system in a zone shall not be excessive in order to limit the size of the central battery bank. In general, there shall be at least two centrally supplied systems on a floor such that alternate emergency luminaires in a row shall be supplied by different centrally supplied systems. For a building with small floor area, it is acceptable to have two centrally supplied systems supplying to more than one floor but emergency lighting on any one floor shall still be supplied in alternate arrangement by the two centrally supplied systems;

(d) For small rooms or spaces remotely located from the main buildings in which installation of the centrally supplied emergency luminaires is not efficient and economical, self-contained emergency luminaires backed up by emergency generator for fire fighting purpose (when available) shall be used in these small remote areas;

(e) When the total number of battery emergency lighting in a building excluding those in the fire exit staircases etc. stated in item (b) above is small (generally less than 30), self-contained emergency luminaires backed up by emergency generator (when available) shall be used;

(f) Any other design or combination to be approved by the FSD and the Supervising Officer.

Emergency lighting system shall be of maintained type or non-maintained type or their combination as required. Emergency lighting in fire exit staircases and main fire exit routes shall be of maintained type.

Other lighting not for the purpose of fire escape shall not be connected to the emergency generator for the Installations unless otherwise approved by the FSD and the Supervising Officer.

8.1.11.1.2 Lighting Luminaire

All emergency luminaires shall be designed and constructed complying with BS EN 60598-2-22:2014 (Incorporating corrigendum June 2014) or approved products having equivalent and approved construction, functions and performance. The emergency luminaires used in fire escape routes shall also comply with non-flammability (resistance to flame and ignition) provisions in BS EN 60598-2-22:2014 (Incorporating corrigendum June 2014) and their external parts shall be compliant with the glow wire test as stated in sub-clause 13.3.2 of IEC 60598-1 but at a temperature of 850°C and any burning parts shall self-extinguish within 30 seconds.

For each enclosed space required to have emergency lighting, the minimum number of emergency luminaires shall follow the requirements of FSDCoP, or as specified in the Particular Specification or Drawings, whichever is the larger unless otherwise accepted by the FSD. In any case, there shall be not less than one emergency luminaire in each of such enclosed spaces.

Emergency luminaires shall be capable of operating satisfactorily in the emergency mode at an ambient temperature of 70°C for at least half of its rated duration or at least 1 hour in according to BS EN 60598-2-22:2014 (Incorporating corrigendum June 2014), whichever is longer.

Emergency luminaires shall achieve at least 50% of its rated lumen output at emergency mode in not more than 5 seconds, or within the activation time specified in FSDCoP, whichever is shorter, after failure of the normal supply, and shall achieve the rated lumen output at emergency mode in less than 60 seconds after failure of the normal supply. For emergency luminaire requiring an activation time shorter than 5 seconds, the activation time shall be determined by the time for it to achieve 50% or more of its rated lumen output at emergency mode.

The light (lumen) output from emergency luminaire shall be maintained at not less than its nominal level (i.e. rated lumen output at emergency operating mode claimed by the manufacturer) throughout the whole design emergency operating period (i.e. rated duration) except the first 60-second period upon activation. In addition, its light (lumen) output at the end of the rated duration shall not be less than 50% of its maximum light output obtained in the emergency operating mode.

The nominal operating voltage of the emergency lighting system shall be clearly marked and readily identifiable. For centralised systems this shall be either on or adjacent to the control unit of the central batteries and for non-centralised systems this shall be either on or adjacent to the appropriate luminaires. In addition, all emergency luminaires shall be marked with details of the replacement lamps necessary to obtain the performance.

Where self-contained emergency luminaires are identical in appearance to the non-emergency luminaires, suitable labels to the approval of the Supervising Officer shall also be attached to the self-contained emergency luminaires for their easy identification during visual inspection.

8.1.11.1.3 Self-contained Emergency Luminaire

Self-contained emergency luminaire shall have adjacent to it or incorporated in it a device for charging the battery from the normal mains supply and an indicator (a charge monitor light) visible in normal use which shall show the following conditions: -

(a) The battery is being charged.

(b) Circuit continuity exists through the lamp element.

Where an electrical light source indicator is used, it shall comply with the colour requirements of IEC 60073:2002. When a single indicator provides dual functions, either red or green is acceptable.

Self-contained emergency luminaire shall have a 'TEST' switch for testing purpose and a low voltage cut-out to disconnect the batteries when fully discharged.

Self-contained emergency luminaire shall use sealed, rechargeable, maintenance free nickel-metal hydride (NiMH) batteries when its rated capacity is not more than 30Ah. When the rated capacity is higher than 30Ah, NiMH batteries or sealed lead acid batteries or other batteries having equivalent or better functions and environmental performance approved by the Supervising Officer shall be used.

The batteries shall have ample capacity to maintain the output of the emergency luminaires for a period complying with FSDCoP and BS 5266-1:2016, BS EN 1838:2013 and for at least 2 hours. For sleeping accommodation, and some particular premises specified in BS 5266-1:2016 or BS EN 50172:2004 where there is no emergency generator, the duration of battery supply shall not be less than 3 hours.

8.1.11.1.4 Centrally Supplied Emergency Luminaire

The power supply to the centrally supplied emergency luminaires shall be fed from a central battery power supply system. A.C. emergency luminaires shall be used. The central battery power supply system shall be capable of providing A.C. power supply to the emergency luminaires.

The central battery power supply system shall comprise rectifier, automatic trickle charger, inverter, storage batteries, switchgears, controls, meters, regulators, pilot lights, instrumentation and other accessories. It shall supply A.C. mains power to the emergency luminaires and at the same time charge the storage batteries during the normal mode. During emergency mode, it shall change over to supply power from its storage batteries.

The central battery power supply system shall be designed to operate in the following modes: -

Normal	A.C. mains supply shall be rectified into regulated D.C. voltage for float charging the batteries. A.C. mains supply shall be directed to the emergency luminaires or be used to power the inverter to supply power to the emergency luminaires.
Emergency (A.C. mains failure)	Upon failure of A.C. mains supply, the power supply shall be changed over and fed from the storage batteries and inverter. Normal mode shall be resumed after A.C. mains supply is restored.

Uninterrupted power supply system comprising static transfer switch, synchronising and phase lock equipment, maintenance bypass switch, storage batteries, charger, rectifier, inverter etc. providing equivalent functions and performance may serve as a central battery power supply system with the approval of the Supervising Officer. However, the charger and storage batteries of uninterrupted power supply system shall be specially designed and adequately sized to cater for the operating period of emergency lighting system. In particular, the charger shall be adequately rated and sized to provide the charging performance specified by the battery manufacturer to charge the batteries within 12 hours after a full discharge, or within such shorter time period as specified in FSDCoP, FSD Requirements and Circular Letters, LPC Rules for Sprinkler Installations and Modified BS 5839-1 etc.

The central battery power supply system shall be designed to support non-maintained type, maintained type or a combination of both types of emergency luminaires connected to the same central battery power supply system.

The central battery power supply system shall be designed and manufactured by a manufacturer certified by ISO 9001 quality system which has continuously manufactured the system for at least 5 years. It shall have a local agent to provide full technical support which includes adequate spare holding policy and technical expertise in testing, commissioning and trouble shooting. The central battery power supply or the manufacturer shall be recognised by international standards of quality assurance programme such as ISO 9001 or BS EN 62040 series.

A monitoring, control and information panel shall be located on the front of the system cubicle. It shall be capable of acquiring, logging and reporting data, alarms and instruction reflecting the operating conditions of the central battery power supply system and other data required for routine testing, which includes, but not limited to, the following: -

Power Input	Input mains voltage Input current
DC Link	Battery voltage Rectifier output current Battery charge/discharge current Remaining capacity Battery cabinet temperature
Inverter Output	Output voltage Output current Output frequency

The following technical information shall be submitted to the Supervising Officer for approval prior to the ordering of equipment: -

(a) Technical catalogues and specification of the central battery power supply system;

(b) Detailed calculation for charger and battery capacity with manufacturer's battery discharge data provided for verification purposes;

(c) Power supply circuit diagram; and

(d) Control circuit diagram.

Centrally supplied emergency luminaire system shall use sealed, rechargeable and maintenance free nickel-metal hydride (NiMH) batteries for central battery power supply system when its rated capacity is not more than 50Ah. When the rated capacity is higher than 50Ah, NiMH batteries or sealed lead acid batteries or other batteries having equivalent or better functions and environmental performance approved by the Supervising Officer shall be used.

The battery system shall have capacity adequate for maintaining the light output, after mains failure, of all centrally supplied emergency luminaires (maintained type and non-maintained type) at not less than their rated lumen output at emergency operating mode. It shall also be capable to power all maintained type emergency luminaires to give not less than 50% of their design light output at normal mains supply during emergency operating mode.

The battery system for centrally supplied emergency luminaire shall have ample capacity to maintain the output of all connected emergency luminaires for a period complying with FSDCoP and BS 5266-1:2016, BS EN 1838:2013, which is for at least 2 hours in cinemas, theatres, scheduled premises, and buildings without emergency generators, and for at least fifteen (15) minutes in other buildings with emergency generators. For sleeping accommodation and some particular premises specified in BS 5266-1:2016 and BS EN 50172:2004 with no emergency generator, the duration of battery supply shall not be less than 3 hours.

The battery system shall be designed to operate at a voltage not less than 24V and not more than 120V D.C.

8.1.11.1.5 Testing Facilities

Emergency lighting system shall have suitable means for simulating failure of the normal supply for test purpose.

For centrally supplied emergency luminaire system, testing facilities shall be supplied and installed for the following tests: -

(a) Weekly voltage test for the battery and, where applicable, hydrometer test;

(b) Monthly discharge test of 1 minute at 10-hour discharge rate;

(c) Annual lamp test for at least half of the rated duration; and

(d) Lamp test for full rated duration in every three years.

For self-contained emergency luminaire, testing facilities (either in the form of an integral test facility or by connecting the luminaire to a remote testing facility) shall be supplied and installed for the following tests:-

(a) Monthly discharge test of 1 minute at 10-hour discharge rate;

(b) Annual lamp test for at least half of the rated duration; and

(c) Lamp test for full rated duration in every three years.

8.1.11.1.6 Battery and Charger

The battery charger shall be compatible with the battery system. It shall provide the rated charging performance specified by the battery manufacturer to charge the batteries within 12 hours after a full discharge, or within such time period specified in FSDCoP, FSD Requirements and Circular Letters, LPC Rules for Sprinkler Installations and Modified BS 5839-1 etc. whichever is shorter. Central battery power supply system shall use automatic trickle charger. The battery charging system and the power circuit shall be designed to prevent frequent and rapid charging and discharging of the batteries thus shortening their lives.

Charging of batteries in luminaires shall not be affected or interrupted under normal operation even when the luminaire is switched off.

Transformers for charging the batteries shall comply with relevant requirements stipulated in BS EN 61558-1:2005+A1:2009 or BS EN 61558-2 series.

The batteries shall be designed to comply with BS EN 60598-2-22:2014 (Incorporating corrigendum June 2014) and shall have a design operating life of not less than 4 years under normal operation, i.e. at the end of four years operation at normal charging and discharging, the batteries shall still be capable of supplying the rated capacity and serving the rated duration, i.e. the design emergency operating period.

8.1.11.1.7 Central Monitoring, Testing and Logging System

Central monitoring, testing and logging (CMTL) system refers to all kinds of automatic, self-testing or remote system for monitoring, testing and logging of the performance of self-contained emergency luminaires in regular test of the emergency lighting installation during operation.

Automatic CMTL system shall have a central computer unit to monitor the status and routine automatic testing of all self-contained emergency luminaires connected to it. Self-testing system shall have built-in facilities to test the emergency luminaires automatically at scheduled intervals and to generate a local alarm or warning if it fails to pass the test. Remote system can initiate a test for self-contained emergency luminaire without physically reaching it which can be used for testing of luminaires installed at high level. Failure of CMTL system shall not affect the functioning of emergency luminaires.

Central monitoring, testing and logging system shall be supplied and installed to all self-contained emergency luminaires in a building to facilitate regular monitoring where the total number of self-contained emergency luminaires in a building excluding those located inside the fire exit staircases separated by fire doors exceeds 50 numbers, or where the total number of self-contained emergency luminaires located at fire exit staircases exceeds 50 numbers. Where the type of CMTL system is not specified, automatic CMTL system shall be adopted.

Automatic CMTL system shall have the facilities to communicate with the luminaires and register failures from a remote location. Each luminaire shall be assigned with a unique address and the CMTL system shall have a minimum capacity of communicating with all the connected luminaires, plus at least 20% spare capacity for future expansion. It shall be a fully automated microprocessor based system providing detailed testing and logging of all emergency luminaires. Tests can be programmed at specified dates and times to suit the end user's requirements. The central computer unit in automatic CMTL system shall also comply with relevant requirements under this General Specification.

The design of CMTL system shall be carried out to perform all routine test functions automatically with minimal labour. Proper, correct and compatible equipment and components shall then be selected to achieve the performance specified in the design. Detailed design as well as full technical information of the system shall be submitted to the Supervising Officer for approval prior to ordering and installation.

In selecting the makes and types of equipment, servicing facilities and replacement spare parts shall be available locally within 3 working days for future maintenance of the system.

CMTL system shall have the capability to initiate all weekly, monthly and annual tests required in FSDCoP, FSD Requirements and Circular Letters. Adequate and separate training courses to not less than four persons nominated by the Supervising Officer to enable them to understand and familiarise with the use, maintenance, programming and re-programming of the CMTL system shall be provided. Details and the proposed training programme shall be submitted to the Supervising Officer for approval. The training shall be conducted during normal working hours by approved trainers of the manufacturer unless otherwise approved by the Supervising Officer. The training shall be so designed that after completion of the course, the trained persons shall be able to carry out all the functions for monitoring, testing and data logging. A certificate/ acceptance letter shall be issued by the manufacturer of the CMTL system or the manufacturer's approved agent stating that they are satisfied with the ability of the trained persons to operate and modify the programmes of the CMTL system without affecting system operation.

At least two times of modifying the computer programme in the automatic CMTL system shall be allowed at no extra cost during the Maintenance Period after the acceptance of the system in order to suit end user's requirements.

8.1.11.1.8 Wiring for Emergency Luminaire

The Installations shall comply with BS 5266-1:2016, BS EN 50172:2004, BS 7671:2018+A1:2020 and all relevant requirements in this General Specification. The wiring shall also comply with the licensing requirements of scheduled premises where applicable.

All wirings for emergency luminaires, battery sets and other equipment for emergency lighting installation shall connect to dedicated power supply point(s) as shown on the Drawings, or to the mains supply where dedicated power supply point is not indicated.

8.1.11.1.9 Segregation

The wiring of escape lighting installation (emergency lighting installation for fire escape purpose) shall be exclusive to the Installations and separate from the wiring of any other circuits, either by installation in a separation steel conduit, trunking, or by separation from the conductors of all other services by a mechanically strong, rigid and continuous partition of steel or other approved non-combustible materials. All metal parts and partitions shall be electrically earthed to BS 7671:2018+A1:2020:-.

8.1.11.1.10 Isolators, Switches and Protective Devices

Every isolator, switch, protective device, key operating device in the emergency lighting installation shall be marked "EMERGENCY", "ESCAPE" or "STANDBY LIGHTING" as appropriate and the marking shall indicate its use. Details shall be submitted to the Supervising Officer for approval.

8.1.11.1.11 Electromagnetic Compatibility

Emergency lighting systems shall be designed and installed such that they shall not cause electromagnetic interference, in accordance with EMC Directive 89/336/EEC.

When LED luminaires are used for emergency lighting, it shall comply with the radiated disturbance limit requirements that specified in the CISPR 15 standard on "Limit and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment" issued by the International Electrotechnical Commission (IEC) and all relevant requirements of OFCA.

8.1.11.1.12 Certifying Emergency Lighting Installation and Exit Sign not included under Fire Service Installation

Where indicated that there are emergency lighting installation and exit signs in the same building by others and not included in the Installations but they are to be inspected by the FSD, submission of such emergency lighting installation and exit signs by others to the FSD shall be included as part of the Installations with the necessary information to be provided by the relevant parties.

Co-ordination with relevant installation parties, inspection, checking and witnessing of the final functional and performance tests on such emergency lighting installation and exit signs by others to identify any non-compliance with the requirements in FSDCoP, FSD Requirements and Circular Letters, FS_TC and EE_TC for the purpose of certifying the satisfactory conditions of the emergency lighting installation and exit

signs shall be included. Any works found not complying with fire service requirements of the FSD shall be rectified when the emergency lighting installation or exit sign is included in the Installations, or be reported to the Supervising Officer when such works are installed by others, before arranging inspection with the FSD. Upon witnessing the satisfactory completion of all final tests and inspections after rectification of non-conformities related to fire service, such emergency lighting installation and exit signs by others shall be certified taking the role as a registered Fire Service Installation Contractor for them. Inspection by the FSD shall be arranged on all the Installations in the building including emergency lighting installation and exit sign by others.

For the purpose of fire service inspection, the emergency lighting installation referred in this clause shall be limited to those required by the FSD and the Buildings Department and shall not include emergency lighting installation solely designed for user's operation at mains power failure.

Information shall be collected from relevant installation parties and include emergency lighting installation and exit signs by others in submissions such as Form 314 to the FSD prior to the commencement of the Works for all the Installations.

8.1.11.1.13 Automatic Control Devices

When an emergency lighting installation is controlled by automatic control device(s) or the like, such as automatic dimming and/or automatic on/off by photo cell and/or motion sensor etc., such automatic control devices and circuit shall be designed and constructed to ensure that they shall not interrupt or affect in any manner the normal operation of and the power supply to any of the emergency lighting.

The automatic control device shall be fail-safe, but in no way affect the operation of the emergency lighting under normal or emergency power supply conditions, when the device fails.

The automatic control device and circuit shall comply with relevant requirements of this General Specification.

When the automatic control device and/or circuit is/are integrated with the emergency lighting luminaire, it/they shall comply with relevant requirements of BS EN 60598-2-22:2014 (Incorporating corrigendum June 2014).

8.1.11.2 EXIT SIGN

Exit sign shall conform to BS ISO 3864-1:2011, BS 5499-4:2013, BS EN 60598-1:2015+A1:2018, BS EN 60598-2-22:2014 (Incorporating corrigendum June 2014), BS 5266-1: 2016, BS EN 50172:2004 and BS EN 1838:2013. Exit sign shall also comply with the requirements in the FSDCoP and the Fire Safety Code. Exit sign shall be visible and conspicuous from any position within the premises to ensure that exit routes can be easily recognised and followed in an emergency and in fire and smoke conditions. The provision of exit sign shall deem to include all related directional signs or series of signs for the exit routes as specified in Clause 4.2 in BS EN 50172:2004 to assist progression towards the exit as indicated by the exit sign.

LED lamps of approved type, size, brightness and colour shall be used for all exit signs for energy saving purpose.

To ensure the visibility and conspicuousness of the exit sign at all times including fire and smoke conditions, exit signs shall conform to all the following requirements as the minimum: -

Exit signs shall be internally illuminated bearing one of the designs that specified in the FSDCoP. Single type of exit sign shall be installed within the same development in order to maintain uniformity, unless otherwise approved by and acceptable to the FSD.

Colour contrast for translucent surrounds to lettering/graphical symbol shall be either one of the following combinations or as specified: -

Colour	Contrasting Colour
Green	White
White	Green

The colour combination selected shall be consistent throughout the same development. The colour shall not deteriorate or become faint throughout the service life and shall last for at least ten years.

The viewing distance of exit sign shall be not less than 25 m under ambient no smoke condition with and without normal lighting. The words shall be easily legible. Uniformity of luminance is the critical factor. The ratio of the maximum to the minimum luminance within either white or green colour area shall be not greater than 10:1.

The exit sign shall be easily visible and conspicuous in fire and smoke conditions. The viewing distance shall not be greatly reduced in the presence of smoke. Brightness of exit sign is the critical factor for visibility in fire and smoke conditions. The exit sign shall produce an average luminance of not less than 100 cd/m^2 unless otherwise specified. The ratio of the luminance at white area of the exit sign to the luminance at green area shall be not less than 5:1 and not greater than 15:1.

For exit sign of lower average luminance but which is capable of achieving equivalent or better viewing distance, visibility and legibility as the 100 cd/m^2 LED exit sign in smoke condition (at optical density not less than 1 m^{-1}) with and without normal lighting, test reports carried out and certified by approved independent laboratory/testing body shall be provided for substantiation and approval.

The exit sign shall be capable of operating satisfactorily in the emergency mode at an ambient temperature of 70°C for at least half of the rated duration or at least 1 hour in according to BS EN 60598-2-22:2014 (Incorporating corrigendum June 2014), whichever is longer, in emergency mode as specified in BS EN 60598-2-22.

The average luminance of the exit sign shall not decrease by more than 30% of its initial design value throughout its rated life in continuous operation when operated at an ambient temperature between 5°C and 40°C.

Where it is shown on the Drawings that a sign cannot be installed immediately above an exit or when an exit sign is not easily visible from all positions within the premises served by the exit sign, additional internally illuminated directional signs or other signs conforming to BS ISO 3864-1:2011, BS 5266-1:2016 and BS EN 50172:2004 shall be supplied and installed at conspicuous locations to indicate the route to the exit. The graphic design of directional sign shall conform to FSDCoP, FSD Requirements and Circular Letters.

For illuminated exit signs supplied and installed in places like theatres, cinemas, etc. and other specified premises used for entertainment with normal operation and performance mostly conducted in dark environment, the maximum luminance of any patch on the exit sign shall not exceed 80 cd/m^2. The average luminance shall however be not less than 25 cd/m^2. In addition, the size of the wording of the exit sign in English and Chinese shall not be less than 175mm. Adequate number of exit signs and directional signs shall be provided in these places to enable the signs indicating the exit routes and progressing towards the exit to be seen at all positions. Where approved, exit signs can have built-in lamps with two-stage controls providing different illumination level for normal and dark environment. Black and green exit signs shall not be used except with the approval of the FSD and the Supervising Officer.

Exit sign shall be safe in construction and use. It shall not create any harmful effect and not generate any additional risk and liability to the building occupants, workers, and public visitors during the whole period of use.

The construction details, finishes, appearance and performance data of exit signs shall be submitted to the Supervising Officer for approval before fabrication. Modification of the appearance and details of the exit signs to the satisfaction of the Supervising Officer shall be allowed.

Illuminated exit signs shall be connected to the mains supply, and to the emergency power supply where available in the building and where indicated. All wirings for the exit signs connecting to the power supply points as shown on the Drawings shall be supplied and installed.

The luminaires for exit signs shall be of type for maintained operation. The number of LED lamps for each internally illuminated sign shall be not less than two. The failure of one or more lamps shall not interrupt the charging current to the battery and shall not cause an overload.

The input current to each LED lamp shall be set at no more than the manufacturer's recommended design value for continuous operation in order to achieve the rated operation life. Exit sign shall be manufactured under quality control standard such as ISO 9000/9002 or equivalent and approved.

LED luminaires in exit sign shall comply with the radiated disturbance limit requirements that specified in the CISPR 15 standard on "Limit and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment" issued by the International Electrotechnical Commission (IEC) and all relevant requirements of OFCA.

Self-contained exit signs shall be provided with secondary battery(s). Centrally supplied exit signs shall be connected to the central battery set of emergency lighting installation provided on the same floor or in the same premise.

Where batteries are provided, the design operating life of the batteries shall be not less than four years. In emergency mode without mains and emergency power supply, the batteries shall be capable of maintaining the operation of exit signs and related directional signs for not less than the period specified for emergency lighting installation and in any case shall be not less than 2 hours after mains failure.

The battery, battery charger, wiring, testing facilities, automatic changeover switch, accessories and related provisions of exit signs shall comply with relevant requirements of emergency lighting installation and the requirements as specified in this General Specification, BS 5266-1:2016, BS EN 50172:2004 and BS EN 1838:2013. Internal wiring and electronic circuits shall be protected from excessive current that may occur during fault conditions by incorporation of safety devices between the batteries and the electronic circuits. There shall be no switch between the batteries and the emergency lighting lamps other than the changeover device. Changeover from normal to emergency supply mode shall be set at 0.85 times rated supply voltage or below.

The flashing exit sign and flashing directional sign shall be synchronised inside the audio/visual advisory system protected area.

8.1.11.3 EMERGENCY GENERATOR

Emergency generator for the Installations shall comply with relevant requirements as specified in this General Specification for diesel generating set and in the Particular Specification, and certified by a Registered Professional Engineer in Hong Kong under the Engineers Registration Ordinance (Cap. 409) in approved disciplines (or equivalent approved professional qualification). All tests shall be carried out to the satisfaction of the Supervising Officer and the FSD on completion of the Installations.

Emergency generator for the Installations is also one type of electrical installation. All works to be carried out by registered company and workers in accordance with the statutory regulations for electrical installation. All certificates/forms shall be duly signed by the Registered Fire Services Installation Contractor and the Registered Electrical Workers and shall be submitted to the Supervising Officer upon completion of the Installations. The whole emergency generator installation shall also be checked and certified by the Registered Professional Engineer.

Only trained workers shall be assigned to work on the fuel oil or diesel installation of the emergency generator. Requirements of dangerous goods store shall be complied where relevant. Necessary submission and co-ordination in obtaining the licence for the dangerous goods store shall be included as required. All mechanical and movable parts

of the emergency generator installation shall be lubricated and balanced, and the controls are accurately set on completion.

Acoustic treatment to the emergency generator installation and its exhaust and air intake points shall be provided so that the noise level shall be kept below the requirements of EPD or as specified in the Particular Specification whichever the lower. The position of exhaust and its height shall also comply with the requirements of EPD. Unless the provision of acoustic treatment by others is explicitly indicated on the Drawings, it shall be assumed that acoustic treatment shall be allowed in the Installations but not by others in the building works.

Where indicated that there is emergency generator installation in the same building by others and not included in the Installations but it is to be inspected by the FSD, such emergency generator installation by others shall be included in the submission to the FSD as part of the Installations with the necessary information to be provided by the relevant parties.

Co-ordination with the relevant installation parties, inspection, checking and witnessing of the final functional and performance tests on the emergency generator installation by others shall be carried out, including the load test of the Installations and equipment using the emergency generator power supply, to identify any non-compliance with the requirements in FSDCoP, FSD Requirements and Circular Letters, FS_TC and EE_TC for the purpose of certifying the satisfactory conditions of the emergency generator installation and its interfacing with the Installations. Any Installations found not complying with the fire service requirements of the FSD shall be rectified, or be reported to the Supervising Officer when such works are carried out by others, before arranging inspection with the FSD. Upon witnessing the satisfactory completion of all final tests and inspections after rectification of non-conformities related to fire service, such emergency generator installation by others shall be certified taking the role as a registered Fire Service Installation Contractor for it. Inspection by the FSD shall be arranged on all the Installations in the building including emergency generator installation.

For the purpose of fire service inspection, the emergency generator installation referred in this clause shall be limited to the one required by the FSD and shall not include emergency generator installation solely designed for user's operation at mains power failure.

Information shall be collected from relevant installation parties and emergency generator installation by others shall be included in submissions such as Form 314 to the FSD prior to the commencement of Works for all the Installations.

During the test on emergency generator installation, all the Installations and equipment, fireman's lifts, and RFSI requiring emergency power supply at the time of fire outbreak and power interruption shall be co-ordinated and checked that are all tested to operate on emergency power.

The emergency generator shall have a minimum continuous full load rating of not less than the consumption of all the Installations and equipment, fireman's lifts, and RFSI connected thereto. A separate dedicated emergency generator supplying emergency power to the Installations, fireman's lifts, and RFSI is required. Emergency generator shall not be connected to other non-fire service essential electrical load without the

approval of the FSD and the Supervising Officer. The emergency generator for the Installations shall be housed in separate room independent from the emergency generators supplying other essential electrical loads unless otherwise approved.

Where the emergency generator for the Installations is accepted by the FSD for supplying other essential electrical load, visual and audible warnings shall be provided on the generator control panel, fire service control panel, and fire service repeater panels in management offices to give warning at low fuel level when the total fuel storage for supplying the fire service equipment, fireman's lifts and RFSI is less than 7.5 hours supply. When the fuel storage is below the 6.5-hour minimum supply requirement, the emergency generator installation shall have facilities to cut off all non-fire service electrical loads connected to the emergency generator with visual and audible warnings.

Non-fire service electrical load shall also be tripped off in case of the failure of the control system or visual and audible warning system when a fire alarm signal is activated. Normal operation of passenger lifts shall avoid being adversely affected by tripping off. All control relays, contactors, and auto-changeover switches for the control system and visual and audible warning system shall be installed in a control panel inside the generator room. Fire resistant cables complying with this General Specification and FSD Circular Letter No. 2/2017 shall be used for the control and signal circuits.

Appropriate notice and sign shall be fixed inside the emergency generator room and main switch room in accordance with FSDCoP to indicate the total essential electrical loading of the Installations and equipment, fireman's lifts and RFSI connected to the emergency generator.

8.1.11.4 INSTALLATION AND CERTIFICATION

Registered Electrical Workers of appropriate grades shall be employed in accordance with the Electricity Ordinance (Cap. 406) to carry out the emergency lighting, exit sign and emergency generator installation. All relevant certificates/test reports shall be duly signed by the Registered Fire Service Installation Contractor and the Registered Electrical Workers and submitted to the Supervising Officer for record. Where specified, Registered Professional Engineer shall be required to certify the Installations and the record shall be submitted to the Supervising Officer.

SUB-SECTION 8.1.12

MECHANICAL, SPECIAL AND RELATED FIRE SERVICE INSTALLATIONS

8.1.12.1 MECHANICAL FIRE SERVICE INSTALLATION

Mechanical Fire Service Installation shall include ventilation/air conditioning control system, pressurisation of staircases system, smoke extraction system and automatic actuating devices.

A contractor in the List of Approved Suppliers of Materials and Specialist Contractors for Public Works in the Category of Air-conditioning Installation shall be employed to carry out works for the mechanical ventilation system, smoke extraction system and pressurisation of staircases system in the buildings and this contractor shall also be a Registered Fire Service Installation Contractor of relevant Classes registered with the FSD. The name of this contractor shall be submitted to the Supervising Officer for approval prior to employment.

A Registered Professional Engineer in Hong Kong under the Engineers Registration Ordinance (Cap. 409) in Fire, Building Services or Mechanical discipline (or equivalent approved professional qualification) with proof of experience of at least 3 years in relevant design works, who emphasises on and is specialised in mechanical ventilation and air handling installation shall be employed to the approval of the Supervising Officer to carry out the design and supervision of the submission, installation and testing of the pressurisation of staircases system and smoke extraction system. The professional status and qualifications of the Registered Professional Engineer shall also be acceptable by FSD and the Supervising Officer.

All linings for acoustic, thermal insulation and decorative purposes in ducting and piping shall be of Class 1 or 2 rate of surface spread of flame complying BS 476-7:1997, or brought up to that required standard by the use of an approved fire retardant product.

Where indicated that there are some portions or systems of the mechanical Fire Service Installation in the same building by others and not included in the Installations but it is to be inspected by the FSD, such mechanical Fire Service Installation by others shall be included in the submission to the FSD as part of the Installations with the necessary information to be provided by the relevant parties.

Co-ordination with relevant installation parties, inspection, checking and witnessing of the final functional and performance tests on mechanical Fire Service Installation by others shall be included to identify any non-compliance with the requirements in FSDCoP, FSD Requirements and Circular Letters, and FS_TC for the purpose of certifying the satisfactory conditions of the mechanical Fire Service Installation and its interfacing with other systems. Any Installations found not complying with fire service requirements of the FSD shall be rectified when the mechanical Fire Service Installation is included in the Installations, or be reported to the Supervising Officer when such works are installed by others, before arranging inspection with the FSD. Upon witnessing the satisfactory completion of all final tests and inspections after rectification of non-conformities related to fire service, such mechanical Fire Service Installation by others shall be certified taking the role as a registered Fire Service Installation Contractor for

it. Inspection by the FSD shall be arranged on all the Installations in the building including mechanical Fire Service Installation by others. Information shall be collected from relevant installation parties and mechanical Fire Service Installation by others shall be included in the submissions such as Form 314 and Form 501 to the FSD prior to the commencement and completion of all the installation works.

8.1.12.2 VENTILATION/AIR CONDITIONING (VAC) CONTROL SYSTEM

Unless otherwise specified, ventilation/air conditioning (VAC) control system required by the FSD shall be included in the Installations. Co-ordination with relevant parties held responsible for the Ventilation and Air-conditioning Installation works is required and drawings giving all details of the installation works as listed below shall be submitted to the Supervising Officer and to the FSD for approval: -

(a) Flow rate of each ventilation fan;

(b) Ventilation fans required to be tripped off;

(c) Method used to trip off the fans;

(d) Location of manual stop switch;

(e) Schematic diagram showing air side arrangement;

(f) Operating principles for tripping the fans; and

(g) Location and layout of indication/control panel, or if any, interconnection with fire alarm control system.

Co-ordination with the relevant parties to obtain the necessary information and schematic diagram on Ventilation and Air-conditioning Installation is required such that all details of the Installations as stipulated above are included in the submitted drawings.

The VAC control system shall be of fail-safe design, reliable in operation and comply with all the related requirements of FSD. A bypass key switch with visual and audible warnings in the panels shall be included for isolating the VAC control system temporarily during routine maintenance fire alarm testing. Three keys shall be provided.

Where required by the FSD and approved by the Supervising Officer, activation of detectors provided solely for the VAC control system shall not sound the general fire alarm and shall not send the fire signal via the fire alarm direct link and alarm transmitter. However, an alarm with visual and audible warnings shall be provided on the control panels.

8.1.12.3 PRESSURISATION OF STAIRCASES SYSTEM

8.1.12.3.1 Where indicated that pressurisation of staircases system is included in the Installations, design, supply and installation of the system shall be included. The pressurisation of staircases system shall comply with the requirements in FSDCoP, FSD Requirements and Circular Letters, BS EN 12101-3:2015, BS EN 12101-6:2005 and where appropriate BS EN 12101-6:2005. The design, drawings and the calculation of the pressurisation of staircases system shall be submitted to the Supervising Officer and to the FSD for approval giving all details confirming compliance with the FSDCoP, operating principles, schematic diagram, layout, control and catalogues on the door sets and other equipment. The relationship between the pressures in various parts of the building especially in areas provided with air conditioning and the pressure in the staircase shall be indicated.

8.1.12.3.2 Where part or whole of the system is carried out by others and not included in the Installations, co-ordination with the relevant parties, inspection, checking and witnessing of the final tests shall be required to identify any non-compliance with FSDCoP, FSD Requirements and Circular Letters, and to verify the system meeting the functional and performance requirements. Any works found not complying with the fire service requirements of the FSD shall be rectified when they are included in the Installations or be reported to the Supervising Officer when such works are carried out by others before arranging inspection with the FSD. The pressurisation of staircases system shall be included in the submission to the FSD with the necessary information to be provided by the relevant parties.

8.1.12.3.3 Co-ordination shall be required on various parts of the works particularly on the co-ordination of the builder's portions e.g. door frames and closers etc., the mechanical portions e.g. fans etc. and electrical portions e.g. cables etc. to ensure the system meeting the functional and performance requirements.

8.1.12.3.4 The pressurisation of staircases system shall comply with the followings: -

(a) The compartment to be protected and the location of pressurisation of staircases fans / equipment shall be as indicated on the Drawings. The layout of ductwork and associated accessories shown on the Drawings are indicative. The complete system shall be designed according to the assessment of the final resistance and with allowance for adjustment, based on the actual duct run and the effects on performance with respect to the offered equipment used for the system.

(b) The Registered Professional Engineer for the pressurisation of staircases system shall arrange all submissions including all necessary forms, drawings and technical information to the FSD for the consent and inspection of pressurisation of staircases system installation. The submission shall include all necessary

schematic diagrams required to fully explain the operation of the Installations including at least information on "normal", "fire", and "no power" modes with full co-ordination with other services. The Registered Professional Engineer shall sign and certify on the submission that the entire system has been properly designed, selected, tested and checked, and that all components, materials and workmanship comply fully with the requirements of FSDCoP, BS EN 12101-6:2005 - "Smoke and heat control systems. Specification for pressure differential systems. Kits" and the FSD Requirements and Circular Letters.

Notwithstanding that the whole system shall be demonstrated to perform to the standard requirements via numerical calculation to the satisfaction of the Supervising Officer and the FSD, the system under test shall be performed in accordance with the Specification with fire compartment be maintained at all times.

All components necessary for full operation of the system in automatic or manual mode regardless of whether such components are specified or not shall be provided. The pressurisation of staircases system shall be able to maintain minimum pressurisation level at 50 Pa minimum inside the stairwell with all doors closed and all pressure relief systems remain operating. The maximum pressurisation level shall be maintained such that under no circumstances shall the combined force, to overcome the pressure differential across any door and the action of the door closer, exceed 100 N or a figure agreed by the FSD when applied at the door opening handle or push plate position. The pressurisation of staircases system shall maintain air flow through the open door of air velocity not less than the requirement in FSD Circular Letter No. 2/2006 and BS EN 12101-6:2005 for various system classes, or a figure agreed by the FSD during the open door situation. The number of open doors shall be as required by the FSD.

(c) Pressurisation fans shall be supplied and installed as shown on the Drawings and where required to satisfy the pressurisation requirements. For buildings with more than one pressurised staircase, duplicate motors for each fan shall be supplied and installed. The pressurisation fans shall have variable flow control such that the pressurisation requirements can be met within a period accepted by the FSD with a door opened or closed.

When the pressurisation fan is not installed inside a separate fire resistant plant room or when the plant room contains other services installations, the fan and motor assemblies shall be enclosed by fire resistant enclosure with a FRR not less than that of the staircase served.

The nominal motor for the ventilating fans (extraction or make-up) shall provide a rating of minimum 20% higher than the motor operating power input under nominal operating requirement. The

motor windings shall be insulated to permit motor operation at design conditions for a period of 1 hour in an ambient temperature of 250°C.

(d) Pressurisation ductwork, the associated fittings for the pressurisation of staircases system and the associated fire resistant enclosure shall be provided. The fabrication and testing of all ductwork shall conform to DW 143 & DW 144 and the requirements stipulated in the Specification. All ductwork shall be fabricated from galvanised sheet steel. Aluminium sheets shall not be accepted.

All pressurisation ductwork installed outside the pressurised staircase shall be enclosed by fire resistant enclosure with a FRR not less than the compartment served. Another arrangement is for the ductwork section installed inside the designated plant room for pressurisation of staircases system, which is protected from other areas by fire resistant enclosure (including self-closing door) and contains no other services.

(e) The power supply for the pressurisation of staircases system shall feed from the building normal and essential supply sources fully comply with the requirements of the FSD. All wiring, cables, electrical equipment, starters relays, controls etc. shall be suitable for continuous operation at not less than 250 °C ambient for 1 hour. Where the motor control panel is used in serving the pressurisation of staircases plants, it shall be a type tested cubicle form constructed to IEC 61439-1:2011 and IEC 61439-2:2011 from not less than 2 mm thick panel steel. All sub-distribution boards, all wirings and cables etc. shall be installed inside a room or enclosure having a FRR of not less than 2 hours and containing no other equipment.

(f) All systems shall be automatically actuated whenever any Fire Service Installation in the building is activated and shall remain in operation until manually reset. Visual indication and audible alarm shall be supplied and installed on the control panel. Actuation of all systems shall be directed from the fire alarm control system whenever that panel transmits a “Fire” signal. Dry contacts shall be provided for transmission of “Fire” signal in the actuation of the pressurisation of staircases system. The Installations for all out-going wirings and associated accessories connected between these dry contacts to the motor control panel of pressurisation of staircases system shall meet FSD’s latest requirement.

When in “fire” mode, the pressurisation of staircases system shall not be controlled or under the influence of any other services and systems including the building management or automation system nor shall failure or close down of such systems prevent its operation. However, such systems may monitor the operations as required.

Each system shall be provided with a manual on / off control switch and indicator light at the fire control panel. The indicator lights to show manual on or off operation shall be provided with a red bezel and be flashing. Those indicating lights showing satisfactory operation of the fan(s) shall have a green bezel and be a steady light.

In each pressurisation of staircases system fan intake duct, smoke detector(s) shall be installed which, when sensing the passage of smoke, shall override all other controlling devices, and shut down the fan of the pressurisation of staircases system.

Pressure sensors in the pressurised space shall be suitable for normal ambient conditions i.e. not less than 40 °C and 99 % R.H. All wirings used in connecting the pressure sensors shall be of high temperature grade P.V.C. to BS EN 50525-1:2011, BS EN 50525-2-41:2011 and BS EN 50525-2-42:2011 (minimum 135 °C). The cables shall run in either galvanised conduit within the pressurised space in fire resistant duct or embedded in concealed steel conduit as close as possible to the face of the wall in the space. The pressure sensors and associated equipment used in pressurisation of staircases systems shall be of industrial process grade to BS EN 60654-1:1993. Commercial quality for heating, ventilation and air-conditioning equipment shall not be accepted.

Barometric pressure relief damper shall be supplied and installed for the pressurisation of staircases system for over-pressure relief. The framework of dampers shall be 3.2 mm minimum stainless steel sheet formed into a rigid channel section.

(g) "Notice Plate" in accordance with the latest FSD Circular Letter shall be provided to give a clear picture on the availability and operational status of each Staircase Pressurisation System (SPS). The "Notice Plate" shall specify the Class of system (A or B) installed, bear with red indicator light and shall be "on" with supply fan of the SPS in operation, and illuminated by emergency lighting, internally illuminated or backed up by emergency power supply.

The notice plates shall be provided at every staircase protected by SPS and shall be firmly affixed at a conspicuous position including outside the final exit, both inside and outside the exit on the top floor, and both inside and outside the exit/entrance of the staircase(s) on the refuge floor(s) if any.

8.1.12.4 SMOKE EXTRACTION SYSTEM

8.1.12.4.1 Where indicated that the smoke extraction system is included in the Installations, design, supply and installation of the system shall be included. The smoke extraction system shall include static smoke extraction system and dynamic smoke extraction system. The smoke extraction system shall comply with the requirements in FSDCoP, FSD Requirements and Circular Letters, and with the international standards acceptable to the Supervising Officer. Design, drawings and the calculation of the smoke extraction system giving all details confirming compliance with the FSDCoP, operating principles, schematic diagram, layout, control and catalogues, shall be submitted to the Supervising Officer and to the FSD for approval. The relationship between the pressures and flow in various parts of the building during fire scenarios shall be indicated. Where necessary, performance based fire engineering approach shall be used in the analysis, simulation and calculation.

8.1.12.4.2 Where part of the system or the whole of the system is carried out by others and not included in the Installations, co-ordination with the relevant parties, inspection, checking and witnessing of the final functional and performance tests shall be carried out to identify any non-compliance with FSDCoP, FSD Requirements and Circular Letters, and to verify the system complying with the functional and performance requirements. Any works found not complying with the fire service requirements of the FSD shall be rectified when they are included in the Installations or be reported to the Supervising Officer when such works are carried out by others before arranging inspection with the FSD. The smoke extraction system shall be included in the submission to the FSD with the necessary information to be provided by the relevant parties.

8.1.12.4.3 For static smoke extraction system, co-ordination with relevant parties on the building design to provide the required smoke reservoirs, automatic smoke/fire vents and necessary smoke discharges shall be required. Fixing of the smoke curtains shall be by approved means to the recommendation of the manufacturers, complying with the fire service requirements and to the approval of the Supervising Officer.

8.1.12.4.4 For dynamic smoke extraction system, the systems most appropriate to the occupancy and the function of the concerned areas shall be supplied and installed. Where smoke extraction system is provided only to part of the building, the worst case scenarios shall be adopted in the calculation on the effect of air-conditioning and ventilation fans in various parts of the building.

8.1.12.4.5 The complete design and installation of the system shall be included, and the system shall be well co-ordinated with other parties. The Registered Professional Engineer for the smoke extraction system shall arrange the submissions to the Supervising Officer and the FSD for the consent and inspection of the smoke extraction system installation. The submission shall include all necessary forms, drawings and technical calculation / information required to fully explain the full operation modes including at least information on “normal”, “fire”, and “no power” conditions. The

Registered Professional Engineer shall sign and certify that the entire systems have been properly designed, selected, tested and checked by him, and all components, materials and workmanship shall comply fully with the requirements of the smoke extraction system as stated in the FSD's latest requirements.

8.1.12.4.6 Notwithstanding that the calculation shall be demonstrated to the satisfaction of the Supervising Officer that the system will perform to the standard required, the system, under test at any time, shall be performed in accordance with this General Specification and the Particular Specification.

8.1.12.4.7 The smoke extraction system shall be able to maintain the smoke travel at counter-flow mode and away from that of the egress/escape route. Within the protected fire compartment, the make-up air and smoke extraction paths shall be arranged such that a "scouring" or "cross-flow" effect occurs in all areas. The supply of make-up air shall enter at low level and / or in such a manner as to avoid premature mixing with the hot gases. Whenever the make-up air is not mechanically propelled, the air path shall be as direct as possible with the shortest route. The points of smoke extraction shall be at high level in the space concerned and shall be reasonably distributed such that the smoke shall not be travelled at more than 30 m before entering the nearest inlet of the extraction system. At least one extraction point shall be supplied and installed within each 500 m^2 unit of floor area.

8.1.12.4.8 Suitable types of supply diffusers / extraction grilles / louvres etc. shall be supplied and installed to maintain maximum velocities as follows, calculated using free area: -

Make-up air inlets where not mechanically propelled	3 m/s
Make-up air inlets where mechanically propelled	6 m/s
Extraction grilles or outlets	6 m/s

8.1.12.4.9 Minimum supply or make-up air rate at minimum 80 % of the overall extraction rate shall be maintained. When supply or make-up air is provided by mechanical means, this shall be supplied by an independent supply air system. Where it is acceptable to use normal air conditioning system to supply the make-up air, facilities to the air conditioning system shall be supplied and installed such that the system can be changed over during fire from the normal operating mode to that extracting full outside air to the required compartment.

8.1.12.4.10 All systems and installations shall be fail-safe, reliable in operation and meeting with all the related requirements of FSD, as to maintain free passage of smoke with all equipment / components necessary for the full operation of system under automatic or manual mode regardless of whether such equipment / components are specified or not.

8.1.12.4.11 Smoke Extraction / Make-up Air Fan

Smoke extraction and make-up air fans which shall meet all specified requirements including construction, capacity, efficiency, motor size, sound rating, and constraints on physical dimensions as may be imposed by the design and to suit the smoke extraction requirements shall be supplied and installed.

All smoke extraction fans shall be constructed or coated with finishing materials capable of withstanding exposure to an ambient temperature of at least 250°C for a period of not less than 1 hour, without producing smoke or any sort of toxic fumes. The respective manufacturer shall certify with substantiation that such coating finishes shall be factory-applied with specified requirement complied. The fans shall be connected directly to outside by non-combustible ductwork including flexible connection, if installed. When smoke extraction / make-up air fans are installed within the served compartment, the system including fans, motors, drives, electrical works, ductwork linking fans etc. shall be protected by a fire resisting material or enclosure complying with the Fire Safety Code.

The motor for the ventilating fans (extraction or make-up) shall provide nominal rating of minimum 20% higher than the motor operating power input under nominal operating requirement. The motor windings shall be insulated to permit motor operation at design conditions for a period of 1 hour in an ambient temperature of at least 250°C. The fan motor shall be installed outside the hot air stream where possible.

In order to prevent re-circulation of smoke, the discharge points of smoke shall be separated by not less than 5 metres in any direction from all air inlets or other openings into any buildings. The discharge of smoke into any means of escape or a fireman's staircase is strictly prohibited.

The following requirements shall be noted: -

(a) The smoke shall not be discharged at the underside of any canopy or overhang; and

(b) No discharges shall be at a height less than 3 metres measured from the surrounding horizontal surface to the bottom of the outlet and where the height is below 6 metres, the smoke shall not be discharged downwards.

8.1.12.4.12 Ductwork and Fittings

Ductwork and associated fittings for smoke extraction system installation shall be supplied and installed as shown on the Drawings and as required to suit the smoke extraction requirements. The fabrication and testing of all ductworks shall conform to DW 143 & DW 144, industrial grade, and the requirements stipulated in this General Specification and the Particular Specification. All ductwork shall be fabricated from galvanised sheet steel. Aluminium sheets shall not be accepted.

The smoke extraction system ductwork shall not be provided with fire or smoke dampers and any other restrictions in the ductwork unless otherwise accepted by the FSD. Exceptions will be where only one extraction or supply system is used to serve several compartments where motorised fire and smoke dampers complying with FSD's requirements may be required. Also, motorised fire and smoke dampers complying with FSD's requirements shall be required at the main exhaust outlet louvre and main make-up intake louvre. If smoke extraction system ductwork passes through compartments, all parts of the ductwork outside the served compartment shall be protected by enclosure or covered with fire resistant materials as required in the Fire Safety Code, such part shall be fire resisting to BS 476-24:1987 or to be totally enclosed by fire resistant construction to BS 476-20:1987 having FRR not less than that of the wall or floor of the served compartment or the compartment containing the ductwork whichever is higher.

Motor operated fire and smoke dampers shall comply with UL 555S:2014 Class I, and where relevant BS ISO 10294-5:2005, and other international standards approved by the Supervising Officer and the FSD. Motor operated fire and smoke dampers shall be fail-safe design. The damper shall be complete with electric motor actuator enclosed with suitable fire rated enclosure. Damper module installations shall be fully sealed by gaskets or approved materials between the module frame and the mounting frame. Apart from meeting the fire resistance requirements in the Fire Safety Code, the gasket material shall be capable of withstanding exposure to an ambient temperature of at least 250 °C for not less than 1 hour without producing smoke or any toxic fumes. Damper manufacturer shall certify that the assembled dampers, including all accessories and controls, can withstand 250 °C for the duration of 1 hour without distortion, buckling, damage to seals, bearings, or any deleterious effect.

8.1.12.4.13 Electrical Installation

The essential power supply and distribution systems feeding the smoke extraction & make-up air supply system shall fully comply with the requirements of the FSD. All wiring, cables, electrical equipment, starters relays, controls etc. from the building primary and secondary sources of supply shall be suitable for continuous operation at 250 °C ambient for 1 hour minimum.

When the motor control panel are used for supplying the smoke extraction & make-up air supply systems, the motor control panel shall be of a type tested cubicle form constructed to IEC 61439-1:2011 and IEC 61439-2:2011 from not less than 2 mm thick panel steel and all sub-distribution boards, wirings, cables etc. shall be located in a room or enclosure having a FRR of not less than 2 hours and containing no other equipment.

Cables shall be fire resistant type and shall comply with FSD's requirements.

8.1.12.4.14 Control and Actuation

All system shall be automatically activated whenever the smoke detector and any control/sensing device designated as its actuation device is activated and shall remain in operation until manually reset with visual and audible warnings. The system shall also be activated by manual control switch and/or designated sprinkler flow switch in the same area in case the smoke detection system fails to activate the smoke extraction system before sprinkler operates. Where the smoke extraction system is installed in areas vulnerable to unwanted fire alarms, suitable special detection system to the approval of the Supervising Officer and the FSD shall be supplied and installed. Co-ordination, supply and installation of dry contacts for transmission of "fire" signal for actuating the smoke extraction systems which shall connect directly from the fire alarm control system shall be provided. All outgoing wirings and accessories from these dry contacts to the motor control panel of smoke extraction system shall comply with FSD's requirements.

When in "fire" mode, no smoke extraction system connected therewith shall be controlled by or under the influence of any other building services systems nor shall failure or close down of such building services systems prevent its operation. However, such building services systems may monitor the operations of smoke extraction system as required.

Each system shall be supplied and installed with a manual on/off control switch and indicator light at the fire control panel. The indicator lights to show manual on or off operation shall be supplied and installed with a red bezel and be flashing and those showing satisfactory operation of the fan(s) shall have a green bezel and be a steady light.

The detection system selected for the dynamic smoke extraction system shall be of early detection types. For clean areas, very early smoke detection alarm (VESDA) system or system having equivalent functions and performance as approved shall be adopted. For unclean areas and areas with high humidity, detection system shall be generally of early response type appropriate to the applications which can respond at an early stage of fire with low smoke. The system shall however be equipped with necessary facilities such as cross-zoned design (coincidence connection) to the approval of the FSD, compensation for high humidity, sensitivity drift adjustment etc. to avoid false fire alarm and unwanted fire alarm. Special detection system shall be used as necessary or specified. For cross-zoned design, an alarm with visual and audible warnings on the control panel shall be raised when one detector is activated. Smoke extraction system shall operate with the actuation of any two detectors in coincidence connection. Where required by the FSD and approved by the Supervising Officer, activation of the detectors provided solely for the smoke extraction system shall not sound the general fire alarm and shall not send the fire signal via the fire alarm direct link and the alarm transmitter.

Control switches shall be supplied and installed in the control panels and in the main fire alarm control and indicating panel/fire control centre for activating and switching off each fan of the dynamic smoke extraction system manually.

8.1.12.5 AUTOMATIC ACTUATING DEVICES AND DAMPERS

Automatic actuating devices controlled by fire/smoke/explosion detection system, fire alarm system and automatic facilities such as sprinkler flow switches etc. where indicated on the Drawings for protection of compartment, for closing an area for gas flooding system, for licensed areas and where required, shall be supplied and installed. All power, controls and wiring shall be included. The automatic actuating devices shall be of approved type and shall be suitable for the hazard class in the area protected.

Automatic actuating devices for fire shutters shall be operated by smoke detectors and complete with manual controls on both sides except for fire shutters located in car park areas and in kitchens which shall be operated by heat detectors or special approved devices with manual controls.

For the dampers installed on a door, the automatic actuating device shall be connected to an electromagnetic remote damper release unit. The electromagnetic remote damper release unit shall be suitable for mounting outdoor, with appropriate weatherproofing type for remote actuation of the dampers. The actuating mechanism shall be durable and reliable. The unit shall be of fail-safe design such that the damper shall be released at no power supply, and shall be reliable in operation and meeting with all the related requirements of FSD. The unit shall consist of a sheathed steel wire connected to the electromagnetic remote damper release unit at one end and the fire damper locking device at the other end or a similar approved facility. The sheathed steel wire shall be anchored at strategic points such that the steel wire can move freely relative to the outer skin. A fire signal shall actuate the unit by spring return mechanism or similar that will pull the steel wire and release the damper. The design shall be such that none or only a small section of the sheathed wire is located outside the room for good appearance and the unit installed outdoor shall be mounted inside a dust and moisture proof stainless steel box recessed in the external wall. The electromagnetic remote damper release unit shall be complete with power on indication and damper reset facilities.

Fire dampers shall be provided at locations and constructed to standards as required by the FSD and Buildings Department to comply with the Buildings Regulations for compartments and openings. Where specified, fire dampers shall also be designed and constructed to comply with UL 555S:2014 Class I, or equivalent approved international standard for smoke dampers, to restrict the spread of smoke. The combined fire and smoke damper shall be complete with electric motor actuator enclosed with suitable fire rated enclosure and shall be able to close completely at design air pressure and flow during fire. Apart from meeting the fire resistance requirements in the Fire Safety Code, damper manufacturer shall certify that the assembled fire and smoke dampers, including all accessories and controls, can withstand 250°C for the duration of 1 hour without distortion, buckling, damage to seals, bearings, or any deleterious effect. The fire and smoke dampers shall be operated by the building fire alarm system provided in the same building zone which includes manual fire alarm, flow switches in sprinkler system and fire detectors.

An inspection door shall be provided for each damper and associated fusible link for regular inspection and for each automatic actuating devices for maintenance purpose.

When required by the FSD and approved by the Supervising Officer, activation of detectors provided solely for the automatic actuating devices shall not sound the general fire alarm and shall not send the fire signal via the fire alarm direct link and alarm transmitter. However, an alarm with visual and audible warnings shall be provided on the control panels. The detectors for the automatic actuating devices shall be wired in coincidence connection when two or more detectors are provided.

Automatic actuating devices shall be installed outside all lift door openings which do not discharge to protected means of escape unless the building is sprinkler protected or that it is a domestic type building with 3-storey or below. The actuation of any of the smoke detectors on any floor shall initiate home landing of the respective lift car.

8.1.12.6 SPECIAL FIRE SERVICE INSTALLATION

Special Fire Service Installation shall include, but not limited to, fixed and mobile foam system, dry chemical system, foam water system, water mist system, explosion protection system, water spray system, dust detection system, dry powder system, wet chemical system, restaurant fire suppression system, gas detection system, life safety system, industrial fire protection system for high hazard areas and other fire service systems not covered in other parts of this General Specification.

Special Fire Service Installation shall be supplied and installed where specified and as required. The special Fire Service Installation shall be designed, supplied and installed to comply with the statutory requirements and with careful consideration on the factors of performance, maintenance, reliability and resilience. Unless otherwise approved by the Supervising Officer for minor design, a qualified professional engineer shall be employed to be responsible and to carry out the design for the special Fire Service Installation. The engineer employed shall be a Registered Professional Engineer in Hong Kong under the Engineers Registration Ordinance (Cap. 409) in Fire, Building Services or Mechanical discipline (or equivalent approved professional qualification) with proof of experience of at least 3 years specialised in Fire Service Installation design. The professional status and qualifications of the Registered Professional Engineer shall also be acceptable by FSD and the Supervising Officer.

The detailed design of the special Fire Service Installation including drawings, calculation, equipment catalogues and other information shall be submitted for acceptance by the FSD and approval by the Supervising Officer. For proprietary system, the design and design calculation shall be supported by manufacturer's data and according to manufacturer's design manual. Acceptance of the FSD and the approval by the Supervising Officer shall be obtained on the design before ordering of equipment and carrying out installation work on Site.

Where pre-engineered system is used, the system manufacturer's design manual and calculation shall be provided. Where engineered system is used, full mathematical calculation or computer modelling with manufacturer's design manual shall be submitted. When proprietary computer programme is required to complete the design and the computer programme does not show all calculation steps, evidence shall be

produced that the result generated by the computer programme is in accordance with the relevant international standards and accepted by the FSD.

All equipment used shall be of FSD approved type or shall be listed by the Product Certification Bodies in accordance with FSD Circular Letter No. 1/2007. For equipment model that has not been accepted by the FSD before or has not been listed by the Product Certification Bodies, endorsement of the FSD and the Supervising Officer shall be obtained before ordering. The Installations shall follow manufacturer's recommendation and the best practices in appropriate standards such as NFPA codes, BS standards etc. to the acceptance of the FSD and the approval of the Supervising Officer.

For special equipment that has not been accepted by the FSD before, a Registered Professional Engineer in Hong Kong under the Engineers Registration Ordinance (Cap. 409) with proof of experience of at least 3 years in the relevant and approved discipline shall be employed to certify the performance and functioning of the special equipment and the endorsement of the FSD and the Supervising Officer shall be obtained.

Where specified for better life safety protection, emergency telecommunication system shall be provided within building such as fixed intercom unit at fireman lift lobby of each floor with main/repeater panels at fire control centre and building security/guard room to facilitate rescue operation and reporting during emergency.

8.1.12.7 RELATED FIRE SERVICE INSTALLATIONS AND PROVISIONS

RFSI and RFSP shall comply with FSDCoP, FSD Requirements and Circular Letters, Fire Safety Code and relevant statutory requirements.

Where there are RFSI in the same building to be inspected by the FSD, co-ordination with others, inspection, checking and witnessing of the final functional and performance tests on all RFSI by others shall be required to identify any non-compliance with the requirements in FSDCoP, FSD Requirements and Circular Letters, Fire Safety Code and FS_TC. Any works found not complying with the fire service requirements of the FSD shall be rectified when they are included in the Installations or be reported to the Supervising Officer when such works are carried out by others before arranging inspection with the FSD. Upon witnessing the satisfactory completion of all final tests and inspections after rectification of non-conformities related to fire service, inspection by the FSD on all the Installations in the building including RFSI by others shall be arranged.

Where there are RFSP in the same building to be inspected by the FSD, co-ordination shall be required with others, and the information and certification from relevant parties on all RFSP by others shall be obtained and checked to confirm their completion and readiness for inspection by the FSD.

Co-ordination and checking shall be required that all RFSI and RFSP by others to be inspected by the FSD are tested, rectified where necessary and certified by relevant parties before arranging the inspection with the FSD.

Information shall be collected from relevant parties and the RFSI shall be included in the submissions such as Form 314 and Form 501 to the FSD. The drawings with calculation on the RFSP shall also be submitted where necessary to the FSD for approval.

A commissioning engineer in charge approved by the Supervising Officer as required in this General Specification shall be employed to co-ordinate and oversee the completion of all Installations in a building or project required to be inspected by the FSD irrespective of whether the installation of such works are included in the Installations or by others. All RFSI and RFSP by others shall be included. Particular attention shall be paid to the interfacing works and signal transmission to different installations as well as the communication link with outside.

Where certificates and licences are required by the FSD for completion of the fire service inspections, co-ordination shall be required with relevant parties, and all the licences and certificates shall be checked and obtained before the arrangement of inspection with FSD. The licences and certificates may include, but not limited to, licences for emergency generator rooms, fuel tank rooms and dangerous goods stores, certificates for gas cylinders, certificates for radioactive substances, and other statutory licences as required.

In licensed premises, approved equipment of appropriate types such as explosive proof, flameproof, weatherproof, corrosive resistance, spark-proof, intrinsically safe etc. shall be used to suit the applications. Where mechanical ventilation systems in licensed premises are included in the Installations, all necessary fire dampers and smoke dampers shall be provided. The ventilation system shall also be interlinked with the gas detection system and other detection systems, when they are supplied and installed in the licensed premises as required by the FSD.

SUB-SECTION 8.1.13

MISCELLANEOUS

8.1.13.1 SPARES AND TOOLS

For plant and/or equipment included in the Contract, the types of spare parts generally wherever these are appropriate to the plant and/or equipment involved plus any additional items for the particular plant and/or equipment shall be provided. Unless specified in detail, any spare part or component of the plant or equipment that is subject to frictional wear, vibration or temperature fatigue, rupture to safety (or otherwise), corrosion, erosion, decay, limited operating life, unacceptable deposits and/or saturation, normal fair wear and tear and is likely to fail or reach an unacceptably low performance level shall be considered to include.

Spare parts and special tools including spare sprinkler heads, detectors, replacement break glass plates, indicator lamps, special keys, fuses, parts for the gas extinguishing system after discharge and the special tools, kits, electronic/computerised devices or instruments together with any required hardware and software licensing agreements, instructions and manuals for addressable detection system etc. shall be provided as required for all the following: -

(a) Required by the statutory rules and the FSD;

(b) Required by this General Specifications;

(c) Required for one year operation and maintenance after expiry of the Maintenance Period; (All spares and tools for use and consumption within the Maintenance Period shall be provided separately)

(d) Required by the codes and standards adopted in this General Specification and other requirements in this General Specification at the time of completion of the Installations and before commencement of the Maintenance Period.

Locked cabinet or cabinets of at least 1.6mm thick stainless steel to BS EN 10088-1:2014 No. 1.4401 and of robust construction to the satisfaction of the Supervising Officer in the plant room(s) and/or control room(s) for housing the spares and tools. Such sets of spare parts and special tools shall be submitted to the Supervising Officer for approval within 4 months after commencement of the Contract, or in such period as has been agreed by the Supervising Officer in writing.

All the spare parts and special tools required for the whole Maintenance Period for operation and maintenance of the plant and installation shall be supplied. The spare parts and special tools shall be in addition to the requirements in this General Specification. At the end of the Maintenance Period, the spare parts and special tools required in the second paragraph of this clause shall be provided and stored in the cabinet. The spare parts that may have been used during the Maintenance Period shall be replenished and supplied at no extra cost.

In addition, a complete manufacturer's recommended list of all the replaceable parts, spares and special tools with model number, part number and quantity which are likely to prove necessary to service the plant and/or equipment shall be included in the operation and maintenance manual. The list shall include diagrams or catalogue details of the parts concerned and with bona fide manufacturer's published price lists. Apart from this, an undertaking shall be included in the manual stating that all the essential components/parts of all the installed systems for operating the systems at an acceptable performance level can be delivered to Site for replacement in 7 working days upon order.

Information on the design operating life for equipment such as batteries, detectors, fire extinguishers, gas extinguishing system etc. that are required to be replaced some years later shall be submitted.

Minimum three keys shall be provided for each key operating facility, locks and switches unless otherwise specified.

8.1.13.2 PROVISION FOR WATER METER

Metering of water supplies to the Installations is not required. Provision shall, however, be made for the possible future connection of the WSD meter at each point of connection to the main, immediately downstream of the main stop valve. The position of this future meter shall be shown on the installation drawings. Co-ordination shall be required with the Building Contractor to obtain the information where necessary.

8.1.13.3 EQUIPMENT BASES

All bases and supports for plant and equipment shall be supplied and installed, except concrete plinths and blocks, which will be provided by the Building Contractor unless otherwise specified but shall be designed to suit the actual equipment.

Plinths and blocks shall be designed to project approximately 100 mm above the finished floor level.

8.1.13.4 SAFETY FACILITIES

Facilities for operational and maintenance safety shall be supplied and installed to comply with the Occupational Safety and Health Ordinance and with the requirements of Labour Department. All moving parts shall be appropriately covered and emergency stops shall be supplied and installed where necessary. Adequate spaces and facilities shall be allowed for maintenance and access.

SECTION 8.2

PERFORMANCE BASED FIRE ENGINEERING

SUB-SECTION 8.2.1

GENERAL

8.2.1.1 SCOPE

Performance based fire engineering (PBFE) approach shall be adopted where specified in the Particular Specification for the study, assessment, design, analysis, problem solving, selection and/or holistic evaluation of the whole fire service and building design, fire service equipment/installation, building material/construction, life safety protection, property protection, fire intervention approach, associated fire risk and hazard, and performance of systems in fire.

Where PBFE approach is required, adequate and not less than one competent and qualified professional engineer(s) specialised and experienced in the PBFE and approved by the Supervising Officer shall be employed to carry out the works for PBFE and to be responsible for the interfacing of PBFE with works by others. Details including names, curriculum vitae, qualifications and professional experience of the professional engineer(s) specialising in fire engineering shall be submitted for approval. The professional engineer(s) responsible for the PBFE shall be a Registered Professional Engineer in Hong Kong under the Engineers Registration Ordinance (Cap. 409) in Fire, Building Services, Mechanical or Electrical discipline (or other equivalent approved professional qualifications) with proof of experience of completed successful cases of at least 3 years in relevant Fire Service Installation design and fire safety engineering studies, have recognised and approved academic qualifications, training and post-qualification professional experience in PBFE, and have adequate knowledge of Building Regulations in Hong Kong, all to the satisfaction and approval by the Supervising Officer. The completed successful cases to be submitted as a proof of experience in relevant Fire Service Installation design and fire safety engineering studies shall be those cases successfully approved by the Fire Safety Committee of the Buildings Department of the Government of the HKSAR, and the approval letter from the Fire Safety Committee for each of such cases shall be submitted for Supervising Officer's inspection and approval. The professional status and qualifications of the Registered Professional Engineer shall also be acceptable by the Supervising Officer.

The Registered Professional Engineer employed for works on PBFE shall not be the professional independent checking engineer or the commissioning engineer as required in this General Specification for any part of the Installations and the Works

8.2.1.2 STANDARDS AND GUIDES

The performance based fire engineering approach, study, analysis, assessment, application or similar works shall follow internationally recognised fire engineering standards, codes and guides acceptable to the FSD and Buildings Department, and approved by the Supervising Officer. Some known standards, codes and guides shall include, but not limited to, the following: -

(a) Code of Practice for Fire Safety in Buildings: 2011;

(b) Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment;

(c) Society of Fire Protection Engineers - SPFE Handbook of Fire Protection Engineering, 5th Edition, 2015;

(d) National Fire Protection Association - NFPA 92 Standard for Smoke Control Systems, 2018 Edition;

(e) Society of Fire Protection Engineers - Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings, and The Society of Fire Protection Engineers Code Official Guide to Performance Based Design Review and Analysis of Building;

(f) BS 7974:2019 and PD 7974 (parts 0 to 8) for Application of Fire Safety Engineering Principles to the Design of Buildings;

(g) BS 9999:2017, Code of practice for fire safety in the design, management and use of buildings;

(h) PAS 79:2012, Fire risk assessment – Guidance and a recommended methodology;

(i) PAS 911:2007, Fire strategies – Guidance and framework for their formulation;

(j) Chartered Institution of Building Services Engineers - Guide E on Fire Engineering;

(k) Recommendations of the International Organisation for Standardisation Sub-Committee - ISO/TC92/SC4, BS ISO/TR 13387:1999 (parts 1 to 8) and associated standards;

(l) Performance Based Option in NFPA 101:2015, NFPA 101A:2016 and NFPA 5000:2015; and

(m) Performance Based Building Codes/Fire Codes in U.K./Sweden/ Australia/New Zealand/Japan/other developed countries.

The most appropriate standards, codes and methodologies for the PBFE approach shall be selected and the agreement of the FSD and Buildings Department and the approval by the Supervising Officer shall be obtained.

Practice Notes for Authorized Persons and Registered Structural Engineers and Registered Geotechnical Engineers (PNAP) APP-87 – Guide to Fire Engineering Approach published by the Buildings Department shall be followed.

The latest codes, guides, manuals and other requirements on PBFE (if applicable) issued by the FSD and Buildings Department shall also be complied with.

SUB-SECTION 8.2.2

EXECUTION OF WORKS

8.2.2.1 COMPUTER SOFTWARE AND TOOLS

Where the PBFE approach requires the use of computer software and/or tools for the modelling, analysis, simulation and/or calculation, the cost for the use of all such facilities, computer hardware, software and computing works shall deem to be included. Hard and electronic copy of the computed result and output shall be submitted. The demonstration to the Supervising Officer the output including the modelled result locally on computers shall be provided at no extra cost.

Accredited/validated certificate(s), appropriate evidence and/or substantiation showing the acceptance of the computer software and tools by internationally recognised bodies for similar PBFE analysis shall be provided. Details of the principles, formulae, assumptions, limitations, data, and calculation adopted in these computer software and tools shall be provided when required by the Supervising Officer. All calculations and computed results shall be checked and endorsed by the competent and experienced professional engineer(s).

8.2.2.2 TESTS

Where the completion of PBFE require site tests, fire/smoke tests, laboratory tests and/or full scale tests for completion of the studies and evaluation, all such tests including fire tests, mock-up tests, simulation tests, smoke tests, field tests and trial tests, on site and/or off-site, shall deem to be included in the Installations works. All laboratory fire/smoke tests shall be carried out by approved independent laboratories/testing bodies experienced and widely recognised internationally for carrying out tests for fire studies and fire materials. Details shall be submitted for approval.

8.2.2.3 INDEPENDENT CHECKING

For PBFE approach used for fire service/fire safety/building design, selection of fire service system/installations/equipment, evaluation of alternate solutions for compliance with statutory requirements, evaluation of new fire service systems/installations, risk assessment of major modification works, and assessment of building/structural fire protection and life safety provisions such as fire compartments and occupant evacuation, an independent qualified and experienced professional checking engineer specialised in the PBFE shall be employed to the approval by the Supervising Officer to check, validate and audit on all the design, assessments, analysis, calculations, computer modelling, submissions and all works on the PBFE and to report all the findings independently to the Supervising Officer. The independent checking engineer shall be a Registered Professional Engineer in Hong Kong under the Engineers Registration Ordinance (Cap. 409) in Fire, Building Services, Mechanical or Electrical discipline (or other equivalent approved professional qualifications) with proof of experience of completed successful cases of at least 3 years in relevant Fire Service Installation design and fire safety engineering studies, have recognised and approved academic qualifications, training and post-qualification professional experience in PBFE, and have adequate knowledge of

Building Regulations in Hong Kong, all to the satisfaction and approval by the Supervising Officer. The completed successful cases to be submitted as a proof of experience in relevant Fire Service Installation design and fire safety engineering studies shall be those cases successfully approved by the Fire Safety Committee of the Buildings Department of the Government of the HKSAR, and the approval letter from the Fire Safety Committee for each of such cases shall be submitted for Supervising Officer's inspection and approval. The professional status and qualifications of the Registered Professional Engineer shall also be acceptable by FSD and the Supervising Officer.

The professional independent checking engineer employed shall be neutral, and independent and cannot be an employee of either the Employer or Contractor or any Specialist Sub-contractor who may be engaged for the execution of any part of the Installations and the Works and shall not have any actual conflict of interest. He shall not be the professional engineer employed for works on PBFE or the commissioning engineer as required in this General Specification for any part of the Installations and the Works or other Registered Professional Engineers employed for the execution of any part of the Installations and the Works.

8.2.2.4 PROGRAMME AND SUBMISSION

8.2.2.4.1 General

A detailed programme for the PBFE study including the time allowed for consultation, detail vetting and approval by various authorities and parties. Since the results of PBFE study will affect the provisions of Fire Service Installation and building design, adequate time for carrying out the PBFE studies shall be allowed and the results shall be adopted in the early stage of the Contract well before commencing all the installation works.

All the data, statistics and information used for the studies and evaluation in fire engineering shall be collected and provided. The comments and approvals from the FSD, Buildings Department, and relevant government departments and authorities on the assumptions used, statistical and fire data, approaches, methodologies and the results of the PBFE shall be obtained. The cost for making submissions, re-submissions and discussion with relevant parties and authorities before finalising the studies and evaluation shall be allowed.

The results and reports of the PBFE in a format acceptable to the Supervising Officer covering details of the objectives, functional and performance statement, methodologies, principles, assumptions, limitations, statistics, data, formulae, calculations, standards adopted, risk analysis, computer modelling, figures, diagrams, models, test results, evaluation, solutions, recommendations and other relevant information shall be submitted. At least 3 copies, each or as specified, of both hard and electronic copy (stored in CD ROMs) of the documents on the results/reports of the PBFE shall be submitted and re-submitted as necessary to the Supervising Officer. The electronic copy shall be of file format as specified or approved by the Supervising Officer. Before submission of the final results of the PBFE to the Supervising Officer for

approval, the approval of submission to relevant authorities such as the FSD and Buildings Department on all the results, solutions and recommendations shall be obtained. The professional engineer specialised in fire engineering employed under this General Specification shall endorse all the documents before making the submission. The documents shall also be checked by the independent checking party when provided.

After the approval by relevant parties and authorities, the results and reports of the PBFE shall be included, with all the approved amendments made during the installation, in the operation and maintenance manuals.

8.2.2.4.2 Before carrying out the detailed PBFE study, preliminary report shall be submitted to seek comments from the Supervising Officer, the FSD and the Buildings Department on the approach and scope in the study. The preliminary report shall cover but not limited to the following:-

(a) Objectives;

(b) Project description and identification of areas of fire risk for the study;

(c) Assumptions;

(d) Acceptance criteria and risk level;

(e) Hazard identifications;

(f) Fire scenarios;

(g) Functional, performance and code requirements;

(h) Building designs with deviations from code requirements;

(i) Alternate solution/trial concept design to be investigated;

(j) Evaluation method and level; and

(k) Tools/tests/software to be used.

8.2.2.4.3 The final reports of PBFE shall include but not limited to the following: -

(a) Objectives, project description, code requirements, assumptions, functional statements, performance statements, documentary evidence, deviations from codes, alternate solutions, recommendation and all other sections as required in relevant standards, codes and guides;

(b) Qualitative assessment and/or quantitative assessment (deterministic and probabilistic) as appropriate following relevant standards, procedures and guides;

(c) Risk assessment where applicable, except for simple cases where comparative method, expert judgement and verification method are acceptable;

(d) Fire engineering solution;

(e) Sensitivity analysis of the assumptions used and data;

(f) Assessment on the safety factors, redundancy, limitation, and contingency provided in the solution in comparison with the prescriptive codes;

(g) Recommendation and conclusion; and

(h) Recommended precautionary measures and boundary conditions that shall be followed by the users/operators in future. This shall include the submission of a fire safety management plan for ensuring that the fire safety measures essential to achieve the accepted fire engineering performance level as alternative to the prescriptive design be implemented and up-kept.

8.2.2.5 ACCEPTANCE CRITERIA

PBFE aims to improve and strengthen the fire safety in the buildings in particular life safety of the occupants. The analysis and evaluation shall target to improve the building design and fire service provisions to satisfy the fire safety requirements, building regulations, and the concern on the fire risk and fire hazards particularly for those parts of the design that may not be adequately covered in the prescriptive fire codes and building codes.

The PBFE studies shall not be used as the tool primarily to reduce the building and/or fire service provisions in the prescriptive fire codes, building codes, standards and regulations because factors of redundancy, safety margin, contingency and spare capacity may often have been built into the provisions of such codes, standards and regulations to cater for the variance in performance and unforeseen circumstances. Any reduction of the safety margin and allowance, though may still comply with the minimum standard, will reduce the overall fire safety standard of the building and will not be accepted. Adequate safety margin, redundancy and allowance in the performance based fire engineering studies and applications shall be allowed to maintain equivalent or better fire safety standards in comparison to the prescriptive codes and other similar buildings in the territory.

The PBFE studies shall not be used as the tool solely to delete any requirement in the prescriptive fire/building codes and regulations unless alternate and/or additional fire safety measures to the approval by the Supervising Officer, the FSD and the Buildings Department shall be provided to strengthen or maintain the fire safety. Use of the PBFE studies to prove the building is still fire safe on deleting some requirements in the prescriptive fire codes/building codes and regulations and without corresponding alternate/additional fire safety measures added will not be approved.

A holistic approach in carrying out the PBFE study shall be used.

The following are the minimum criteria to be considered in the assessment: -

(a) Occupant's/public life safety;

(b) Human behaviour and responses when a fire occurs;

(c) Fire fighter's life safety;

(d) Fire spread to adjacent compartments and buildings;

(e) Property loss and structural fire protection;

(f) Loss of business operation/opportunities as appropriate;

(g) Damage to heritage buildings where applicable;

(h) Environmental and community impact as appropriate; and

(i) Cost effectiveness where appropriate and not at the sacrifice of fire safety.

8.2.2.6 RESULT OF THE STUDY

Where the approved result of the PBFE indicates or requires addition and/or modification of the design, materials, equipment and/or installation details of Fire Service Installation or building design to comply with the requirements, all such additional works and/or modifications shall be included in the Installations at no additional cost and as approved by the Supervising Officer unless otherwise specified. Where the approved result of PBFE indicate deletion of some parts of fire service systems or fire resistant materials in whole in a zone or in any room, the deletion of such systems or materials shall not be carried out without the prior approval of the Supervising Officer and the cost saving for the deletion of such part of the Installations shall be assessed and the Contract Sum will be adjusted in accordance with the Contract as appropriate.

8.2.2.7 LIFE SAFETY PROTECTION

A holistic approach shall be adopted for the PBFE assessment. The PBFE assessment shall in particular put emphasis on life safety protection and human safety including the safety of the persons with disability, the elderly, the pregnant women and the children complying with current international standards. All possible fire and smoke scenarios shall be covered in the study. Fire may be initiated by various incidents including fire accidents, failure of electrical and mechanical equipment, sabotage, natural disasters, and arsons. They shall all be addressed as appropriate and approved. Additional facilities such as emergency communication system, smoke control dampers and equipment etc. that can improve life safety protection shall be considered and utilised.

Smoke is one of the major hazards in fire accident. The assessment shall elaborate the details of mitigating the risk of smoke for life safety protection of building occupants. The approved measures for mitigating the fire and smoke risk for life safety protection in the PBFE assessment may be above the minimum standards under the statutory requirements. All additional measures for life safety protection approved under the PBFE assessment, study or similar works shall be included in the Installations when PBFE assessment forms part of the scope of the Installations.

SECTION 8.3

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 8.3.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

8.3.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

All the Installations shall be suitably commissioned and tested to the satisfaction and approval of the FSD and the Supervising Officer. Qualified and experienced commissioning engineers approved by the Supervising Officer shall be employed to carry out the testing and commissioning of the Installations.

8.3.1.2 TESTING AND COMMISSIONING ENGINEER

Not less than one competent and experienced testing and commissioning engineer (referred to as the Commissioning Engineer in Charge (CEIC)), responsible for the overall planning, organising, coordinating, supervising and monitoring of the testing and commissioning works and also certifying all results and reports from the testing and commissioning works shall be employed. Information detailing the qualification and experience of the CEIC and other testing and commissioning engineers shall be submitted, after the acceptance of the Tender, for the Supervising Officer's approval.

The CEIC shall be a Registered Professional Engineer in Hong Kong under the Engineers Registration Ordinance (Cap. 409) in fire, building services, mechanical or electrical discipline (or other equivalent approved professional qualifications) with proof of at least 3 years on-site experience in similar type and scale of testing and commissioning works, having at least 3 past project references with the fire service systems tested and commissioned by the CEIC personally, unless otherwise approved by the Supervising Officer for minor installation. The professional status and qualifications of the CEIC shall also be acceptable by FSD and the Supervising Officer. The CEIC shall also possess the relevant qualifications and experience required by the FSD for carrying out the corresponding testing and commissioning works for special systems included as part of the Installations.

The CEIC employed shall not be the professional engineer employed for works on the PBFE studies or the professional independent checking engineer as required in this General Specification for any part of the Installations and the Works.

The CEIC shall also oversee, co-ordinate and monitor the completion of all RFSI and RFSP stated in this General Specification. The CEIC shall be responsible for the submission of detailed testing and commissioning procedures and methodologies, co-ordinating the programme and sequence of testing and commissioning works, arranging for the testing and re-testing of the Installations, supervising the testing and commissioning works, and certifying the results of all the tests. The CEIC shall personally lead and co-ordinate the final mock-up test and the statutory inspections with the FSD.

8.3.1.3 WATER SYSTEM TESTS

Water systems and circuits shall be tested hydraulically to a minimum pressure of 1,000 kPa or 1.5 times the working pressure whichever is the higher applied at the highest point of the system, and held for a period of not less than 15 minutes or the required period as stipulated in the relevant system design standards or FSD Circular Letters whichever is the higher, without leaks appearing. For automatic sprinkler system, the hydraulic test for all installation pipework shall be in accordance with the LPC Rules for Sprinkler Installations and the modifications in FSD Circular Letters.

All pipework shall be thoroughly cleaned and flushed before test. Adequate drainage shall be ascertained nearby to discharge by large hose in order to ensure flooding of low level areas will not occur. Where necessary, chemical cleaning to the pipes shall be provided. After flushing out the pipework, a flow test shall be performed on the hydrant/hose reel system in accordance with the requirements of the Code of Practice for Minimum Fire Service Installations and Equipment.

A water supply test shall be made on the sprinkler system in accordance with the requirements of the LPC Rules for Sprinkler Installations. An alarm test for at least 30 seconds on the water gong shall also be carried out by opening the test valve to ensure that it shall sound continuously after water flow in the system is detected. All controls and air supply system for the pre-action system, recycling pre-action system and dry pipe system shall be tested.

An actual water discharge test shall be performed on the long throw sprinkler system/extended coverage of sprinkler system/drencher/deluge/water spray/water mist system and for other automatic fixed installations using water to test the actual system performance. The T&C procedure of the actual water discharge test shall be submitted by the Contractor and approved by the Supervising Officer prior to the testing and commissioning.

For street hydrant system without pumps, the incoming water supply pressure at a nearby supply point and at such time as agreed with the Supervising Officer shall be tested before the commencement of the installation works to establish the adequacy of the water supply pressure. If the supply pressure is inadequate, remedial measures shall be proposed for the approval by the Supervising Officer. The most appropriate nearby supply point shall be found and selected for the test.

Drainage facilities including but not limited to hoses or drainage channels required to safely remove the test water discharged shall be provided while carrying out these tests in order to ensure that no damage to the building and property will be caused by the test water.

Hydraulic test certificates/reports that shall be signed by the CEIC and by the Supervising Officer or the Supervising Officer's representative who has witnessed the test shall be submitted. The test certificates/reports shall contain the following particulars: -

(a) Date of test;

(b) Apparatus or section under test;

(c) Makers number (if any);

(d) Nature, duration and conditions of test;

(e) Result of test;

(f) Name of Registered Fire Service Installation Contractor's representative (in block letter) in charge of test; and

(g) Name of Employer's representative at witness the test.

8.3.1.4 ELECTRICAL AND ALARM SYSTEM TESTS

Electrical wiring systems shall be tested generally as required by this General Specification, EE_TC and FS_TC. Extra low voltage wiring shall be insulation tested to a D.C. voltage of twice the normal working voltage of the system. Any tests that are liable to cause damage to the delicate components such as those incorporating electronic circuits shall be carried out with the components disconnected.

Smoke detectors shall be checked for correct sensitivity settings by means of manufacturer's test set and for operation by simulated smoke tests. The smoke detectors shall be tested and checked for correct settings after every cleaning and right after the occupation of the building.

Rate-of-rise heat detectors shall be tested by gentle application of a heat source such as hair dryer. Fixed temperature heat detectors shall not be tested other than using simulated tests.

Each sensing element of the multi-sensor detectors shall be checked for correct sensitivity settings by means of manufacturer's test set approved by the Supervising Officer and for operation by simulated tests.

Soak test of at least 1 week shall be carried out for all automatic detectors at the time after the completion of all the Installations including fitting-out works and the whole area is cleaned up, normally at the time of or immediately after users' occupation. Such test shall be deemed to be successful only if during such period no false fire alarm is occurred or necessary action has been taken to rectify the causes of false fire alarm.

Battery capacity shall be tested by discharging through the alarm circuits and being charged via the incorporated charger unit. The specific gravity of the electrolyte shall be tested with a clean hydrometer where applicable. Battery voltage shall be checked.

Power failure load tests shall be arranged to prove proper functioning of the Installations and the associated power supply changeover control during power failure and fire mode.

The input D.C. supply to the alarm supervisory circuitry shall be checked for correct voltage and stability such as to match the signal and alarm triggering devices.

Application of the fire alarm direct link to the FSD or FSD's approved centre shall be initiated to the appropriate agencies within 3 months after commencement of the Contract unless approved by the Supervising Officer, so that the fire alarm direct link will be connected and tested before the fire service inspections. A return copy of the application document shall be submitted to the Supervising Officer for record.

Co-ordination and close monitoring of the completion status of fire alarm direct link and the telephone line shall be required before the fire service inspections by the FSD. The required telephone point for connection of the fire alarm direct link shall be applied and provided at no extra cost as required. If the fire alarm direct link cannot be completed by the date of fire service inspection by the FSD, all necessary manpower and telephone equipment shall be provided at no extra cost, solely for the purpose of a 24-hour/day full attendant service to substitute the fire alarm direct link, to the approval by the FSD and the Supervising Officer, up to the date of the completion of the fire alarm direct link.

The states of "Normal", "Fire" and "Out of order" of fire alarm direct link shall be tested after connection.

8.3.1.5 GASEOUS EXTINGUISHING SYSTEM TESTS

Gaseous extinguishing system and manifolds shall be tested in accordance with this General Specification and FSD Requirements and Circular Letters. Pipework shall be tested for 10 minutes to a minimum of 1.5 times the operating pressure of the system or 10 bars whichever is larger. A 'puff' test(s) to the installed pipework is required.

D.G. Certificate of cylinder shall be submitted before the cylinders are delivered to site. Related documents including charging certificates etc. shall be submitted for record.

An enclosure integrity test complying with NFPA 2001:2018 shall be conducted to the satisfaction of the FSD and the Supervising Officer. A test report shall be duly signed by the Registered Fire Service Installation Contractor and submitted to the FSD. If there is work carried out on the enclosure after completion of the Installations, relevant FSD requirements shall be followed and the enclosure integrity test shall be carried out if required.

On-site full discharge test shall be allowed after completion of the Installations when required by the FSD to confirm the design conditions can be met and to the satisfaction of the FSD and approval by the Supervising Officer. Relevant FSD Requirements and Circular Letters on the requirements of discharge tests shall be followed. The gas cylinders shall be refilled with the design agents after the tests and all the equipment shall be reset after the discharge test.

8.3.1.6 EMERGENCY LIGHTING AND EXIT SIGN TESTS

Each self-contained luminaire, internally illuminated exit sign and central battery system shall be energised from its battery by simulation of a failure of the supply to the normal lighting for a period of the rated duration of the battery. During this period all luminaires and/or signs shall be examined and tested in accordance with BS 5266-1:2016 and BS EN 50172:2004, BS EN 1838:2013, BS EN 60598-1:2015+A1:2018, BS EN 60598-2-22:2014 and the requirements of the FSD and the Buildings Department wherever applicable to ensure that they are functioning correctly and properly to the relevant requirements. All tests required in the FSDCoP, FS_TC and EE_TC shall be carried out and recorded.

For those emergency lighting system with battery and backed up by emergency generators, each emergency generator shall be started up and allowed to energise the emergency lighting system for a continuous period of at least 1 hour. During this period all luminaires and/or signs shall be examined visually to ensure that they are functioning correctly. The start up time of the generator and the illumination level in terms of "lux" and "cd/m^2" etc. shall be recorded and the start up time shall match with FSD's requirements.

For emergency lighting system and exit signs provided with central monitoring, testing and logging system, the system shall be tested in accordance with the manufacturer's specification and to meet the requirements in the FSDCoP, FS_TC and EE_TC.

Where indicated that there are emergency lighting installation and/or exit signs in a building carried out by others and not included in the Installations, the requirements in this General Specification shall be followed. The emergency lighting installation and exit signs shall be included as part of the Installations in the submission to the FSD with the necessary information to be provided by the relevant parties.

8.3.1.7 EMERGENCY GENERATOR TESTS

Full visual inspection, safety check, functional and performance test for the emergency generator installation shall be carried out. The tests shall include measurement on noise confirming compliance with the statutory requirements and/or conditions as required by the EPD. Emergency generators for Fire Service Installation shall be located in separate room unless otherwise agreed by the FSD and approved by the Supervising Officer.

After full test of the Installations in a building or premises have been carried out, with all systems connected to the mains electricity supply, the mains electricity supply shall be switched off to simulate power failure and the emergency generator shall start automatically. For supply system with more than one automatically changeover devices, each automatically changeover device shall be tested individually to verify the automatic start function of emergency generators.

When the emergency generator has gained its capacity and is ready to accept the fire service load, each Fire Service Installation shall be switched on until all Installations are in operating conditions. If an automatic starting programme or device is provided for controlling the starting sequence of the equipment using emergency power supply, the programme or device shall be allowed to operate and test. A "simultaneous running" test shall then take place and shall last for a continuous period of 1 hour. During this

period, the performance of each Fire Service Installation shall be monitored and recorded.

After 1 hour of testing, the emergency generator set shall be examined and all instruments, safety devices etc. shall indicate normal running of the generator.

The fuel tank shall be topped up after the tests.

Where the emergency generator installation is provided under the Installations, in addition to the tests required by the FSD, the emergency generator installation shall be tested and commissioned complying with the requirements in this General Specification and EE_TC.

Where indicated that there is emergency generator installation in the same building carried out by others and not included in the Installations, the requirements in this General Specification shall be followed. The emergency generator installation shall be included as part of the Installations in the submission to the FSD with the necessary information to be provided by the relevant parties.

8.3.1.8 HOT SMOKE TEST

8.3.1.8.1 General

Hot smoke test shall be carried out where specified or required by the FSD. The hot smoke test shall be arranged, coordinated and carried out to meet the purpose for simulating the prototype of a real fire under specific dynamic buoyant flow of smoke and heat intensity in a controlled manner and for assessing the performance of smoke management system, smoke control system and smoke extraction system with the given building geometry. Hot smoke test shall follow FSDCoP, Australian Standard AS 4391-1999 “Smoke Management System – Hot Smoke Test” or approved international standards and practices and to the satisfaction of the FSD and the Supervising Officer. Comments from the FSD and all relevant parties shall be obtained on the detailed requirements and arrangement for the hot smoke test at early stage of the Contract.

All materials, equipment, facilities, fuels, manpower and the like shall be provided for hot smoke test. Co-ordination and arrangement with the Building Contractor to provide all necessary temporary protection to the building finishes, parts, fixtures, furniture and other building works shall be required during the test. The details of such requirements shall be submitted to the Building Contractor in good times before the test and to the Supervising Officer for approval. All necessary protections shall be supplied and installed and all appropriate provisions shall be allowed to other parts of the building not covered by the Building Contractor so as not to cause any damage, and to keep any disturbance to the possible minimum to any occupants or services during hot smoke test. Co-ordination shall be required with the Building Contractor and the FSD and a suitable location and a suitable fire size shall be proposed to the approval by the FSD for carrying out the hot smoke test. A risk assessment of the hot smoke test shall be carried out and adequate protection and provisions

for the risk shall be allowed. A standby firefighting team shall be employed during hot smoke test for the purpose of fire safety. All necessary insurance coverage shall be deemed to allow at no extra cost for the hot smoke test when such or any part of it is not covered under the general insurance policy of the Building Contractor for the Site.

Arrangement and co-ordination with relevant parties shall be required in carrying out the hot smoke test. A qualified professional engineer shall be employed to arrange the details and co-ordinate the hot smoke test. The engineer employed shall be a Registered Professional Engineer in Hong Kong under the Engineers Registration Ordinance (Cap. 409) in fire, building services or mechanical discipline (or other equivalent approved professional qualifications) with proof of experience of at least 3 years in hot smoke test and Fire Service Installation works. The professional status and qualifications of the Registered Professional Engineer shall also be acceptable by FSD and the Supervising Officer.

Where hot smoke test indicates deficiency in smoke management system, smoke control system, smoke extraction system and the like included in the Installations, the deficiency shall be rectified to the satisfaction of the FSD and the Supervising Officer at no additional cost. Where the smoke management system is not included in the Installations, the deficiency shall be reported to the Supervising Officer and improvement measures shall be proposed. A detailed test report shall be submitted at the end of the test that shall include all the recommendations and improvement measures.

8.3.1.8.2 Arrangement

The hot smoke test can be conducted in existing buildings or in new development just prior to final completion. Until the specific performance requirements for the system resemble the conditions under which the system is intended to operate including criteria of differential pressures, air velocities and exhaust rates etc., the hot smoke test shall be arranged for FSD's inspection.

All details on the arrangements / objectives / methods / apparatus / test set up of the required operational and functional tests shall be agreed with the FSD and be approved by the Supervising Officer before such test(s) is commenced. The submission shall include, but not limited to, the following items: -

(a) All smoke extraction ducts located outside the compartment including concrete ducts or shafts and other constructions shall be pressure tested. The pressure test of ductwork shall comply with DW/143: Guide to Good Practice - Ductwork Air Leakage Testing issued by the Building Engineering Services Association (formerly known as the Heating and Ventilating Contractors' Association) and all subsequent amendments. The test records shall be submitted for record.

(b) Submission shall include drawings presented in the format as set out in the FSD Requirements and Circular Letters issued with associated schematic diagrams which fully explain the operation of the Installations including at least information on “normal”, “fire”, and “no power” modes as well as a fully written description thereof.

(c) Proposal shall be submitted and the procedures for equipment set up, test process and safety precautions necessary for carrying out the hot smoke test shall be listed out. The full set up shall be carefully sized for safe application and simulation of the anticipated interior fire conditions to the building envelope including the dimension of equipment, the estimated quantity of fuel required to suit individual building geometry, acceptable designed fire size, fire load, active fire suppression system and fire growth rate etc.

(d) All details, certificates etc. shall be submitted. The accuracy and reliability of all test equipment on item-by-item basis or on a complete system basis shall be recognised.

(e) The installation of smoke extraction systems shall be completed; satisfied the design intent and functioning correctly before the final full test and demonstration taking place with the FSD.

(f) Full set of test and functional operation check records shall be submitted and the attendance of the FSD shall be requested. Accompanying the records, the submission shall be checked and signed by the Registered Professional Engineer stating the Registered Professional Engineer’s satisfaction that the Installations are operating in accordance with the requirements of the FSD.

(g) Full and complete records shall be taken with information on the tests and the results thereof including not less than: -

- Make, serial no., type and owner of all instruments used, with a copy of the calibration certificates;
- Data on actual measurements taken;
- Data on corrected measurement, if any;
- Data on resulting air flows;
- Make, serial no., type and use of every device checked;
- Date and time of test;
- Signature of operator or supervisor and any witness for each test; and

- Signature on acceptance of whole system by the Registered Professional Engineer.

8.3.1.8.3 Hot Smoke Test Preparation

All smoke management systems under normal operating mode shall be capable of handling the smoke volume generated during the test under reasonable time period to the satisfaction of the Supervising Officer and the FSD. Furthermore, the systems in the test compartment shall be operated continuously and shall be under closely monitoring such that no adverse internal environmental conditions caused by air stratification and air velocities are generated.

The format / method / procedures / apparatus of the required operational and functional test for hot smoke test shall be agreed with the FSD before any tests be commenced. The hot smoke test shall be used to validate the effectiveness of the smoke removal system against the following and with reference to the latest version of all corresponding international standards (e.g. AS 4391:1999; NFPA 92:2018 etc.).

(a) The air flow patterns (i.e. scouring or cross flow effect with low level supply and high level extract);

(b) Smoke removal rate; and

(c) Integration between smoke extraction and detection system.

All test apparatus, equipment and materials for the test shall be provided and shall include but not limited to the following. The detail arrangement and any other extra equipment or apparatus used in performing the test shall be agreed with the FSD and all details shall be submitted to the Supervising Officer for approval.

(a) Smoke generators;

(b) Fire chamber;

(c) Stainless steel tray for load cell; water bath & sand base;

(d) Combustion fuel;

(e) Temperature monitoring tree;

(f) Fire fighting equipment;

(g) Safety measures and procedure to be agreed with the FSD.

The approval of the Supervising Officer and the FSD for the criteria used in respective test shall be obtained. Some guidelines for hot smoke test are listed below for reference: -

Test Fire Size : At least 1MW and as agreed by the FSD

Minimum Smoke Clear Height	:	Designed smoke clear height and as agreed by the FSD
Temperature at Plume and Smoke Layer Interface	:	Not less than 10°C below temperature rating of ceiling sprinkler, around 45°C to 50°C maximum.
Combustion Fuel	:	Non-contaminating industrial grade methylated spirit
Smoke Generator	:	Non-toxic oil-based type
Safety Measures	:	Fire suppression equipment and personnel

8.3.1.8.4 Fire Safety during Hot Smoke Test

Flowchart and working procedures for the hot smoke test shall be prepared and trial runs shall be performed before the actual testing is conducted with the FSD. A team of experienced fire fighters/fire watchers to the approval of the Supervising Officer shall be employed to oversee the test procedure and shall be present throughout the test. These personnel shall be equipped with full fire fighting apparel including self-contained breathing apparatus, fire extinguisher and charged fire brigade hose. An auxiliary team of experienced fire fighters fully equipped with fire fighting apparatus shall be employed to the approval by the Supervising Officer as the standby safety officers in order to monitor the impact of smoke movement, cumulative smoke layer and internal temperatures and to take all necessary action to ensure that the test will not generate any adverse effect to the observers and will not cause damage to the property.

The test can be terminated if it is considered that continuation of the test may cause damage to the building or may have a great adverse effect to the people inside the building. The hot smoke test shall be re-arranged at no additional cost until the test is completed to the satisfaction of the Supervising Officer and the FSD. Sufficient number of personnel shall station in appointed position to control the test fire and provide guidance to the observers / attendees. Sufficient training shall be provided to all the contractor's employees and staff present in the test to ensure that they are fully aware that prolonged exposure to tracer smoke may cause irritation and breathing difficulties.

The temperature of hot smoke plume shall be carefully controlled for not causing damage to building structure and other finishing and not triggering the automatic sprinkler system.

8.3.1.9 TESTS ON OTHER FIRE SERVICE INSTALLATIONS

Tests on other Fire Service Installations shall be in accordance with EE_TC, FS_TC, FSDCoP and FSD Requirements and Circular Letters, and the approved detailed testing and commissioning procedures approved by the Supervising Officer. Detailed testing and commissioning procedures for all the Installations shall be proposed and submitted for approval by the Supervising Officer irrespective of whether such details of testing and commissioning are available in EE_TC, FS_TC and FSDCoP or not as pressurisation of staircases system, smoke extraction system etc. The detailed testing and commissioning procedures submitted shall be comprehensive and sufficient to demonstrate the functioning and performance of all the systems and equipment.

8.3.1.10 FINAL MOCK-UP TEST

Before arranging inspections with the FSD, a final mock-up test shall be arranged with the Supervising Officer to demonstrate that all the items required for the fire service inspections by the FSD have been completed and tested to the satisfaction of the Supervising Officer. The final mock-up test shall be a full inspection test same as the fire service or statutory inspection to be conducted for the FSD.

Before the final mock-up test, all the documents required for fire service or statutory inspections shall be available on Site.

Further mock-up tests shall be required if the Installations fail to meet with the satisfaction of the Supervising Officer in the test. Inspection with the FSD shall not be arranged until the satisfactory acceptance of the mock-up tests by the Supervising Officer. Adequate time shall be allowed in the testing and commissioning programme for re-testing of the whole Installations in case of failure. The final mock-up test and the fire service inspections by the FSD as the milestone events in the critical path of the programme to be submitted shall be indicated to the Supervising Officer at the commencement of the Installations.

8.3.1.11 FIRE SERVICES DEPARTMENT INSPECTIONS AND WITNESS OF TESTS

Additional tests, where not specified above, shall also be carried out to meet the requirements of the Codes of Practice for Minimum Fire Service Installations and Equipment to the satisfaction of the FSD and the Supervising Officer. All necessary applications to the FSD shall be made and all necessary inspections shall be attended. The completion of the inspection and acceptance of the Installations by the FSD is one of the considerations for certifying the completion of the Installations.

Prior to FSD's inspections, all the required equipment/materials' lists, test certificates, test records, duly completed and signed forms and checklists to FSD shall be ready and submitted as required under FSD Circular Letter No. 1/2015, No. 1/2020 and other relevant circular letters issued by FSD.

8.3.1.12 TESTING OF FIRE SERVICE INSTALLATIONS AND PROVISIONS INSTALLED BY OTHERS

Where indicated that there are Fire Service Installations, RFSI and RFSP installed in the same building or project by others, co-ordination with relevant parties, inspection, checking, and witnessing of the final functional and performance tests of the Installations, RFSI and RFSP by others on their compliance with FSDCoP, FSD Requirements and Circular Letters, FS_TC, EE_TC, and relevant statutory requirements shall be required. The inspection, checking and witnessing of the final tests on installations by others shall confine to those items and aspects that are required for inspection by the FSD and/or required to satisfy the requirements of the FSD only.

Upon completion of the tests carried out and certified by others and with no non-compliance found, all the Fire Service Installation of a building or project shall be included in the submission to the FSD for inspection. Co-ordination shall be required and the drawings and information shall be obtained from the relevant parties and all Fire Service Installations shall be included in the submission to the FSD for comment and inspection.

8.3.1.13 CLEANING OF DETECTORS

During building construction and before testing and commissioning, suitable temporary cover or protection to the detectors shall be supplied and installed to protect them from dirt and dust after installation. Such temporary protection shall only be removed at the time of the tests and for inspection by the FSD. All the detectors shall be cleaned using manufacturers' recommended methods before the tests as well as before inspection by the FSD.

After inspection by the FSD and completion of all installations including fitting-out works with the whole area cleaned up, normally at the time when the occupants start to move in or immediately after, all the automatic detectors shall be taken down and cleaned "in situ", and test if necessary, using cleaning methods in accordance with the manufacturer's recommendation. Cleaning of detectors is part of the testing and commissioning work and shall be carried out. Co-ordination shall be required with relevant parties on the programme for carrying out such cleaning work so as to ensure that the cleaning work of detectors shall not be in conflict with all other activities such as fitting-out works to be carried out on Site. The cleaning programme shall be to the approval by the Supervising Officer. Cleaning of detectors without notifying the Supervising Officer shall not be accepted and the detectors shall be required to clean again no matter whether the cleaning work has been done so or not. Where the detectors are required to be factory-cleaned, all detectors removed for factory cleaning shall be temporarily replaced with spare units to cover the unprotected areas as resulted. All expenses for the above work shall be at no extra cost.

After cleaning, the soak test for all the automatic detectors as required in this General Specification shall be arranged.

8.3.1.14 TESTING AND COMMISSIONING REPORT AND CERTIFICATE OF COMPLETION

All testing and commissioning results shall be properly recorded during testing and commissioning at the witness of the Supervising Officer or the Supervising Officer's Representative. Immediately after the testing and commissioning, the CEIC shall endorse the data record sheets on Site and obtain the endorsement of the Supervising Officer's representative witnessing the testing and commissioning, irrespective whether the tests are successful or not, and submit a copy of the data record sheets to the Supervising Officer. A full testing and commissioning report shall be forwarded to the Supervising Officer within 14 working days after completion of the testing and commissioning of the relevant installation.

The testing and commissioning report shall comply with the requirements in FS_TC, checklist contained in the FSDCoP, and as required by the FSD and the Supervising Officer. The report shall be checked, verified, and endorsed by the CEIC and certified by another Registered Professional Engineer of the same qualification and requirements as CEIC that specified in this General Specification, except the report for minor installations, as approved by the Supervising Officer, shall be checked, verified and endorsed by the CEIC and certified by a staff of the Fire Service Specialist Contractor having the approved professional/technical qualification and experience.

Different parts of the report shall also be signed and certified by relevant parties such as registered electrical contractors/workers employed for the electrical part of Fire Service Installation and Electrical Installation, registered professional engineers employed for the smoke extraction system, pressurisation of staircases, hot smoke test and emergency generator installation, relevant contractors of RFSI and RFSP, qualified persons for the surveyor certificates, design engineers as appropriate, independent checker where provided etc. The testing and commissioning report shall also be included as an appendix in the operation and maintenance manual.

Together with these, a certificate of completion duly signed by the Registered Fire Service Installation Contractor shall be issued to the Supervising Officer with a copy of the certificate forwarded to the Director of Fire Services in conformity with Regulation 9 of the Fire Service (Installations and Equipment) Regulations.

SUB-SECTION 8.3.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

8.3.2.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during Maintenance Period shall also comply with the specific requirements in this Sub-section.

Operation, servicing and maintenance of the Installations, if specified, shall also refer to the equipment manufacturer's recommendations and specifications.

8.3.2.2 TRAINING REQUIREMENTS

Adequate training shall be provided to the Employer's staff to operate the fire alarm control system and to monitor and to reset/mute alarms in the Fire Service Installation at completion of the Installations and before the commencement of the Maintenance Period. Adequate training to the Employer's staff on the operation of the Installations during fire alarm, fault alarm, warning alarm and other emergency situations as appropriate shall be provided.

8.3.2.3 MAINTENANCE SERVICES DURING MAINTENANCE PERIOD

Maintenance services for the complete fire services installation during the Maintenance Period shall be provided. The scope of maintenance services shall include the following: -

(a) Routine quarterly inspections, tests and maintenance services, and routine inspections, tests and maintenance service as necessary;

(b) Emergency inspections, tests and repairs;

(c) Final inspections, tests and maintenance services, and annual inspections, tests and maintenance services; and

(d) All the services and requirements specified in this General Specification and the Particular Specification.

All inspections, tests, maintenance services and repairs shall be carried out generally in accordance with the manufacturers' recommendations/instructions and to the satisfaction of the Supervising Officer. The maintenance services are to maintain the Installations in good and functional working conditions. The maintenance services shall include preventive maintenance services to all installed systems and all spare parts and spares required in the Maintenance Period. Additional spares and spare parts when ordered by the Supervising Officer are for the use after the Maintenance Period only.

Competent and experienced engineers and technicians equipped with appropriate testing instruments, tools, equipment etc. shall be dispatched to inspect, service, test, adjust, repair and maintain the Installations in satisfactory operating conditions. The scope shall

allow for carrying out such inspection, service, testing, adjustment, repair and maintenance at a time outside normal office hours including general holidays where and when required. A list with at least two names, telephone numbers and addresses of the servicing personnel of English-speaking and Cantonese-speaking representatives shall be provided.

Particularly in the case of complex Fire Service Installation, at least two senior servicemen being thoroughly familiarised with all aspects of such installation to be responsible for emergency repair, inspection, maintenance and testing of the Installations shall be provided.

All fire extinguishing media and other materials expended or used during the tests including diesel or petrol fuel shall be replenished under the Works. Connection and subscription for the fire alarm direct link shall be included under the Works.

The gas cylinders for the gaseous extinguishing systems shall be refilled upon discharge and put the system into normal operation within a time as short as possible but in no case shall be longer than 7 working days. Unless otherwise there are evidences that the discharge of gases in the gaseous extinguishing systems is due to a fire, smoke that generated a fire alarm, or the default operation/act of the occupiers of the building, the cost for refilling the gas cylinders of the gaseous extinguishing systems after discharge during the Maintenance Period including after false fire alarms shall be covered under the Works.

All materials and equipment reaching expiry date of service life shall be replaced.

Repairs and replacement necessary to maintain the Installations in a safe, reliable and operative condition at all times shall be included under the Works. Manufacturer's original replacement parts shall be used.

Minimum interruption to the functioning of the Installations during each inspection, test, adjustment, repair or maintenance service shall be maintained. FSD shall be informed on the commencement and completion of each job whenever the disconnection, reconnection or testing of the fire alarm direct link is involved.

Any component taken down for servicing shall be repaired, tested and then reinstated within 2 hours. Should the repair work cannot be completed within 2 hours, the defective parts shall be replaced by utilising manufacturer's original replacement spare unit(s).

In case the manufacturer's original replacement spare unit is not available for immediate replacement, the defective parts of the system shall be isolated immediately to ensure that the proper functioning of the other parts of the installed fire service system. Remedial proposal detailing the proposed defects rectification method and time needed shall be submitted to the Supervising Officer for approval within 24 hours of the fault identification. Upon approval by the Supervising Officer, the remedial work shall be carried out following the agreed programme and method.

Where the repair and maintenance works require temporary suspension of parts of the Installations inside or outside the Site such as in landlord's area, prior consent from the landlord and relevant parties shall be obtained. FSD shall be informed and suitable notice in a prominent position on the control panel shall be placed so that the client/occupiers are aware of the situation and the FSD will not be called out unnecessarily. This is,

however, not to be construed as an authority to leave any part inoperative for an undue length of time. All necessary temporary facilities, fire protection, and fire safety precautionary measures in all affected areas shall be arranged to the satisfaction of the Supervising Officer, landlord/client/occupiers and the FSD during the work period and shall advise the client/occupiers to stay alert and to make corresponding management action.

All the inspections, attendance, operation, maintenance and testing of the Installations shall follow all the relevant FSD Requirements, and in addition the procedures and measures stipulated in FSDCoP for cases that involve the shutting down or isolation of installations, to the acceptance of the FSD and the Supervising Officer.

The sprinkler subsidiary stop valves management system in accordance with the requirements of FSD Circular Letter No. 4/2010 on the inspections, tests, operation, maintenance services and repair works of sprinkler system shall be adopted.

Fire retardant paint/spray shall be repainted or re-sprayed at the end of Maintenance Period.

Final inspection, testing and maintenance of the Installations at the end of the Maintenance Period shall be carried out. Duly signed FSD Form FS251, Certificate of Fire Service Installation and Equipment after the final inspection, testing and maintenance of all the installed systems and equipment shall be submitted to FSD at the end of the Maintenance Period. The copies of FS251 and proof of FS251's submission record to FSD shall also be submitted to the Supervising Officer and the relevant maintenance agents.

Where the Maintenance Period is longer than one year, the annual inspection, testing, maintenance and certification of the Installations within the Maintenance Period complying with the requirements of the statutory authorities shall be carried out.

Where there are Fire Service Installations carried out by others and not included in the Installations, the Works shall also include the coordination with relevant parties and collection of information on the final/annual inspection/testing on Fire Service Installations by others to confirm their compliance with the requirements of the FSD. Any installations/maintenance works found not complying with the requirements of the FSD shall be reported to the Supervising Officer.

Quarterly inspections, tests and maintenance services covering all the installed systems and equipment shall be arranged. Prior to carry out the quarterly services, a schedule showing the scope of maintenance service shall be submitted to the Supervising Officer for agreement and approval.

Clear and legible record of all fault call-outs shall be kept. The record shall be submitted within 3 working days upon request by the Supervising Officer for inspection.

8.3.2.4 ROUTINE QUARTERLY INSPECTION, TESTING AND MAINTENANCE OF FIRE DETECTION AND ALARM SYSTEM

8.3.2.4.1 The Installations shall be visited at least once every 3 months to carry out all necessary tests, repairs, maintenance and adjustments as relevant. For environmentally sensitive devices, e.g. smoke and heat detectors, air filters at the end of the probes for duct type detectors, electronic sensors, relay contacts, plug and socket contacts, printed circuit boards, edge connectors etc. that required to be inspected, cleaned, adjusted, tested and calibrated more frequently, corresponding visits, inspections, cleaning, adjustment, testing and calibration in shorter time intervals shall be arranged, to the satisfaction of the Supervising Officer. For this purpose, a schedule of inspection, cleaning, adjustment, testing, and calibration of all installed devices shall be submitted, in accordance with the recommendations or instructions of manufacturers/ suppliers, the actual site conditions, and performance requirement within the Maintenance Period to the Supervising Officer for approval.

8.3.2.4.2 For those panels with built-in maintenance system or tool kits as specified in this General Specification, system scanning and checking shall be carried out at least once every 3 months. All problematic devices shall be repaired or replaced immediately. Scanning report shall be submitted together with the routine quarterly report to the Supervising Officer.

8.3.2.4.3 During each visit, a test sequence shall be carried out in accordance with the manufacturer's instructions. The test sequence shall prove that: -

(a) the condition of the wiring, controls and indicating equipment of all zone circuits are in good working order;

(b) the alarm condition on each zone will activate the common alarm circuits. If manual call points are fitted the alarm conditions shall also be initiated by the operation of one such call point in each zone. A different manual call point shall be used on each occasion and a record shall be kept;

(c) activating the common alarm circuits will result in the operation of the alarm bells and the satisfactory transmission of the alarm signal to the FSD or FSD's approved centre if equipped with a fire alarm direct line connection; and

(d) activating the common alarm circuits will result in the starting/stopping of the ventilating fans and/or fire booster pumps as desired and result in the initiation of any lift operation, if control circuits for such operation are provided in the system.

The operation of alarm bells and the transmission of the alarm signal may be suppressed during tests (a) and (b). Test (c) and (d) shall prove that all system alarms and relevant controls are operating correctly.

In the course of the test sequence, the correct operation of all indicators including fault warnings and all alarm bells shall be noted and checked.

All indicating lamps shall be checked and if found defective shall be replaced at no extra cost.

8.3.2.4.4 At least 25% of the detectors shall be selected for tests in accordance with the approved schedule in each quarter, in such a way that all the installed detectors shall be tested at least once in each year. Smoke detectors shall be tested with simulated smoke, and rate-of-rise heat detectors with an artificial heat source, e.g. hair dryer, smoke generator or others.

8.3.2.4.5 Batteries and chargers shall be examined and tested to ensure they are in good and proper serviceable condition. Battery terminals and connectors shall be tightened and the former shall be cleaned and protected with petroleum jelly. Electrolyte shall be topped up as necessary and its specific gravity shall be measured and corrected to the appropriate value if required. Batteries shall also be discharged and recharged to ensure compliance with the specified requirements. Battery service life shall be checked and batteries shall be replaced as necessary. All used batteries shall be sent for disposal to approved collectors or agencies in Hong Kong for recycling purpose.

8.3.2.4.6 When false fire alarm from the fire detection system is reported or found in the Maintenance Period, all detectors in the Installations irrespective whether such detectors have caused the alarm shall be taken down, cleaned "in situ" and tested. All detectors that cannot pass the test or cannot be cleaned shall be replaced with new one at no extra cost. Where the detectors are required to be factory-cleaned, all detectors removed for factory cleaning shall be replaced with spare units to cover the unprotected areas as resulted. All expenses for the above work shall be at no extra cost. The setting of the detector and control panel shall be checked and re-adjusted as necessary. The causes of the alarm shall also be checked and identified and a full report shall be submitted to the Supervising Officer. All faults shall be rectified immediately to the satisfaction of the Supervising Officer and the FSD. All alarms reported shall be recorded in the log book and in the routine quarterly report submitted to the Supervising Officer. The report shall in particular highlight the investigation, recommendation and the rectification action carried out for the following circumstances: -

(a) If the rate of false fire alarms in the Maintenance Period or since the time of last inspection has exceeded the rate of one false fire alarm per 100 alarm initiating devices or exceed the rate of one false fire alarm per 80 detectors per annum;

(b) If more than three false fire alarms have occurred within the previous 6 months;

(c) If two or more false fire alarms have arisen from any single detector or manual call point or sprinkler flow switch since the time of last inspection; and

(d) If any persistent cause of false fire alarm is identified.

If the sources or reasons for false fire alarms can be identified or established, measures shall be implemented and maintenance work such as cleaning, adjustment, etc. shall be carried out to the acceptance and satisfaction of the Supervising Officer to eliminate similar causes of false fire alarms in all other detectors/initiating devices in the building including those not having any false fire alarms reported. Measures shall include but not limited to relocation of detectors, change of appropriate types of detectors, re-routing of cables and conduit works, sealing up conduits to avoid water ingress, installation of proprietary heaters for beam detectors, etc. to the approval of the Supervising Officer.

8.3.2.5 FINAL/ANNUAL INSPECTION, TESTING AND MAINTENANCE OF FIRE DETECTION AND ALARM SYSTEM

At the final/annual inspection and in addition to the quarterly inspection and testing, all smoke detectors shall be taken down, cleaned 'in-situ' and tested in accordance with the manufacturer's instructions for correct operation and functioning with the manufacturer's test set before reinstate them for service. Any defective detectors shall be replaced or 'factory cleaned' in accordance with the manufacturer's recommendation before reinstated for service. Any smoke detectors subjected to dust and dirt accumulation shall be despatched for factory cleaning or as instructed by the Supervising Officer. All detectors removed for factory cleaning shall be replaced with spare units or alternatively a separate surveillance system shall be supplied and installed to cover the unprotected areas as resulted. All expenses for the above work shall be at no extra cost. All equipment reaching expiry date of service life shall be replaced.

8.3.2.6 ROUTINE QUARTERLY INSPECTION, TESTING AND MAINTENANCE OF GASEOUS EXTINGUISHING SYSTEMS

Each installation shall be visited at least once every 3 months and carry out the following tests including necessary repairs and adjustments: -

(a) All electrical components, including cables, detectors, relays, alarm panel and bells, batteries etc. shall be tested and examined as specified in this General Specification;

(b) All automatic/manual release mechanism shall be checked and serviced in accordance with the manufacturer's instructions to ensure their proper operation. All such mechanisms shall be properly lubricated and kept free from corrosion;

(c) All pipes and fittings shall be checked for leakage and corrosion and repaired or repainted as necessary. All valves shall be checked for freedom of operation and nozzles shall be cleaned by removing the dust, dirt and other obstacles deposited on them;

(d) All cylinders containing the chemical extinguishing agents shall be checked to ensure that the contents are up to the specified standard and are so marked with paint on the outside of cylinders. Any cylinders shall be recharged to the specified content level if carbon dioxide cylinders are

found to exhibit a 10% loss and other gas cylinders a 5% loss of content by weight. Where the discharge is due to a genuine fire or the default operation/act of the occupiers, recharging of cylinders will be carried out at an additional cost with prior notice to and approved by the Supervising Officer. However, where the discharge is due to a faulty detector or other equipment of the system causing false fire alarm, the system shall be recharged at no extra cost;

(e) All warning notices and operating instructions shall be checked to ensure that they are fixed in the proper position, are in a readable condition and are both in English and Chinese unless otherwise confirmed in writing by the Supervising Officer;

(f) All time delay and lock-off devices shall be inspected and tested to ensure that they are in correct working condition;

(g) The coincident unit shall be checked for proper function by actuating detectors of two separate zones; and

(h) All ancillary functions of the system such as shutting off air-conditioning/ventilation plant, lowering fire shutters/dampers or curtains etc. shall be checked for proper operation.

(i) The enclosure of the protected room shall be inspected and monitored for changes in barrier integrity and enclosure dimensions. Where changes could result in the inability of the enclosure to maintain the extinguishing agent concentration, the conditions shall be corrected immediately. Unless the changes of the enclosure are due to the real fire incident or the operation of the occupiers, all the measures and tests to restore the protected room integrity shall be included in the Works within Maintenance Period.

8.3.2.7 FINAL/ANNUAL INSPECTION, TESTING AND MAINTENANCE OF GASEOUS EXTINGUISHING SYSTEMS

The same amount of work as the quarterly inspection, testing and maintenance services shall be carried out. All equipment reaching expiry date of service life or going to reach such expiry date within 3 months after the Maintenance Period shall be replaced.

8.3.2.8 ROUTINE MONTHLY/QUARTERLY INSPECTION, TESTING AND MAINTENANCE OF FIXED FIRE PROTECTION SYSTEMS USING WATER AS AN EXTINGUISHING AGENT

The Installations shall be visited at least once every 3 months, unless otherwise specified, and carry out the following inspections, tests, adjustments and repairs: -

(a) All electrical components including cables, alarm panel and bells, batteries, control relays, starters etc. shall be inspected and tested as specified in this General Specification;

(b) All pipes and fittings shall be checked not less than ONCE IN A MONTH for leakage and corrosion and repaired or repainted as necessary. All valves shall also be checked not less than once in a month for freedom of operation, and shall make sure that all control valves are kept locked in the 'open' position by the SVMS system as applicable according to FSD Circular Letter No. 6/2016 and all the subsequent amendments, and this General Specification, inlet valves correctly bonded to earth, water supplies maintained in service, etc.;

(c) Inspection shall be carried out to ensure that all sprinkler heads are maintained in good working condition, clean and free from corrosion and are not covered with distemper, paint, dust, fluff etc. Any sprinkler heads found defective and suspected of being defective shall be replaced;

(d) Water and air pressure gauges shall be inspected to ensure that correct pressures are maintained. Gauges shall be calibrated at regular intervals. Water levels and air pressure in pressure tanks shall be checked to ensure that they are maintained in proper conditions;

(e) An alarm test shall be made on the sprinkler system by opening the test valve and the time taken to sound the alarm gong noted. The alarm shall be allowed to ring for about 30 seconds in order to ascertain that it is not ringing intermittently. Any repairs or adjustments that may prove to be necessary after the test shall be carried out with no delay;

(f) All metallic elevated, priming and pressure tanks shall be inspected for sediments, rust and corrosion. Sediments and rust shall be removed and the corroded parts shall be repainted as necessary;

(g) The valves, the bearing and other relevant mechanical parts of the pumps, motors and engines shall be greased as recommended by the manufacturers. An automatic pump starting test and a test run of at least 10 minutes shall be performed on each pump to ensure the pumping systems are in satisfactory operating conditions. Engine driven pumps shall be capable of starting in 30 second or less. All manual and automatic starting and control mechanism, components, switches etc. shall be checked for proper functioning;

(h) All sprinkler flow switches shall be checked for correct functioning;

(i) All water tanks shall be checked for filling with water; and

(j) All water check meters for the Installations shall be checked and recorded to see any abnormal large consumption of water in the period.

All parts such as bearings, valve seats, packing etc. due to wear and tear shall be replaced as required. In addition the engines, the motors and the electrical power supply to the pumps from its electrical isolator or switch, including changeover switches, starters, fixed and flexible conduits between isolator/switch and cables therein shall be maintained in good working order. All pump control pressure and level switches shall also be maintained in good order and the circuitry as previously indicated for electrical systems shall be inspected. All drain valves shall be checked to be in the close position.

8.3.2.9 FINAL/ANNUAL INSPECTION, TESTING AND MAINTENANCE OF FIXED FIRE PROTECTION SYSTEMS USING WATER AS AN EXTINGUISHING AGENT

At the final/annual inspection and in addition to the quarterly inspection and testing, the following inspections, tests, adjustments and repairs shall be carried out as required: -

(a) Inspection and testing, by means of wet drill on the hydrant and hose reel installation, shall be carried out in accordance with the FSD requirements. The wet drill shall consist of coupling lengths of hose to two or more hydrants and opening the valve to produce water at the nozzles. Great care and precise liaison with all relevant parties concerned shall be exercised to guard against flooding and seepage of water. The full cost of any damage due to flooding and seepage of water shall be included.

Hydrants not used at the wet drill shall each be fitted with a blank cap over the outlet, and checked by opening and closing the valve and spindle to ensure that they are free in operation.

Testing of the pressure and flow of the water supply on the hydrant and hose reel installation shall be done for the outlets at the highest point or at the lowest static pressure location. The opening of two or more outlets and directing the water from the roof tanks is sufficient to indicate the state of the water supply, but if there is any doubt as to the flow or pressure of the water, a more accurate test with suitable gauges shall be carried out.

After the test or wet drills, care shall be taken to see that the hose is thoroughly drained, dried and aired before being replaced in position.

(b) Each length of hose shall be uncoiled, laid out straight and examined, with particular care being taken to see that the washers in the female couplings are intact and in good condition and that the hose is not damp or attacked by mildew.

(c) Each water supply to the sprinkler installation shall be tested individually. Before making the test on any one water supply, it is necessary to shut off all the other supplies. The test shall be made with the drain and test valves fully open in accordance with the requirements of the LPC Rules for Sprinkler Installations.

(d) After shutting off all water supplies and draining the installation via the flow test/drain valve, the sprinkler control valve front cover shall be removed to inspect and maintain its internal components. The work shall include checking the freedom of movement of the main clapper assembly and cleaning as required, greasing and replacing worn seals and gaskets, replacing all valve glands as necessary and replacing any worn seats in small bore valves etc. The sprinkler control valve front cover shall then be replaced and the installation shall be re-commissioned.

(e) The concrete water tanks constructed by the builder shall be inspected for rusting and sediments. The Supervising Officer shall be informed in writing if any cleaning and rectification on the tanks are necessary.

8.3.2.10 ROUTINE WEEKLY /MONTHLY INSPECTION, TESTING AND MAINTENANCE OF EMERGENCY LIGHTING AND EXIT SIGNS

Each installation shall be visited at least once every month (or once every week if weekly voltage test on emergency luminaire is involved) and the following tests shall be carried out including necessary repairs and adjustments: -

(a) Each self-contained luminaire and internally illuminated exit sign shall be energised from its battery by simulation of a failure of the supply to the normal lighting for a period of at least 1 minute at 10-hour discharge rate and sufficient to ensure that each lamp is illuminated. The period of simulated failure shall not exceed one quarter of the rated duration of the fully charged battery. During this period all luminaires and/or signs shall be examined and tested in accordance with BS 5266-1:2016 and BS EN 50172:2004 (or tested by the Central Monitoring, Testing and Logging System) to ensure that they are functioning correctly and giving out the designed illumination level in "lux" and "cd/m^2". At the end of this test period the supply to the normal lighting shall be restored and any indicator lamp or device checked to ensure that it is showing that the normal supply has been restored.

(b) Each central battery system shall be energised from its battery by simulation of a failure of the supply to the normal lighting for a period of at least 1 minute at 10-hour discharge rate and sufficiently to ensure that each lamp is illuminated. The period of simulated failure shall not exceed one quarter of the rated duration of the fully charged battery. During this period all luminaires and/or signs shall be examined and tested in accordance with BS 5266-1:2016 and BS EN 50172:2004 (or tested by the Central Monitoring, Testing and Logging System) to ensure that they are functioning correctly. All tests required in the Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment shall be carried out and recorded. At the end of this test period the supply to the normal lighting shall be restored and any indicator lamp or device checked to ensure that it is showing that the normal supply has been restored.

(c) For emergency lighting system backed up by emergency generators, the emergency lighting shall be tested during on-load test of the emergency generator. After the emergency generator was started up, it shall be allowed to energise the emergency lighting system for a continuous period of at least 1 minute and sufficient to ensure that each lamp is illuminated. During this period all luminaires and/or signs shall be examined visually (or tested by the Central Monitoring, Testing and Logging System) to ensure that they are functioning correctly and giving out the designed illumination level in 'lux' and 'cd/$m^{2'}$. At the end of this test period the normal supply to the lighting shall be restored and any indicator lamp or device checked to ensure that it is showing that the normal supply has been restored.

Where central battery system is supplied and installed, the Installations shall be visited at least once every week in addition and weekly voltage and hydrometer test shall be

carried out as required in the Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment.

8.3.2.11 FINAL /ANNUAL INSPECTION, TESTING AND MAINTENANCE OF EMERGENCY LIGHTING AND EXIT SIGNS

The following tests shall be carried out annually and at the end of the Maintenance Period including necessary repairs and adjustments: -

(a) Each self-contained luminaire and internally illuminated exit sign shall be energised from its battery by simulation of a failure of the normal supply to the lighting for a continuous period of at least half of the rated duration of the fully charged battery. During this period all luminaires and/or signs shall be examined and tested in accordance with BS 5266-1:2016 and BS EN 50172:2004 to ensure that they are functioning correctly and giving out the designed illumination level in 'lux' and 'cd/m^2'. At the end of this test period the normal supply to the lighting shall be restored and any indicator lamp or device checked to ensure that it is showing that the normal supply has been restored.

(b) Each central battery system shall be energised from its battery by simulation of a failure of the normal supply to the lighting for a continuous period of at least half of the rated duration of the fully charged battery. During this period all luminaires and/or signs shall be examined and tested in accordance with BS 5266-1:2016 and BS EN 50172:2004 to ensure that they are functioning correctly. All tests required in the Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment shall be carried out and recorded. At the end of this test period the normal supply to the lighting shall be restored and any indicator lamp or device checked to ensure that it is showing that the normal supply has been restored.

(c) For those emergency lighting systems backed up by emergency generators, the emergency lighting shall be tested during on-load test of the emergency generator. After the emergency generator was started up, it shall be allowed to energise the emergency lighting system for a continuous period of at least 10 minutes. During this period all luminaires and/or signs shall be examined visually to ensure that they are functioning correctly. The test shall be repeated for 5 minutes with the emergency generator shut off and the lighting supplied by the battery system only. At the end of the test period the normal supply to the lighting shall be restored and any indicator lamp or device checked to ensure that it is showing that the normal supply has been restored. The fuel tanks shall be filled up and the oil and the coolant levels topped up as necessary.

Batteries and chargers shall be examined and tested to ensure they are in good and proper serviceable condition. Battery terminals and connectors shall be tightened and the former shall be cleaned and protected with petroleum jelly. Electrolyte shall be topped up as necessary and its specific gravity shall be measured and corrected to the appropriate value if required. Battery service life shall be checked and batteries shall be replaced as

necessary. All used batteries shall be sent for disposal to approved collector or agency in Hong Kong for recycling purpose.

Where the emergency lighting installation and/or exit signs are carried out by others and not included in the Installations, co-ordination with relevant parties shall be required and the information on the final/annual inspection/testing on emergency lighting installation/exit signs to confirm their compliance with the requirements of the FSD shall be collected. Any installations/maintenance works found not complying with the requirements of the FSD shall be reported to the Supervising Officer.

All equipment reaching expiry date of service life shall be replaced.

8.3.2.12 ROUTINE MONTHLY INSPECTION, TESTING AND MAINTENANCE OF EMERGENCY GENERATORS

Each installation shall be visited at least once every month and carry out the following tests including necessary repairs and adjustments: -

The emergency generator shall be run once per month under design load conditions for a period of not less than 30 minutes. During this running period all operating conditions shall be checked. Following this running period functional tests shall be carried out on all automatic and manual starting devices and safety controls. All the diesel fuel used in all the tests shall be included. After each test, all the fuel storage tanks and daily fuel tanks shall be re-filled to its normal level to comply with the FSD's requirements.

All the details of operation: faults and corrective actions taken, routine servicing, maintenance and periodic operation, inspection, testing, repairs, results, actions etc.; including dates, time of calls, time of attending, meter readings, cause of faults, time to remove fault, workers/supervisors names and signatures, location and identification of faults, description of equipment serviced etc. shall be recorded in the log book in this General Specification.

8.3.2.13 FINAL/ANNUAL INSPECTION, TESTING AND MAINTENANCE OF EMERGENCY GENERATORS

The emergency generator shall be run under design load conditions for a period of at least 1 hour. During this running period all operating conditions shall be checked. Following this running period functional tests shall be carried out on all automatic and manual starting devices and safety controls.

Where the emergency generator installation is carried out by others and not included in the Installations, co-ordination with relevant parties shall be required and the information on the final/annual inspection/testing on the emergency generator to confirm their compliance with the requirements of the FSD shall be collected. Duly signed FSD Form FS251, Certificate of Fire Service Installation and Equipment shall be checked and submitted to FSD. Any installations found not complying with the requirements of the FSD shall be reported to the Supervising Officer.

8.3.2.14 QUARTERLY AND FINAL/ANNUAL INSPECTION AND MAINTENANCE OF PORTABLE FIRE EXTINGUISHERS

Portable fire extinguishers and appliances supplied and installed shall be inspected and checked quarterly to ensure that they are in good working condition. Any extinguisher and appliance found not in proper working condition shall be reconditioned and/or recharged/replaced to the required standard. All equipment reaching expiry date of service life shall be replaced. At the final inspection and maintenance, all portable fire extinguishers and appliances going to reach the expiry date within 3 months after the Maintenance Period shall be replaced.

8.3.2.15 INSPECTION, TESTING AND MAINTENANCE OF OTHER FIRE SERVICE INSTALLATIONS

Routine quarterly and final/annual inspection, testing and maintenance of all other Fire Service Installation shall be carried out. The inspection, testing and maintenance shall follow the statutory requirements, the recommendation of the manufacturers, good engineering practice in the fire service trade, the relevant standards and the Particular Specification to maintain the Fire Service Installation in an operable and functional status.

8.3.2.16 CERTIFICATE OF MAINTENANCE

After completion of the final inspection, testing and maintenance service to the Installations at the end of the Maintenance Period to the satisfaction of the Supervising Officer, a certificate of maintenance duly signed by the Registered Fire Service Installation Contractor shall be issued to the Supervising Officer within 14 working days, with a copy forwarded to the Director of Fire Services. Where the Maintenance Period is longer than one year, a certificate of maintenance after the completion of each annual inspection, testing and maintenance shall be submitted to the satisfaction of the Supervising Officer with a copy forwarded to the Director of Fire Services in compliance with the requirements of the FSD.

8.3.2.17 ADDITIONAL REQUIREMENTS FOR ADDRESSABLE SYSTEM

8.3.2.17.1 Where addressable fire alarm, detection, control or similar system is supplied and installed, the Operation and Maintenance Manuals and the as-built drawings submitted shall include, but not limited to, the following details, in addition to all requirements as mentioned in Part 1 of this General Specification: -

(a) As-built interconnecting field wiring diagrams, or wiring lists, of the complete field installed system with complete, properly identified, ordering number of each device and system component;

(b) Operator manual with step-by-step procedures. The manual shall be indexed, and shall have a separate tabled section for each operator function;

(c) Operator's /Programmer's Manual with complete description of all programming functions, including sample written programs, related to operation;

(d) Layout plan showing the fire control panel, field device locations and field device point list;

(e) Schedule of set points of the system; and

(f) Complete description of the sequence of operation of the fire alarm control system with flow charts and decision trees.

8.3.2.17.2 All the keys and passwords required for accessing all parts of the addressable system without restriction shall be provided.

8.3.2.17.3 The User Manuals submitted shall include, but not limited to, the following details, in addition to all requirements as mentioned above: -

(a) Operator manual with step-by-step procedures. The manual shall be indexed, and shall have a separate tabled section for each operator function;

(b) Layout plan showing the fire control panel, field device locations and field device point list;

(c) Schedule of set points of the system; and

(d) Complete description of the sequence of operation of the fire alarm control system with flow charts and decision trees.

PART 9 – BROADCAST RECEPTION INSTALLATION

SECTION 9.1

INSTALLATION METHODOLOGY

SUB-SECTION 9.1.1

BROADCAST RECEPTION SYSTEM DESIGN

9.1.1.1 GENERAL

The design of broadcast reception installation shall be included under this Works. The system shall be designed with an aim to convey the best receivable signal at a particular site to individual users sharing the same system. The Broadcast Reception system performance shall comply with BS EN 60728-1:2014 and BS EN 60728-10:2014.

9.1.1.2 ONLY ONE BROADCAST RECEPTION SYSTEM PER SITE

Only one system shall be installed at a site where a number of blocks are constructed.

The system shall not radiate interference exceeding the radiation limits as specified in HKCA 1102:2001.

9.1.1.3 SELECTING THE GAIN OF TV AND FM AERIALS

To maximise signal to noise ratio and to achieve good directivity, the gain of TV and FM aerials shall be chosen to be as high as possible and in compliance with other requirements when specified in the Particular Specification for the Installations for Broadcast Reception system.

9.1.1.4 SEPARATE DOWN LEADS FOR THE TV AND FM SIGNALS

The TV and FM signals shall be conveyed through separate down leads to the respective amplifiers in the headend circuit for amplification.

9.1.1.5 SELECTION OF AMPLIFIERS

For systems design, which involves the use of amplifiers in the headend to drive the TV channel amplifiers and/or FM channel amplifier, the first amplifiers to be used for the TV and/or FM signal path shall be a TV bandpass preamplifier and/or a FM band preamplifier respectively. Alternatively, a TV bandpass filter shall be used for the TV signal path and shall be connected to the input of the first wideband amplifier, notwithstanding that it is a preamplifier or a distribution amplifier. Such design practice shall ensure that the amplifiers of the system shall not be overloaded by strong out-of-band signals.

9.1.1.6 LOSS ALLOWANCE

A 3 dB attenuation factor shall be included in the calculation of system level to account for practical installation losses such as cable joints.

9.1.1.7 ENCLOSURE OF HEADEND CIRCUIT COMPONENTS

The headend circuit components shall be enclosed in a well-ventilated enclosure fitted with lock. The equipment shall be adequately screened from radio interference caused by lift equipment, starters, etc. The case shall be properly secured against the wall and have sufficient space for cable routing and bending.

9.1.1.8 COMPATIBILITY FOR THE DISTRIBUTION OF DIGITAL TELEVISION SIGNALS

The system shall include all equipment and accessories necessary for the successful connection to the signal adaptors/set top boxes/digital terrestrial television baseline receivers for the distribution of digital television signals.

As specified in HKCA 1104:2011, the distribution of digital television signals shall not affect or interference with other services, such as telecommunications and security services. The wanted and unwanted signal levels and the spurious emissions outside the 8 MHz channel bandwidth shall be controlled such that other signals and services will not be affected.

SUB-SECTION 9.1.2

SIGNAL LEVEL AT FM/TV/DATA OUTLET

9.1.2.1 SIGNAL LEVELS

The root mean square (r.m.s.) voltage of each carrier at the peak of the modulation envelope when measured at the user's outlet across a non-inductive 75 ohm resistor (or referred to 75 ohm) shall be: -

Minimum Level	:	50 dBμV for digital TV signal (470 MHz to 862 MHz)
	:	40 dBμV for FM signal (mono)
	:	54 dBμV for FM signal (stereo)
Maximum Level	:	74 dBμV for digital TV signal (470 MHz to 862 MHz)
	:	74 dBμV for FM signal (mono)
	:	74 dBμV for FM signal (stereo)

9.1.2.2 PERMISSIBLE DIFFERENT SIGNAL LEVELS IN AN OUTLET

For digital TV signals, the difference in carrier levels shall not exceed the followings: -

Frequency range	Interval	Maximum level difference (dB)
300 MHz to 1 GHz	Entire range	15
	100 MHz range	9
	Adjacent channel	3

The maximum level difference at any system outlet between any two distributed digital terrestrial television broadcast channels shall be 3 dB.

If FM sound signals are present at the outlet intended for the TV signals, the level of any FM signal shall be at least 3 dB lower than the lowest TV signal at the outlet.

The difference in level between the weakest and the strongest FM signals at the same outlet shall not exceed the followings: -

Entire band of 87 – 108 MHz	< 8 dB
Adjacent channel	< 6 dB

9.1.2.3 CARRIER TO NOISE RATIO

At any outlet, the level of any unwanted signal generated in the system in any channel shall be: -

The carrier to noise ratio to be not less than	:	34 dB for digital TV signal
	:	25 dB for FM signal (mono)
	:	45 dB for FM signal (stereo)

For distributing digital television signals, the bit error rate (BER) of the signal after error correction shall be better than 3 x 10-6 and the modulation error ratio (MER) shall be not less than 30 dB.

9.1.2.4 MUTUAL ISOLATION BETWEEN OUTLETS

To minimise the local oscillator energy from one receiver causing interference to other receivers on the same cable system, the mutual isolation between outlets connected separately to a spur feeder shall not be less than 33 dB for digital TV signal and 42 dB for FM signal.

9.1.2.5 SYSTEM PERFORMANCE WITH RETURN PATH

With a QPSK 1,544 Mbits/s injected into any system outlets, the signal received at the Headend shall be: -

Carrier to noise ratio	≥ 22 dB
Amplitude response variation	≤ 8 dB

SUB-SECTION 9.1.3

TERRESTRIAL MASTER ANTENNA TELEVISION SYSTEM

9.1.3.1 TERRESTRIAL AERIALS

The mast or poles and the aerials shall be of heavy duty construction and able to operate normally under a loading pressure associated with a sustained wind speed of up to 170 km/hr and gusts up to 240 km/hr. Detailed builder's work requirements shall be submitted and coordinated with the Building Contractor within 2 months after the award of the Contract and prior to commencement of the works. The works shall include the coordination with the Building Contractor on the adequate structure support and associated builder's works to be provided by the Building Contractor for the installation as appropriate, and also include the checking for the positions of the builder's work on Site where reception is at its best before any concrete work has carried out.

If the FM aerial is required to be mounted on the same mast for the TV aerial, the two aerials shall be separated by at least 1.8 m apart so as to achieve the minimum interference.

The aerial system shall be adequately earthed and protected against lightning in accordance with IEC 62305-1:2010 & relevant current parts by mean of bonding the aerial masts or supporting frames of antenna to the air termination for the lightning protection system with at least 25 mm x 3 mm copper tape or an acceptable equivalent.

Separate downleads shall be employed for the TV and FM aerials. The TV and FM signals shall not be combined in front of the channel amplifiers.

9.1.3.2 PREAMPLIFIERS AND FILTERS

TV bandpass preamplifiers shall be used in weak TV field strength areas. Similarly, FM band preamplifiers shall be used in weak FM field areas.

Alternatively, TV/FM bandpass filters shall be incorporated if wideband preamplifier is used.

9.1.3.3 AMPLIFIERS

Signal amplification within the system shall be provided with channel amplifiers at the headend for signal processing and wideband distribution amplifiers.

At sites where the aerial is not in direct line-of-sight with the transmitter, the channel amplifier shall be equipped with automatic gain control circuitry.

When channel amplifiers are required, this shall include one channel for FM reception, one channel for closed circuit TV reception, two channel spaces for other paid TV receptions and the numbers of digital channels required for reception of any one free TV programme channel group as required by the location of reception in accordance with the frequency plans allocated for TV and FM receptions, which are announced by OFCA.

Only one TV channel group transmitted by any one transmitter location/station shall be relayed.

The design levels used for the output of all amplifiers shall be 4 dB lower than their respective maximum allowable output with the exception of channel amplifiers equipped with automatic gain control (AGC) and all amplifiers following these AGC channel amplifiers. The maximum allowable output is the output level at which the specification limit for unwanted signal detailed in the wideband amplifiers, FM channel amplifiers and TV channel amplifiers & AGC channel amplifiers etc. can no longer be met with further increase in outputs.

A lockable well-ventilated metal enclosure shall be installed to house all headend circuit components. The case shall be properly secured against the wall and have sufficient space for cable routing and bending.

The headend equipment of each system shall be installed in the Telecommunication & Broadcasting Equipment (TBE) Room or in the location of Headend Equipment Room as shown on the Drawings.

Cable routing shall be as short as possible from antennae to the channel amplifiers/modulator.

9.1.3.4 FREQUENCY CONVERTERS

Television signals shall be conveyed at the received signal frequencies. If frequency conversion is required, the outlet frequencies shall be in the frequencies 470 to 862 MHz for television reception.

9.1.3.5 UHF MODULATORS

If closed circuit television system camera signals are to be included in the Broadcast Reception system, the video signals shall be modulated to UHF range channels and combined at the headend of the system.

9.1.3.6 SPLITTERS/TEE-UNITS

All splitters and tee units shall have a wide bandwidth to allow for cascaded mode of operation. The maximum number of tee units in cascade shall be limited to 6. Mock-up tests may be required to assess the design prior to installation if, in the opinion of the Supervising Officer, the cascaded chain is too long as to create unacceptable signal strength.

9.1.3.7 COAXIAL CABLES

The minimum bending radius of the coaxial cable during installation shall be 20 times of the cable diameter and the permanent turning radius for the coaxial cable shall at least be 10 times of its diameter. Joints in the cable runs and looping of cables at outlet terminals shall NOT be allowed.

All wiring shall be properly installed and segregated in accordance with the latest edition of the "Code of Practice for the Electricity (Wiring) Regulations" issued by EMSD and Part 7 of this General Specification.

The equipment, cabling, etc. shall be installed in location as indicated on the Drawings accompanied with the specification. All cables and wiring shall be run and terminated inside concealed conduits/trunkings and 47 mm deep conduit box, etc. in compliance with Part 7 of this General Specification.

If an electricity supply cable or service is to run in parallel with or cross the coaxial cable, the following minimum segregation between electricity supply cables and the coaxial cable shall be provided: -

(a) For low voltage cables (not exceeding 600 V between phase and earth), a minimum clearance of 50 mm shall be given.

(b) For high voltage cables (exceeding 600 V between phase and earth), a minimum clearance of 300 mm shall be given.

9.1.3.8 FM/TV/DATA OUTLETS

Looping of outlets to achieve the sufficient isolation shall NOT be acceptable. Only isolation using splitters and tee units with isolation shall be considered.

9.1.3.9 FIBRE OPTICAL CABLE SYSTEM

Fibre optical cable system shall be provided where the length of main trunk cable without joint exceeds 200 metres. The fibre optical cable in riser shall be enclosed in a galvanised iron cable trunking with space factor not exceeding 40%. In any case, the cable trunking shall not be smaller than 50 mm x 50 mm. Where the main trunk is installed underground, the fibre optical cables shall be protected by minimum 100 mm dia. galvanised iron pipes and cable draw pits.

Fibre optical cable amplifier shall be provided where the total attenuation loss of the optical circuit exceeds the maximum output power of the transmitter.

The length of fibre optical cables without joint between the optical transmitter and the fibre optical splitter shall not exceed 5000 metres and that between the fibre optical splitter and the fibre optical transceiver shall not exceed 2000 metres.

The minimum bending radius of the fibre optical cable during installation shall be 20 times of the cable diameter and the permanent turning radius for the fibre optical cable shall at least be 10 times of its diameter.

9.1.3.10 GENERAL REQUIREMENTS OF CABLE NETWORK SYSTEMS

Separate conduits, ducts and trunking systems shall be separately provided for the electricity power supply cables, other telecommunication cables in the building, and

coaxial cables for broadcasting services. The same shall also be separately provided to fibre optical cables, if any, as far as possible. For metal duct system including the conduits, ducts, pipes, trunking, boxes etc., they shall be fully bonded and earthed.

SUB-SECTION 9.1.4

SATELLITE MASTER ANTENNA TELEVISION SYSTEM

9.1.4.1 SMATV SYSTEM INSTALLER REQUIREMENTS

The works shall be carried out by a licence holder on the List of SMATV Licence Holders registered in OFCA. Application to the OFCA for SMATV system installation shall also be made under this works.

9.1.4.2 THE SMATV SYSTEM REQUIREMENTS

9.1.4.2.1 Antenna Location

The SMATV System shall be installed in the location such that: -

(a) It has a clear, unobstructed view of the target satellite;

(b) It has no condensation in its vicinity; and

(c) It is at least 3 metres clear of fences or enclosure.

9.1.4.2.2 Support for the Dish Antenna

The steel framework and mounting of the dish antenna shall be capable to withstand the loading pressure associated with sustained wind speed up to 170 km/hr and gusts up to 240 km/hr without any physical damage. The works shall include the coordination with the Building Contractor on the adequate structure support and associated builder's works to be provided by the Building Contractor for the installation as appropriate.

9.1.4.2.3 Antenna Installation

The antenna shall be of heavy duty construction and able to operate normally under a loading pressure associated with a sustained wind speed of up to 170 km/hr and gusts up to 240 km/hr and shall be installed in such a way that it shall not warp. The antenna shall be smooth, not rough or bumpy. The antenna shall not twist or rock under stress.

Rubber grommets shall be inserted between the steel supports and the aluminium dish antenna to prevent electrolysis action.

Both the antenna and its supports shall be adequately earthed and protected against lightning in accordance with IEC 62305-1:2010 & relevant current parts by means of bonding the antenna and its supporting frames to the air termination of the lightning protection system with at least 25 mm x 3 mm copper tape or product having equivalent functions or performance. Necessary earth bonding shall be carried out under this Works.

The antenna and its supporting structure shall be provided with a durable protective coating.

9.1.4.3 FEEDHORN/LOW NOISE AMPLIFIER (LNA)/LOW NOISE BLOCK DOWN CONVERTER (LNB)

The feedhorn shall be strictly installed in accordance with manufacturer's recommendation. The manufacturer's recommended installation method shall be submitted to the Supervising Officer for approval within 2 months after award of the Contract. The feedhorn shall be positioned in the focus point of the satellite TV antenna and adequately supported. Gaskets recommended by the manufacturer shall be used between the feedhorn and the LNA/LNB to avoid leakage of signal.

The sealant between the gaskets shall be in accordance with the manufacturer's recommendation to ensure that the waveguide is in good metal-to-metal contact.

9.1.4.4 SATELLITE RECEIVERS AND MODULATORS

The satellite receivers and modulators shall be earthed in accordance with Part 7 of this General Specification.

SUB-SECTION 9.1.5

ANCILLARY SYSTEM

9.1.5.1 CONDUITS & CABLE TRUNKINGS

The equipment, cabling, etc. shall be installed in locations as indicated on the Drawings accompanied with the specification. All cables and wiring shall be run and terminated inside conduits/trunkings and 47 mm deep box, etc. in compliance with Part 7 of this General Specification.

25 mm dia. conduit terminating at the headend equipment cabinet in the headend equipment room to enclose the down leads all the way from the antenna shall be supplied and installed.

9.1.5.2 POWER SUPPLY

Power supply for the amplifier/receivers shall be taken from the 13A fused spur unit c/w pilot light at positions as shown on the Drawings. All the wiring from this location to the power supply unit, amplifier, etc. shall be included under the Works. Additional 13A fused spur units c/w pilot light shall also be supplied and installed under the Works if required. Automatic voltage regulators and/or uninterruptible power supply shall be supplied and installed where required in the Particular Specification, for proper functioning of the entire system.

SECTION 9.2

MATERIAL AND EQUIPMENT SPECIFICATION

SUB-SECTION 9.2.1

GENERAL

9.2.1.1 GENERAL REQUIREMENT

The supply voltage may be interrupted such that its frequency or voltage value may fluctuate outside the acceptable range as indicated in Clause 1.1.3.18. The installed equipment shall be able to ride through or function properly due to any unavoidable disturbance illustrated in BS EN 50160:2010+A3:2019.

SUB-SECTION 9.2.2

TERRESTRIAL MASTER ANTENNA TELEVISION SYSTEM

9.2.2.1 TERRESTRIAL AERIALS

The terrestrial aerials shall be suitable for digital terrestrial television and shall comply with the following: -

(a) TV aerial shall have a gain of at least 13 dB and a front to back ratio of at least 28 dB. The aerial shall be of the type to minimise ghost image;

(b) FM aerial shall have a gain of at least 6 dB;

(c) The impedance of the aerial shall be 75 ohm unbalanced;

(d) The aerial system shall be provided with a durable protective coating;

(e) The aerial mast shall be made of stainless steel; and

(f) The aerial shall be capable of receiving digital signals.

9.2.2.2 PREAMPLIFIERS AND FILTERS

The performance of the preamplifiers, TV bandpass preamplifiers, FM bandpass preamplifiers, TV bandpass filters and FM bandpass filters shall be suitable for digital terrestrial television and shall comply with the following:

9.2.2.2.1 Preamplifiers

Frequency	FM : 88 to 108 MHz TV : 470 to 862 MHz
Gain	≥ 20 dB
Input	Split input configuration
Output Level	≥ 90 dBμV
Noise Figure	< 5.5 dB
Impedance (Input & Output)	75 ohm
Housing	Weatherproof housing suitable for outdoor mounting

9.2.2.2.2 TV Bandpass Preamplifiers

Frequency Range	Within CH 21 – CH 62
Passband	Frequency range to suit the digital receptions for any one free TV programme channel group by the location of reception in accordance with the frequency plans allocated for TV and FM receptions by OFCA

Gain within passband	≥ 20 dB
Input	Split input configuration
Output Level	≥ 90 dBμV
Noise figure	< 5.5 dB
Impedance (Input & Output)	75 ohm
Housing	Weatherproof housing suitable for outdoor mounting

9.2.2.2.3 FM Bandpass Preamplifiers

Frequency Range	88 to108 MHz
Gain	≥ 20 dB
Input	Split input configuration
Output Level	≥ 90 dBμV
Noise figure	< 5.5 dB
Impedance (Input & Output)	75 ohm
Housing	Weatherproof housing suitable for outdoor mounting

9.2.2.2.4 TV Bandpass Filters

Frequency Range	Within CH 21 – CH 62
Passband	Frequency range to suit the digital receptions for any one free TV programme channel group by the location of reception in accordance with the frequency plans allocated for TV and FM receptions by OFCA
Loss within passband	Not more than 5.0 dB
Impedance (Input & Output)	75 ohm

9.2.2.2.5 FM Bandpass Filters

Frequency Range	88 to108 MHz
Loss within passband	Not more than 5.0 dB
Impedance (Input & Output)	75 ohm

9.2.2.3 AMPLIFIERS

The performances of the wideband amplifiers, FM channel amplifiers and TV channel amplifiers with AGC modules shall be suitable for digital terrestrial television and shall comply with the following:

9.2.2.3.1 Wideband Amplifiers

Frequency Range & Passive Return Path	54 to 862 MHz 5 to 42 MHz
Gain & Return Path Gain	≥ 25 dB & 10 dB
Output Level & Return Path Output Level	≥ 100 dBμV & ≥ 90 dBμV

Noise Figure	< 8.5 dB
Nominal Impedance (Input & Output)	75 ohm
Return Loss (Input & Output)	≥ 10 dB
Housing	Either internally or externally fully screened metal box complete with suitable mounting legs for vertical mounting
Earthing	All metal parts to be properly earthed
Identification	Clearly marked 'IN' & 'OUT' signal sockets
Accessories	All necessary coaxial cable plugs and accessories

9.2.2.3.2 FM Channel Amplifiers with Processor

Frequency Band	FM
Input Frequency Range	88 to 108 MHz
Gain	≥ 20 dB
Noise Figure	Less than 7 dB
Input Level	Between 40 - 80 dBμV
Output Level	≥ 70 dB μ V
Output Frequency Range	Convert to the frequency range within 88 to 108 MHz
Impedance (Input & Output)	75 ohm
Return Loss (Input & Output)	≥ 10 dB
Weather proofing	Indoor application
Housing	Modular type construction of robust plug-in units with connecting links between TV channel amplifier outputs. Fully internally metal-screened. Earthing on metal chassis.
Identification	Clearly marked 'IN' & 'OUT' signal sockets

9.2.2.3.3 TV Channel Amplifiers with Processor and Automatic Gain Control (AGC) Modules

The TV channel amplifiers with processor shall be suitable for working with a group of adjacent channels.

Input Frequency Range	470 to 862 MHz
Gain	≥ 40 dB
Automatic Gain Control Range	≥ 20 dB
Input Level	55 - 85 dBμV
Output Level	≥ 80 dBμV
Noise Figure	< 9 dB

AGC Facility	> + 1 dB output variation for a full range change of at least + 10 dB of the nominal input
Impedance (Input & Output)	75 ohm
Output Frequency Range	Convert to the frequency range within 54 to 862 MHz
Return Loss (Input & Output)	≥ 10 dB
Weather Proofing	Indoor application
Housing	Modular type construction of robust plug-in with connecting links between amplifiers outputs. Fully internally metal-screened. Earthing on metal chassis.
Identification	Clearly marked 'IN' & 'OUT' signal sockets
Accessories	All necessary coaxial cable plugs and accessories

9.2.2.4 FREQUENCY CONVERTERS

The frequency converters shall comply with the following:

Converted Frequency Band	470 to 862 MHz
Gain	≥ 20 dB
Automatic Gain Control Range	≥ 20 dB
Input Level	55 - 85 dBμV
Output Level	≥ 60 dB μ V
Output RF Bandwidth	< 8 MHz
AGC Facility	> + 1 dB output variation for a full range change of at least + 10 dB of the nominal input
Impedance (Input & Output)	75 ohm
Weather Proofing	Indoor application
Housing	Modular type construction of robust plug-in with connecting links between amplifiers outputs. Fully internally metal-screened. Earthing on metal chassis.
Identification	Clearly marked 'IN' & 'OUT' signal sockets
Accessories	All necessary coaxial cable plugs and accessories

9.2.2.5 DIGITAL UHF MODULATORS

The digital UHF modulators shall comply with the following:

Video Input Resolution	576p up to 1080p
Video Input	HDMI
Video Encoding	H264/AVC
Output Frequency Range	100 to 1218 MHz fixed channel or channel selectable

Output Impedance	75 ohm
Output RF Bandwidth	< 8 MHz
Output Standard	DTMB
Output Level (without integrated channel amp) (with integrated channel amp)	 > 80 dBμV > 110 dBμV

9.2.2.6 SPLITTERS/TEE-UNITS

All splitters and tee units shall have a wide bandwidth to allow for cascaded mode of operation, shall have return path and shall comply with the following:

9.2.2.6.1 Splitters

Frequency Range	5 to 862 MHz
Distribution Loss	<4.5 dB for 2S, <7 dB for 3S, ≤ 8 dB for 4S, <11 dB for 6S, <12 dB for 8S
Mutual Attenuation between Outputs	Not less than 13 dB for splitters at all in-band frequencies
Impedance	75 ohm
Return Loss (Input & Output)	≥ 14 dB

9.2.2.6.2 Tee Units

Frequency Range	5 to 862 MHz
Thru Loss	≤ 6 dB
Side Loss	≤ 16.5 dB
Mutual Attenuation between Outputs	22 to 28 dB for tee units at all in-band frequencies
Impedance	75 ohm
Return Loss (Input & Output)	≥ 18 dB

9.2.2.7 COAXIAL CABLES

All coaxial cables used shall be of 75 ohm type copper cables manufactured for transmitting 5 to 2150 MHz signals and shall have thermosetting insulated, with low emission of smoke and corrosive gases when affected by fire.

The fire performance of the insulated material with low emission of smoke and corrosive gases when affected by fire shall comply with the following requirements:

Flame propagation : IEC 60332-1-1:2004+AMD1:2015;

Smoke emission : IEC 61034-2:2005+COR1:2006+AMD1:2013+AMD2: 2019; and

Acid gas emission : IEC 60754-1:2011+ COR1:2013+AMD1:2019.

The coaxial cables for feeder shall conform to cable designation 8 or above of IEC 60096-3:1982 and the coaxial cables for trunk feeder shall be to cable designation 6 or above of IEC 60096-3:1982.

Underground coaxial cables shall be with polyethylene outer sheath, copper foil outer conductor, and PVC insulation. The cable shall be to cable designation 6 or above of IEC 60096-3:1982.

All coaxial cables shall have distinctive labels/brand name along its length.

9.2.2.8 FM/TV/DATA OUTLETS

Outlets shall be socket type for data (5 to 862 MHz) signal and for FM/TV (54 to 862 MHz) signals complete with frequency dividing network and the respective socket shall be identified with labels embossed on the front plate. The outlet shall be suitable for digital signals.

The outlets shall be suitable for flush mounting on 47 mm deep box in compliance with Part 7 of this General Specification.

Unless otherwise specified, the outlets shall be white or ivory in colour.

The FM/TV/Data outlets shall have a return path and shall comply with the following:

Frequency Range & Return Path Frequency	54 to 862 MHz 5 to 42 MHz
Features	Outlets configuration for data and for FM/TV, flush mounting type complete with cover, connected from tap output of tee unit.
Distribution Loss	FM (88 to108 MHz) < 10 dB TV & Data (5 to 862 MHz) < 9 dB
Mutual Isolation	Between FM, TV & Data not less than 40 dB from 5 to 862 MHz
Impedance	75 ohm
Connector	F connector

9.2.2.9 FIBRE OPTICAL TRANSMITTER

The fibre optical transmitter shall be of modular type and shall comply with the following:

Frequency	54 to 862 MHz
Input Impedance	75 ohm
Optical Wavelength	1310 nm ± 10 nm
Optical Output Power	≥ 6 dBm
Optical Return Loss	≥ 55 dB
RF Input Level per Channel	≥ 60 dBμV
Number of TV channels	42

Light Source – LED Laser Diode	< 2 km < 40 km

The fibre optical return path transmitter shall be of modular type and shall comply with the following:

Return Path Frequency	5 to 42 MHz
Input Impedance	75 ohm
Optical Wavelength	1310 nm ± 10 nm
Optical Output Power	≥ 6 dBm
Optical Return Loss	≥ 55 dB
RF Input Level per Channel	≥ 60 dBμV
Light Source – LED Laser Diode	< 2 km < 40 km

9.2.2.10 FIBRE OPTICAL TRANSCEIVER WITH RETURN PATH

The fibre optical transceiver shall be of modular type and shall comply with the following:

Frequency & Return Path Frequency	54 to 862 MHz 5 to 42 MHz or as specified
Optical Wavelength	1310 nm ± 10 nm
Optical Return Loss	≥ 55 dB
RF Output Level per Channel	> 80 dB μ V
Return Path Loss	> 14 dB
Light Source – LED Laser Diode	< 2 km < 40 km

9.2.2.11 FIBRE OPTICAL SPLITTER

The fibre optical splitter shall be of modular type and shall comply with the following:

Optical Wavelength	1310 nm ± 10 nm
Optical Return Loss	> 55 dB

9.2.2.12 FIBRE OPTICAL CABLE

The fibre optical cable shall be flame retardant type. The cable shall be single mode (1310 nm) and shall be suitable for 5 to 2050 MHz applications. The single mode fibre optical cable used for broadcasting services shall conform to Recommendation ITU-T G.652.

SUB-SECTION 9.2.3

SATELLITE MASTER ANTENNA TELEVISION SYSTEM

9.2.3.1 GENERAL

The system shall enable simultaneous viewing different TV programs from the Terrestrial Master Antenna Television System as well as from satellites. Signals from the Satellite Master Antenna Television System shall be fed to the satellite receivers installed in the Headend Equipment Room, via necessary signal splitting equipment, satellite amplifiers and cabling. The video and audio signals from the satellite receivers shall be modulated to SMATV channels and shall be combined to the Broadcast Reception Installation headend equipment installed in the Headend Equipment Room for distribution to FM/TV/Data outlets.

9.2.3.2 SYSTEM REQUIREMENTS

The SMATV system shall comply with the following:

9.2.3.2.1 Environmental Operating Requirements

The antenna system shall comply with all performance specifications under the following special environmental conditions:

Rain	Up to 100 mm/hr
Wind Survival	Gusts up to 240 km/hr
Wind Operational	Wind loading up to 170 km/hr in any position of operation
Atmospheric Conditions	Capable to withstand salt, hydrogen sulphide and corrosive contaminants

9.2.3.2.2 Electrical Specification

Frequency	C-band (3.7 to 4.2 GHz)	Ku-band (10.75 to 12.75 GHz)
Wideband Antenna Gain	≥ 38 dB	≥ 48 dB
Polarisation	Match with the target satellite	Match with the target satellite
Focus/Diameter Ratio	≤ 0.4	≤ 0.4
Beam Width	≤ 1.7 degrees	≤ 1.7 degrees
Noise Temperature	< 20 dB at 60o elevation	< 20 dB at 60o elevation

9.2.3.2.3 Mechanical Specifications

Antenna Type	Solid Aluminium plate
Antenna Diameter	Not less than 3 m

9.2.3.2.4 Feedhorn

The feedhorn shall be suitable for circular and linear C-band & Ku-band reception. The feedhorn shall be for use with prime-focus reflector. Polarisers shall be provided for selection of the received signals of different polarisation modes. The technical specifications of the feedhorns, including the Polarisers, are as follows:

Frequency	C-band (3.7 to 4.2 GHz)	Ku-band (10.75 to 12.75 GHz)
Focus/Diameter Ratio	0.33 to 0.45	0.33 to 0.45
Polarisation	Circular and linear	Circular and linear
Cross Polarity Isolation	≥ 25 dB for Single Feedhorn > 20dB for Dual Feedhorn	≥ 25 dB for Single Feedhorn > 20dB for Dual Feedhorn
Voltage Standing Wave Ratio (VSWR)	≤ 1.4 : 1	≤ 1.4 : 1

9.2.3.2.5 Low Noise Amplifier (LNA) /Low Noise Block Down Converter (LNB)

Input Frequency	C-band (3.7 to 4.2 GHz)	Ku-band (10.75 to 12.75 GHz)
Minimum Input Level	≤ -100 dBm	≤ -100 dBm
Gain	≥ 55 dB	≥ 55 dB
Input VSWR	≤ 2.5 : 1	≤ 2.5 : 1
Image Rejection Ratio	≥ 40 dB	≥ 40 dB
Output Frequency	950 - 1750 MHz	950 - 2050 MHz
Output VSWR	≤ 1.5 : 1	≤ 1.5 : 1

9.2.3.3 SATELLITE RECEIVERS

The satellite receivers shall be multi-system compatible and shall comply with the following:

9.2.3.3.1 RF Signal

Input frequency	950 – 2050 MHz
Input signal level	- 60 dBm to – 30 dBm
IF bandwidth	18 MHz, 27 MHz
FM threshold	8 dB C/N

9.2.3.3.2 Video Parameters

Video de-emphasis	ITU-R 405 -1 525, 625 lines
Video frequency response	+ 3 dB at 20 Hz to 5 MHz
Video output level	1 Volt peak-to-peak, 75 ohm
Baseband de-emphasis	Flat

9.2.3.3.3 Audio Parameters

Audio subcarrier tuning	4.5 to 8.8 MHz
Audio response	20 Hz to 20 kHz, + 0.5 dB
Audio de-emphasis	50 µs, J17
Audio distortion	less than 2 % THD

9.2.3.4 SATELLITE AMPLIFIER

The satellite amplifier shall be suitable for the SMATV application. The technical specification of the amplifiers receivers are as follows:

Input frequency	950 – 2050 MHz
Gain	≥ 20 dB
Output level at 35dB CMR	≥ 110 dB
Noise figure	≤ 6 dB
Impedance (Input & Output)	75 ohm
Return Loss (Input & Output)	≥ 10 dB

9.2.3.5 SPLITTERS/TEE-UNITS

All splitters and tee units shall have a wide bandwidth to allow for cascaded mode of operation and shall comply with the following:

9.2.3.5.1 Splitters

Frequency Range	950 to 2050 MHz
Distribution Loss	≤ 11 dB
Mutual Attenuation between Outputs	>13 dB for splitters at all in-band frequencies
Impedance	75 ohm
Return Loss (Input & Output)	≥ 10 dB

9.2.3.5.2 Tee Units

Frequency Range	950 to 2050 MHz
Thru Loss	≤ 8.5 dB
Side Loss	≤ 20.5 dB
Mutual Attenuation between Outputs	>28 dB for tee units at all in-band frequencies
Impedance	75 ohm
Return Loss (Input & Output)	≥ 18 dB

SUB-SECTION 9.2.4

ANCILLARY SYSTEM

9.2.4.1 CABLE TRUNKING

Cable trunking shall be in accordance with Part 7 of this General Specification.

9.2.4.2 CONDUIT AND ACCESSORIES

Conduit & accessories shall be in accordance with Part 7 of this General Specification.

9.2.4.3 POWER CABLE

Power cable shall be in accordance with Part 7 of this General Specification.

SECTION 9.3

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 9.3.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

9.3.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

9.3.1.2 CALIBRATED INSTRUMENT

The works shall include the supply of calibrated instruments for testing and commissioning of the system. The instruments shall be suitable for test in according to manufacturer's recommendations and shall be calibrated by organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS.

9.3.1.3 SIGNAL LEVEL MEASUREMENT OF TV HEADEND AND TRUNK DISTRIBUTION EQUIPMENT

(a) Measure the input and output signal levels of each headend and trunk distribution equipment item with the signal level meter, starting from the antenna side. All the TV channels to be distributed shall be measured. For FM signals, three of the principal programmes to be distributed, namely those with the lowest, middle and highest frequencies, shall be measured.

(b) The input and output signal levels shall agree with the calculation done by in approved shop drawings.

9.3.1.4 SIGNAL LEVEL MEASUREMENT AT FM/TV OUTLETS

(a) The signal level at FM/TV outlets shall be measured by the signal level meter for each TV channel and three of the principal FM programmes to be distributed, namely those with the lowest, middle and highest frequencies.

(b) The signal levels shall comply with the requirements specified in Sub-section 9.1.2.

9.3.1.5 MUTUAL ISOLATION BETWEEN FM/TV OUTLETS

(a) The mutual isolation between FM/TV outlets from the same tee unit shall be measured. About 3 pairs of outlets shall be tested for each type of tee unit.

(b) The mutual isolation shall not be less than 33 dB for terrestrial TV and 42 dB for FM signal.

9.3.1.6 SIGNAL TEST AT TV OUTLETS

The picture quality at TV outlets shall be measured by a Portable TV monitor c/w sound monitoring loudspeaker for each TV channel. The test results shall be recorded in the report.

SUB-SECTION 9.3.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

9.3.2.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during Maintenance Period shall also comply with the specific requirements in this Sub-section.

Operation, servicing and maintenance of the Installations, if specified, shall also refer to the equipment manufacturer's recommendations and specifications.

9.3.2.2 SYSTEM CALIBRATION AND ADJUSTMENT

During the Maintenance Period, the whole system installed shall be attended at least every 6 months to carry out checking, fine tuning, calibration and adjustment to ensure that the system is operate at its optimal conditions.

9.3.2.3 INSPECTION REQUIREMENTS IN MAINTENANCE PERIOD

The Installations shall be inspected at least once every 6 months during the Maintenance Period for operation status. All environmentally sensitive devices shall be inspected. Report shall be submitted to the Supervising Officer after each checking.

PART 10 – BURGLAR ALARM AND SECURITY INSTALLATION

SECTION 10.1

GENERAL REQUIREMENTS

SUB-SECTION 10.1.1

GENERAL

10.1.1.1 Weatherproof Requirements

All accessories, equipment designed for outdoor or semi-outdoor application shall be of weatherproof type to minimum IP54 or otherwise specified in particular specifications. For CCTV camera, weatherproof type to IP66 shall be adopted for outdoor or semi-outdoor application.

10.1.1.2 Duress Alarm and Vandal Proof Provisions

For premises, areas or rooms that the facilities or operational staff may be subject to risks of attack or the likes (e.g. Police Stations, Disciplinary Quarters, Control Point Buildings, Shroff Office, etc.), or those areas designated with specific security level, intruder monitoring provisions such as extra CCTV cameras, glass break and motion sensors should be considered as appropriate. Duress push button or kick bar located at appropriate position for actuation of security alarm shall also be considered if necessary. CCTV camera located at outdoor and/or public accessible areas shall be equipped with impact resistant casing to IK10. High resolution (4K) and night vision CCTV camera shall be considered and mounted at not less than 6m(H) for outdoor area or at ceiling for indoor area as appropriate. Vandal proof design and provisions for the entire Burglar Alarm and Security Installation shall be duly considered.

SUB-SECTION 10.1.2

ELECTRICITY SUPPLY

10.1.2.1 GENERAL

Power supply points at mains voltage of 220V, single phase, 50 Hz in the main control location, slave control location, adjacent to camera, and adjacent to local control units shall be provided by contractor carrying out electrical installation. For power supply to field devices, spur units at mains voltage shall be provided adjacent to the local field device units. The contractor carry out the burglar alarm and security installation works shall be responsible for the provision of transformers and rectifiers to suit the voltage pattern of the field devices, and also conduits and wiring for providing electrical power from the power supply points to the field devices. Shop drawings and schedules indicating the required location of the power supply points, their rating and the wattage and power factor of the anticipated load shall be submitted in good time for coordination.

The operation of all the equipment of Installations, including central control devices, field devices, controllers, door locks, etc., shall be connected to the Essential Power Supply which is backed up by the building generator if provided.

All trunkings and conduits shall be properly installed according to Part 7 of this General Specification.

All cables and wirings shall run continuously from device location to the final point of termination. No mid run cable splices shall be allowed unless otherwise approved by the Supervising officer.

All cables and wirings terminals and connectors shall be marked with ferrules at both ends. The labelling shall agree with the record drawings.

The use of those surge protective devices which can effectively isolate from transient overvoltage or surge protection of equipment against lightning electromagnetic impulse shall be installed for isolated building or those building susceptible to lightning.

SUB-SECTION 10.1.3

COMMUNUICATION NETWORK

10.1.3.1 GENERAL

The general design of the communication network shall make reference to IEC 60839-5-1:2014 and the associated parts of the standard or other relevant recognised international standards. The communication network is to transmit the data between the central control station with the field devices. Intelligent local controllers which can store the control programs shall be installed in the vicinity of the field device such that the burglar alarm and security system can still function even the central control station computers are out of order. The communication between the intelligent local controllers with the central control station shall be by means of network or multiplex technology. Intelligent local controller shall be able to store alarm event of a specified period to prevent loss of alarm data in the event when communication cables are sabotaged.

10.1.3.2 COMPONENTS

The communication network is mainly constructed by communication cables, intelligent local controllers and other accessories, etc.

10.1.3.3 PERFORMANCE REQUIREMENTS

10.1.3.3.1 Communication Cables

All cables shall be under continuous supervision such that an open/short circuit shall activate alarm of suspected cable tampering. All alarm shall be transmitted to the central control station to alert the security operator for necessary action and also for logging.

Field devices shall be hard wired to the intelligent local controllers or central control station by means of shielded cables which shall monitor the status of alarm circuits. The circuit shall be arranged to raise alarm when the wiring between a field device and the intelligent local controller or central control station is broken.

Network system shall allow future expansion to accommodate adequate alarm points by connecting additional intelligent local controllers or field devices.

10.1.3.3.2 Intelligent Local Controllers

Network system shall be provided with intelligent local controllers which communicate with the central control station computer via shielded communication cables. The system shall continuously monitor the communication between the central control station computer and each intelligent local controller such that an alarm shall be raised when loss in communication is detected.

Intelligent local controllers shall be standalone microprocessor based controller which shall control its output and store alarms when communication is lost. It shall transmit the data to the computer as soon as communication is restored.

Each intelligent local controller of access control system shall store access control database file and also the access control programme such that door access control for a room shall remain in function in the event of loss of communication between the intelligent local controller and the central control station computer.

The database file and access control programme in intelligent local controller shall be the same as the relevant content in the central control station computer and shall be automatically updated when there is revision of corresponding data in the central control station computer.

Each intelligent local controller shall be provided with battery backup for power supply for memory for at least one (1) hour and shall be installed in rooms protected by Burglar Alarm and Security Installation. Intelligent local controllers shall also be one piece and shall be housed in a tamper-proof housing with tampering switches. Alarm signal shall be sent to central control station when the housing is tampered.

SUB-SECTION 10.1.4

REMOTE SIGNAL TRANSMISSION

10.1.4.1 GENERAL

The general design of the remote alarm transmission to a private security control centre shall make reference to IEC 60839-5-1:2014 and the associated parts of the standard or other relevant recognised international standards.

10.1.4.2 COMPONENTS

The remote alarm transmission to a private security control center shall require a communication line, transmitter and termination, etc.

10.1.4.3 PERFORMANCE REQUIREMENTS

10.1.4.3.1 Communication link including transmitter and termination equipment shall be supplied and installed. Necessary arrangement and subscription for the connection of the system to remote private security control centre shall be provided if necessary.

10.1.4.3.2 The following provisions shall be included in the Works:-

(a) All payment including advance payments and other necessary provisions for connection of communication network for alarm /information transmission to private security control centre;

(b) All monthly charges during the Maintenance Period for the hiring of communication lines, the services provided by the private security control centre and necessary provisions for maintaining 24-hour alarm monitoring and communication service; and

(c) Signal or health checking routine shall be provided from the control centre to detect the continuity and healthy of the communication line.

10.1.4.3.3 An appropriate surge filter shall be provided before the communication line terminates to the signal transmitter of the burglar alarm and security system.

10.1.4.3.4 For a remote site where the provision of fixed communication line is not available, adopting a compatible data to communicate with the security control centre through the mobile communication network with due consideration of the system reliability and recurrent cost could be considered, subject to the Supervising Officer’s approval.

SECTION 10.2

TECHNICAL REQUIREMENTS

SUB-SECTION 10.2.1

CENTRAL CONTROL STATION

10.2.1.1 GENERAL

The general design of the central control station shall make reference to IEC 62642-1:2010 and the associated parts of the standard or other relevant recognised international standards for the computer system, software programmes, and equipment console and racks. Central control station is to monitor the burglar alarm and security system, to download control data and programming parameters to the local intelligent controllers/field devices and to generate required reports. The location of the central control station shall be treated as a high security area, e.g. provided with access control system, in order to minimise the risk of access by unauthorised person to tamper with the computer, and the central control station shall be installed in the main control location such as the Security Guard Room.

10.2.1.2 COMPONENTS

10.2.1.2.1 Central control station shall at least consist of the following major elements:-

(a) Central processor unit (equivalent or better to quad core version), 4GB RAM (minimum), 2 TB hard disk drive (minimum), DVD Writer, 4 USB ports with 2 USB3.0 version (minimum), interface connection ports, keyboard, optical mouse, and all necessary components specifically designed for multi-user, multi-tasking point monitoring and control.

(b) One 24-inch (minimum) Full HD (1080p) LED colour monitor for character display and one 24-inch (minimum) LED colour monitor for graphic display. For system which allows simultaneously display text and graphic in the same screen but with text display away from the alarm graphic, one 24-inch (minimum) LED colour monitor shall be acceptable. But alternate display of text and graphic shall not be acceptable. The type and size of display monitors could be designed and specified according to the system operational requirements.

(c) An event printer and a report printer.

(d) Software programmes for the Burglar Alarm and Security Installation.

(e) Standard application programmes as specified by the Supervising Officer.

(f) Equipment console and racks for grouping different pieces of security equipment in a tidy manner and providing an environment of laying cables between the equipment in a tidy manner.

10.2.1.3 PERFORMANCE REQUIREMENTS

10.2.1.3.1 Computer and Software Programmes

The computer system shall monitor the status of the input points, e.g. door contacts, movement detector, exit control lock, card reader, etc. and output points, such as signal to call up camera of CCTV system, locking and unlocking electric door strikes, etc. User graphic interface shall at least incorporate as-built layout plans and elevation views, alarm alert or abnormal status of monitoring points with popup message/graphic indications on plans /elevation view(s).

User programme, e.g. time programme for arm and disarm, etc., shall be provided to allow the operator to control each input point and to alter the database associated with each input point, such as point number, point type, point priority group, point location, etc.

When an alarm condition is triggered, audible and visual signal shall be announced in both main control location and slave control location(s). The alarm annunciation shall take first priority over all other current activity. When more than one alarm are in the queue, the oldest highest priority alarm shall be presented first.

Every alarm point transaction shall be stored in computer. Data for every alarm transaction shall include but not limited to the time, date, point number, point type, point location, point description, point status and operator comments. The computer shall continuously maintain a database record of all system transactions.

The programme software shall be a purpose made software specially designed for burglar alarm and security and access control and have been successfully applied to other completed projects.

Security operator at the main control location shall be able to select any group of alarm to view status and locations on the LED colour monitor.

At any time, the security operators at the main control location and the slave control location can view a summary status screen consisting of total number of points in alarm, total number of points in system time programme bypass, total number of card readers in system time programme access, etc.

Programmes shall be provided in the main control location for operator to call report including status of any alarm input and output point, listing of points in arm/unarmed, history listing of alarm for past period, etc.

The computer system shall be linked up and communicated with the matrix switching system of the CCTV system for single or multiple camera call up as described in other sections of this Part of the General Specification.

All user programmable functions shall only be accessed by appropriate operator with appropriate passwords and access card if card reader is available. The access level for each function shall be programmable by the highest access level.

A hard disk shall be provided as the primary mass memory storage device. DVD shall be provided as the primary means of backing up the database.

The burglar alarm and security system database including but not limiting to all alarm point data, output point data, cardholder data, access level, priority level, and graphic maps shall be loaded. Supervising Officer shall be informed on what information is required to perform the programming in good time

10.2.1.3.2 Equipment Console and Racks

The console shall match with the decoration and furniture of the room where the operators are stationed.

Security equipment console and racks shall be constructed with hairline stainless steel.

A horizontal flat surface shall be provided at 700 mm above finished floor level for the operator to operate the control keyboards and writing documents. The horizontal surface shall be not less than 1500 mm wide x 700 mm deep. The horizontal surface shall be finished with a plastic laminate. The duress button shall be located in a concealed but convenient position under the flat surface.

All monitors shall be placed at level between 700 mm to 1500 mm above finished floor level unless otherwise accepted by the Supervising Officer.

Digital Video Recorder (DVR) and Network Video Recorders (NVR) shall be located at position easily accessible by the operator for change of storage media.

Vertical rack sections shall be physically attached together to form a continuous rack system. Each end rack shall be provided with a removable side panel. Each rack shall be furnished complete with a full height locking door, front below counter solid door with recessed handle and lock.

The design and construction of the equipment console and racks shall be submitted to the Supervising Officer for approval prior to their fabrication.

SUB-SECTION 10.2.2

ACCESS CONTROL SYSTEM

10.2.2.1 GENERAL

The general design of the Access Control System (ACS) shall make reference to BS EN 60839-11-1:2013, BS EN 60839-11-2:2015 or other relevant recognised international standards. The primary function of ACS system is to authenticate and authorise entry of a person to enter into the premise thereby giving complete protection ensuring security of the premises.

Card access system is for control of personnel access through card reader controlled door based on the person's card number, corresponding passwords and access level. It shall employ various card technologies, e.g. bar code, magnetic card, proximity card and biometrics.

Biometric recognition access system is for control of personnel access by recognising biometrics of that person such as fingerprint, facial, finger/palm vein, etc. Pre-registration of these information in the database of control station is required for verification and authorisation of access.

10.2.2.2 COMPONENTS

A basic access control system shall include the card readers or biometric reading devices (e.g. fingerprint, facial, finger/palm vein), door magnetic contact, electric door locks (e.g. electric door strikes, electromagnetic lock, solenoid drop bolt, etc.), door release buttons and/or toucheless door release sensors, visitor panels or video door phone outside panels and inside stations completed with remote door release buttons, emergency breakglass, controller units, control station for access monitoring and authorisation, control and electrical wirings, etc.

10.2.2.3 PERFORMANCE REQUIREMENTS

An access level hierarchy shall define the doors that the person is allowed to be accessible during a certain time period. The time period shall include specific days and hours.

There shall be no identification on the card to indicate the manufacturer, the identity of cardholder, and the place for use. Only a hot stamped card number shall be shown on the card.

The procedures for a person to go in/out a secured room is as follows:-

(a) The person shall present his card at the card reader or pre-registered biometric at the reader adjacent to the door

(b) The security system computer shall carry out the card/biometric validity checking.

(c) If all tests are passed, the electric lock of the door shall unlock. Data of card no., the person authorised, date and time for all succeeded and failed access authorisation shall be recorded by the security system computer.

(d) The door shall be closed automatically and all locks re-locked automatically.

(e) If the door does not open within a specified time after card/biometric validity test, the electric lock shall re-lock automatically and a low level alarm shall activate.

(f) If the door does not close after an adjustable time (around 15 sec -5 min), an alarm shall activate.

For the system with keypad, the person who goes in a secured room shall key in his password at the keypad adjacent to the card/biometric reader.

In case of emergency, the person who goes out a secured room shall break an emergency breakglass device adjacent to the door. The electric lock shall be unlocked by cutting off electricity supply. At the same time, a high level alarm shall be activated.

The procedures of in/out of the secured room that needs dual card access shall be the same as that for a normal secured room except that the doors shall be opened only after two separate authorised cards have passed the acceptance checking. In the event of failure of acceptance test, an alarm shall be activated. The procedures for evacuation in the event of emergency shall be the same as that for the normal secured room.

Access control system shall be monitored and controlled by the central control station in the main control location.

A system software shall be provided for the central control station for the operator to manage the access level and code matrix with a list of all valid ID numbers, corresponding cardholder's name and name of persons with relevant biometric pre-registered if applicable. The system software shall manage a variety of functions including to add/remove ID groups, set access criteria, control access time, generate access log reports, real-time alerts, etc.

Every access transaction shall be stored in memory. Data stored shall include but not limited to nature, time, date, location, card no., cardholder's /pre-registered person's name and validity status.

When a card is presented at a card reader, the ID number shall be transmitted to the central control station.

Every transaction shall be logged immediately after each transaction. The data of logging shall at least consist of the time of request, name of card holder/biometric pre-registered persons, time of door unlocked and time of door re-locked. Logging report shall be stored in hard disk and also hard copy could be printed out at the printer.

Card reader shall be a one piece device and shall be weather-proof and tamper-proof with tampering switches. Alarm signal shall be sent to central control station when the card

reader is tampered. It shall read the data of the card and transmit the data to the intelligent local controllers or central control station.

For the card/biometric reader installed outside the highly secured room e.g. vault, the card reader shall be integrated with a keypad for entering the passwords.

Both LEDs and an audible tone shall be provided for differentiation of authorised and unauthorised reader usage.

Unless otherwise specified, the electric door lock shall be fail-safe type. When power is cut off, the lock shall be automatically released to allow door opening.

If interconnection is made with the fire alarm system of the premises, the system shall in such a way that all electric door locks of the system are to be released immediately in case of activation of fire alarm unless otherwise specified in the design for fail-secure lock. Alternatively, all electric door locks shall be releasable (either by manual thumb-turn knob or overriding push-button) at will of the people inside the secured area if there are no other routes of escape.

In the event of power failure, the rechargeable backup battery for the controller units shall be able to support at least one (1) hour operation. The memory of the controller units shall be protected at least thirty (30) days without power. The rechargeable back up battery shall get auto recharge once the normal power resumes.

SUB-SECTION 10.2.3

DOORPHONE SYSTEM AND INTERCOM SYSTEM

10.2.3.1 GENERAL

The doorphone system shall be of digital selection and display type complete with secret code door lock release feature. The system shall provide high fidelity communication between the visitors at the entrance and the occupants in a particular premises whom the visitors intend to visit. The system shall enable the occupant to remotely release the entrance door lock to allow the visitors to enter the premises by operating a switch on the handset located within the premises.

The doorphone system shall only permit communication and control between the selected premises and the doorphone panel/door lock at the entrance of the premises. All other premises which are not selected shall be cut off from the system, and voice transmission to and from these premises and operation of the door lock release through the handsets in these premises shall be inhibited intrinsically by the system.

The intercom system shall be provided for temporary refuge space in accordance with Part B Section 4 of the latest version of "Code of Practice for Fire Safety in Building 2011" issued by Buildings Department.

10.2.3.2 COMPONENTS

The doorphone system shall be complete with electro-magnetic lock, doorphone panel, doorphone control unit, handset, combination lock system and other accessories, etc.

The intercom system for temporary refuge space shall include master station located at management office and a slave station at each temporary refuge space.

10.2.3.3 PERFORMANCE REQUIREMENTS OF DOORPHONE SYSTEM

10.2.3.3.1 Electro-magnetic Lock

The entrance shall be provided with electro-magnetic lock which shall have no mechanical moving parts. The lock shall provide instantaneous unlocking with no residual magnetism upon interruption of power supply. Even if the lock is forced open by excessive force, it shall not be damaged and shall be re-locked immediately afterwards. The lock shall be fail-safe type. When power is cut off, the lock shall be automatically released to allow door opening. The circuit for controlling the supply to the electro-magnetic lock shall be designed such that the failure of any electronic components shall cause all the electro-magnetic door locks to be released.

A door release button shall be provided at the inside of the premises and adjacent to the entrance such that by pressing this button, the corresponding electro-magnetic lock shall be released for an adjustable period of 1 to 30 seconds. The lock shall be relocked after the expiry of

the timer period. Another door release button shall be provided at the guard/reception counter for releasing the door lock of the entrance.

10.2.3.3.2 Doorphone Panel

At the entrance of the premises, vandal proof panel with stainless steel faceplate comprising a set of numerical, or alphabetical as specified, selection push button, a "Combination Lock" push button, a LED display unit, self-illuminated operating instruction, a "Clear" push button, a CCTV camera, Braille code instructions for operation, etc. shall be provided. All push buttons and keypads shall be vandal resistant and weatherproof.

Voice message generator for giving audible instructions in Cantonese, Putonghua and English shall be provided as directed by the Supervising Officer for the operational status. The content of the voice message shall be subject to approval. The sound level of the voice message generator shall be adjustable and the maximum level shall not be more than 60 dB at a distance of 1 metre from the doorphone panel.

A set of high fidelity and sensitivity two way communication unit shall be provided in the doorphone panel, and the output shall be clearly audible of at least 60 dB at a distance of 0.5 metre from the doorphone panel.

10.2.3.3.3 Doorphone Control Unit

The doorphone control unit shall be totally enclosed containing all necessary components and accessories for satisfactory doorphone operation. The control unit shall be located as specified by the Supervising Officer and/or the Drawings where an AC supply will be provided.

10.2.3.3.4 Handset

Each premises shall be provided with one handset. A separate and independent push button shall be provided integral with the handset for remotely releasing the entrance door lock. All contacts and other equipment inside the handset shall be of durable type. The handset shall be equipped with independent buzzer for the call tone and the buzzer shall be distinct from the loudspeaker at the handset. The call tone shall be of pleasant type and shall be clearly audible anywhere in the premises.

The handset shall be equipped with one push button for remotely releasing the main entrance door and another separate and independent push button which shall be optional for interfacing with the corridor lighting control system.

10.2.3.3.5 Combination Lock System

Combination lock system for the entrance shall be built in the control unit of the doorphone system. Correct entry of the code at any combination lock control panel shall only cause the electro-magnetic lock of the

corresponding entrance to be released. All the combination lock control panels can be operated at the same time without affecting each other.

The door lock shall be released only when the entry of a pre-assigned code in proper sequence within a pre-set period otherwise a timer will activate causing the code already entered to reset. The unlocked period shall be adjustable from 1 to 30 seconds. When incorrect codes are entered, the system shall reset to its normal condition by pressing the "Clear" button or after a predetermined period adjustable from 1 to 30 seconds.

10.2.3.3.6 Lighting Control Interfacing Panel (Optional)

The lighting control push button in the handset unit shall be connected to the lighting control interfacing panel on the respective floor. When the lighting control push button in the handset is pressed, a voltage-free contact signal will be derived from the doorphone system to the lighting control interfacing panel.

The lighting control interfacing panel shall be equipped with adjustable timer and relay control which are to control the contactors of the respective lighting circuitries in the lighting control boxes in meter room. LED indicating lights shall be provided on the lighting control interfacing panel to indicate the following operational status of each premises: -

(a) Normal;

(b) Triggered; and

(c) Triggered (on hold).

10.2.3.4 PERFORMANCE REQUIREMENTS OF INTERCOM SYSTEM FOR TEMPORARY REFUGE SPACE

The direct intercom system shall be linked to a panel at management office indicating the location of temporary refuge spaces where persons with a disability are waiting for rescue. If the building does not have a management office, such panel shall be placed beside the fire services control panel.

The direct intercom system shall be backed up by UPS for at least 1 hour and provided to every temporary refuge space for communication with the management office of the building.

The height of the intercom slave station shall not be less than 900mm and not more than 1200mm above the floor level.

The intercom system for temporary refuge space shall be designed to allow two-way communication between master station and any one of the slave stations.

SUB-SECTION 10.2.4

SECURITY LOCK AND SWITCH

10.2.4.1 GENERAL

Appropriate security locks and switches shall be provided in the deterrent system for control of personnel access.

10.2.4.2 COMPONENTS

Security locks and switches shall include duress push button, exit control lock, tamper switch and magnetic door contact, etc.

10.2.4.3 PERFORMANCE REQUIREMENTS

10.2.4.3.1 Duress Push Button

Duress push button shall be robust in construction and shall be protected against accidental actuation. The button shall be of self-locking type. Once the device is pressed, it can only be reset by an authorised key.

Contact of the duress push button shall be made of silver alloy rated at the anticipated duty load. Once the device is actuated, the alarm condition shall persist until the associated 'Alarm reset' button in the local control unit is pressed.

10.2.4.3.2 Exit Control Lock

Exit control lock shall include push bar with Braille warning for pushing open. The push bar shall be of heavy construction. Exit control lock shall be housed in a rugged, rust-proof, tampering-proof housing cased in one-piece. The bolt shall be solid and saw-resistant. When the bar is pushed, a local alarm shall sound with alarm signal forwarded to the intelligent local controller.

The circuit of alarm shall be backed up by battery inside the lock.

Exit control lock shall be of fail-safe design such that failure of electricity supply shall not prevent the control lock to be pushed open.

A warning plate indicating both in Chinese and English wording "push open for emergency only, alarm shall sound when pushed" shall be provided.

10.2.4.3.3 Tamper Switch

Tamper switches shall be of plunger type mounted to an enclosure to sense the removal or opening of the enclosure cover. The contact configuration shall be single pole double throw.

10.2.4.3.4 Magnetic Door Contact

Magnetic door contact shall be equipped with concealed magnetic switch and shall be recess mounted into the door.

The design shall offer years of positive fail-safe separating power when door is opened even after years of being held closed. When the door is closed, high contact force shall be developed to ensure proper contact.

The magnetic door contact shall be U.L. listed for the application.

SUB-SECTION 10.2.5

SECURITY CLOSED CIRCUIT TELEVISION SURVEILLANCE SYSTEM

10.2.5.1 GENERAL

The general design of the security closed circuit television (CCTV) surveillance system shall make reference to BS EN 62676-1-1:2014, BS EN 62676-1-2:2014, BS EN 62676-3:2015 and BS EN 62676-4:2015 or other relevant recognised international standards.

10.2.5.2 COMPONENTS

Security closed circuit television system shall be complete with colour cameras, camera enclosures, camera domes with pan/tilt drivers, colour monitors, control keypad, quad units, video recorder, interfacing with the security central control workstation, uninterruptible power supply, cables, wiring, conduits and trunking, etc.

10.2.5.3 PERFORMANCE REQUIREMENTS FOR ANALOG CCTV SYSTEM

10.2.5.3.1 Camera

Camera shall be fully automatic with interline colour image sensor device either progressive scan complementary metal–oxide–semiconductor (CMOS) or charge-coupled device (CCD) type. Camera shall be continuous automatic 'through the lens' white balance, line lock with phase adjustment to ensure roll-free switching recording, automatic gain control and 'backlight compensation' circuitry for high contrast scenes. Camera shall have automatic electronic shutter supported with auto-iris lenses. Camera shall be incorporated with zoom lens of vibration resistant and Infrared (IR) cut filter to improve colour representation.

The camera shall have 75 ohm high definition video output in PAL / NTSC standards. The analog camera shall be designed to operate at 24V ac or 12V dc.

CCTV Camera inside lift shall be supplied and installed by the contractor carrying out the lift works.

10.2.5.3.2 Infrared Light Source

The camera shall be equipped with the infrared light source illumination such that it is capable to capture a visible and clear image or video recording under 0 lux environment. The working distance of the light source shall be better than 20 metres

10.2.5.3.3 Cables and Distribution

All cables shall be run in conduits and trunking. At every 300m coaxial cable or 100m unshielded twisted pair (UTP) cables run, or when video

signal is splitted such that the status and noise from the output have no effect on another outputs, video distribution amplifier shall be provided. Each output of video amplifier shall be driven by isolating amplifier. For Fibre-Optic Transmission system, it shall make use of optical fibres to convey single and multi-channel video signals over long distance. The Optical Transmitters and Receivers shall be able to carry multi-video channels & pan/tilt/zoom control signals through each core of the fibre optic cable. The fibres shall comply with ITU-T G.650 series of specifications. Low loss fusion splicing shall be used for interconnecting fibres. The spliced fibre junctions shall be coated and protected in a sealed enclosure. For outdoor scenario, all cables run in underground duct shall be steel wire armoured and designed for installing in potentially water-logged ducts and draw pits.

10.2.5.3.4 Quad Unit

Quad unit shall enable at least 4 video channel inputs to be real-time displayed in a monitor simultaneously. Quad unit shall also allow the operator to call up full screen display of any camera.

10.2.5.3.5 Monitor

The monitor shall be of the flat panel LED type or other type approved by the Supervising Officer. Monitor shall be capable to handle both digital and analogue television / video signal. The monitor shall be supplied with mounting hardware for desk mount, ceiling mount, wall mount and floor standing to suit the installation requirements.

10.2.5.3.6 Digital Video Recorder

The design of DVR shall be an embedded video processor design for stable and reliable operation. DVR shall digitise video images and store them in the system's video database on its internal hard disk drive. DVR shall record at a minimum resolution of the NTSC/PAL standard of D1 (720 x 576 pixels) / 4CIF(704 x 576 pixels) unless otherwise specified by the Supervising Officer using compression technology and at a rate of at least 25 frames per second per video input with at least 16 non-synchronised video inputs condition. DVR shall have a composite video looping output and several connectors for remote control, alarm inputs and relay outputs.

One standard USB style connector (Version 2.0 or later) shall be available, on the rear panel that interfaces with any USB-SATA/SSD hard disk drive for video backup functionality. DVR shall be able to control various speed domes or receivers via its control ports, and the pan/tilt/zoom action of cameras via the buttons on the front or through the remote control software installed in a personal computer (PC) or remote workstation via internet.

If specified by the Supervising Officer and/or in the Drawings, DVR shall incorporate video motion detection for each video with 16 x 12 blocks

motion detection zones to set up and configurable sensitivity and minimum size for triggering.

DVR shall provide a menu for configuring site information and showing the amount of disk used with the start/end recording times. On-screen display shall be configurable to include date, time, status icons, and position of the information on the screen.

DVR shall incorporate automatic video compensation for each video input and optimised video shall be recorded without the need for calibration of camera phase and input signal strength.

The system shall allow for the selection from a variety of recording mode configurations including end of disk (stop recording when hard disk is full or overwrite oldest image first) and recording mode (simplex [record or playback] or duplex [record and playback simultaneously]). The system shall allow the user to select from a variety of recording speeds during standard operation and to define independent image record rate and picture quality setting during an alarm and the duration of an event recording, i.e. from a minimum of one second to a maximum of 300 seconds.

Physically separated hard disks shall be used for system & program storage and image storage. The image storage hard disks shall be of on-line redundant configuration type, e.g RAID 1, RAID 5, etc. The effective hard disk space for image storage shall have capacity to store at least 31 days or other retention period as specified by the Supervising Officer while all channels are recording at least 25 frames per second or specified by the Supervising Officer at the highest image quality mode. The appropriate retention period could be further determined according to the operational requirements.

10.2.5.3.7 Video Codec

The digital video codec shall use compression technology conforming to the appropriate ITU-T H.264/MPEG-4 Advanced Video Coding (AVC) standard and be capable of streaming video images from one camera input at least 25 frames per second with resolution of at least 1080 horizontal lines. The digital video codec decoder shall be a video decoder capable of accepting digitally encoded digital stream and converting it into standard PAL video format. The digital video codec shall support NTSC/PAL signal format with a programmable resolution. The bandwidth used by the digital video codec module shall be programmable.

10.2.5.4 PERFORMANCE REQUIREMENTS FOR DIGITAL CCTV SYSTEM

10.2.5.4.1 Camera

The internet protocol camera (IP camera) shall operate at 24V ac or 12V dc or Power on Ethernet (PoE). The IP camera shall be equipped with RJ-45 10/100Mbps self-adaptive Ethernet port for network

communication. The IP camera shall be able to use video compression standard H.264, H.265 or JPEG or specified by the Supervising Officer. The IP camera shall be ONVIF (Open Network Video Interface Forum)/ISAPI (Internet Server Application Programming Interface) compliant to enhance interoperability. The IP camera shall also comply with the camera requirements as specified in 10.2.5.3.1.

Resolution of camera shall be minimum 1080P (i.e. full HD or 2MP) or otherwise specified in particular specification.

10.2.5.4.2 Infra Red Light Source and wide dynamic range

The IP camera shall comply with the infrared light source, support low light performance with 0.005 lux in colour mode, adaptive smart IR Technology provides even distribution of IR LEDs in dimly lit or night-time scenes. It shall also support wide dynamic range to ensure glare-free images.

10.2.5.4.3 Wireless CCTV System

The system with wireless sender and receiver can either operate under conventional analogue transmission method or digital video transmission method with wireless local area network (WLAN) of IEEE802.11 standards or contemporary wireless Ethernet protocol basis. The frequency band of transmission and received equipment shall be type approved for use by the Office of the Communications Authority (OFCA).

10.2.5.4.4 Network Switch

The network switch shall provide Ethernet ports. Each port shall support 10/100/1000 Mbps connection speed. For cameras running on PoE, switch port shall be built-in with 802.3af PoE support by optional PoE inline adapter.

10.2.5.4.5 Cables and Distribution

All cables shall comply with the cables and distribution requirements as specified in Clause 10.2.5.3.3. Video streams shall be encrypted.

10.2.5.4.6 Network Video Recorder

NVR shall support all CCTV video management and control function such as live camera image view and playback of the recorded camera images via a PC workstation installed with original design software of the video recorder.

The NVR shall be an embedded operation system design for controlling IP cameras in areas of alarms, video management, real time recording and storage of IP camera image in an IP based CCTV system. The NVR shall be able to record at a minimum resolution of at least 1080 horizontal lines with at least 25 frames per second for each channel under the condition of

at least 16 input channels simultaneously. Video outputs on HDMI and VGA shall also support dual stream function. The NVR shall also comply with the recording and storage requirements as specified in 10.2.5.3.6.

10.2.5.4.7 Video Management System

The central CCTV video management and control function shall be provided by PCs in the IP camera based CCTV system by installing designated client software with functions including but not limited to easily live view the channels, playback, record and store the file, remotely configure the device parameters, control pan/tilt/zoom, get alarm information, respond, and control motion of cameras, etc. The PCs shall serve as local work station in LAN or remote work station via internet. The set of PCs shall be equipped at least with monitor requirements as specified in 10.2.5.3.5, processing unit, keyboard, mouse and accessories to form a complete set of CCTV operation workstation.

Reference requirements may also be obtained from the latest version of "General Technical Specification for Closed Circuit Television System" which is published in the EMSD official website.

SUB-SECTION 10.2.6

SYSTEM INTERFACE WITH LIFT SYSTEM

10.2.6.1 INTERFACE WITH CCTV FOR LIFTS

CCTV facilities inside lift car and lift shaft shall be installed by the contractor carry out lift works. The images taken by the CCTV cameras in lifts shall be displayed at the monitors of security control console in the burglar alarm and security system, and monitor installed in the lift machine room as specified. The works shall include the coordination of the interfacing works.

Upon activation of the alarm push button inside lift car, the image of the concerned lift CCTV shall be displayed on the action monitor and be recorded in the event DVR. However, proper security level can be assigned to the lift alarm such that the activation of lift alarm push button shall not transmit alarm to security control console.

Relevant clause in Part 11 of this General Specification shall be referred on detail arrangement of the interface works.

10.2.6.2 INTERFACE WITH ACCESS CONTROL SYSTEM FOR LIFTS

10.2.6.2.1 General

This feature enables the access control and monitoring of lift car operation by the Burglar Alarm and Security Installation. Basically, there are three modes of access control for lift installation. For Mode 1, a card reader shall be installed to the lift call panel of the specified landing, and only authorised users can call the lift car for their usage. For Mode 2, a card reader shall be installed inside the lift car, and users can present their cards without pressing any floor buttons to get a specific floor as pre-assigned. For Mode 3, a card reader will be installed inside the lift car. After presenting card, users can select the floor which they are authorised to access. The control mode for a lift car of the project shall be either (mode 1 / 2 / 3), (mode 1 and 2) or (mode 1 and 3). The provision of access control for lift installation is subject to the specification requirements of the Supervising Officer.

10.2.6.2.2 Components

The interface shall consist of Intelligent Local Controller, Lift Control Interface Unit, Card Readers, Car Button Isolation/Repeater Panels, associated communication cables and programming.

10.2.6.2.3 Performance Requirements

The access control of lift installation can be enabled or disabled by the Central Control Station manually or according to the pre-defined schedule as specified by the Supervising Officer.

Proximity cards and card readers for access control of lift installation shall be the same type for other areas. The equipment shall be supplied under this works but to be installed by the contractor carry out the lift works.

Any cards used to access the lift installation shall be logged and recorded in the Central Control Station via the intelligent local controller.

If necessary, the Supervising Officer may adopt high-level interface between the Burglar Alarm and Security Installation, and the Lift Installation to perform the above functions. The high-level interface shall do more sophisticated functions and control logics with considerable reduction of cabling and labour works especially when many floors or lift cars need to be controlled and monitored.

10.2.6.2.4 Mode 1 Operation

When user presents a valid card at the card reader installed in the lift call panel at the landing, the card reader will send a signal to the intelligent local controller and this controller will enable the isolated lift call buttons (both directions if applicable) for a fixed period of time for further selection by the user.

10.2.6.2.5 Mode 2 or 3 Operation

When user presents a valid card at the card reader inside the lift car, the card reader will send a signal to energise a specific floor button as pre-assigned or enable all restricted floor buttons of that lift car by Lift Control Interface Unit.

If any of these restricted floor buttons have been pressed, the selections will be sent back to the Lift Control Interface Unit by Car Button Isolation/Repeater Panels and recorded in the Central Control Station. All restricted floor buttons will be automatically reset to restricted mode after a fixed period of time.

SUB-SECTION 10.2.7

WATCHMAN TOUR SYSTEM

10.2.7.1 GENERAL

The watchman tour system is one of the surveillance systems for control of watchman to carry out the required patrol.

10.2.7.2 COMPONENTS

Watchman tour system shall consist of checkpoints, data collector, data transfer units and computer system.

10.2.7.3 PERFOPRMANCE REQUIREMENTS

Data transfer unit shall be located at the specified location, normally the Security Room. During every tour, watchmen shall bring the data collector to record all the data of checkpoints.

Checkpoints shall be in the form of permanent magnetic type encoded with a unique identification number. When read by data collector at predetermined locations, the collector shall register the code of the checkpoint as well as the date and time of each reading. Checkpoints shall be installed permanently on to wall or locations as specified by the Supervising Officer and/or as shown on the Drawings. Checkpoints cannot be removed by anyone using tools and chemicals, etc.

Data collector is to read the coded checkpoints. By simply guiding the head over the magnetic checkpoints, the collector can read the checkpoint data and store the exact time, date and location of the checkpoint in its memory. Data collector shall be of vandal proof and weatherproof in construction.

Data transfer unit is to print out the performance report using the data in the data collector. Data transfer unit can download data stored in the collector and transfer it to computer. Data in the collector shall not be erased until the transfer has been properly executed.

10.2.7.3.1 Checkpoint shall be: -

(a) rugged in design

(b) tamper-proof

(c) resistant to vandalism

(d) maintenance free

(e) efficiency unimpaired even by paint, dirt, grease, or ice up to a thickness of 1mm

10.2.7.3.2 Data collector shall be:-

(a) no contacts or switches and suitable for situations that require rugged operation

(b) tamper-proof

(c) battery operated

(d) weather-proof

(e) provided with LED display

(f) able to display the next station to be toured

(g) programmable for unlimited staff identification

(h) able to generate incident report by key in user programmable codes

10.2.7.3.3 Data transfer shall be:-

(a) suitable for connection to any serial/parallel printers and PC

(b) equipped with visual indicators

(c) supported by software to generate reports, statistical trend-analysis, long term evaluation and in-depth performance analysis. All software shall be run on a PC and print reports on a printer.

(d) able to upload tour schedule to data collector from computer

(e) able to download tour records from the data collectors to computer

SUB-SECTION 10.2.8

FIELD ALARM DEVICE

10.2.8.1 GLASS BREAKAGE DETECTOR

The watchman tour system is one of the surveillance systems for control of watchman to carry out the required patrol.

10.2.8.1.1 General

The general design of the glass breakage detector shall make reference to IEC 62642-1:2010, IEC 62642-2-71:2015, IEC 62642-2-72:2015 and IEC 62642-2-73:2015 or other relevant recognised international standards. Different technologies, such as detecting audio frequency, detecting movement, etc. can be employed in glass breakage detectors.

10.2.8.1.2 Components

The glass breakage detection system shall comprise glass breakage detectors, power supply, local control panel/intelligent local controller and other accessories, etc.

10.2.8.1.3 Performance Requirements

(a) Glass breakage detector shall detect breaking of glass by means of flex detection and audio discrimination.

(b) The detector shall have internal self-checking to verify the functionality of the microphone and audio detector circuit.

(c) When the detector is triggered, suitable display shall be provided to indicate the alarm condition.

(d) The electronic circuit of the detectors shall be protected against high radio frequency interference

(e) The detector shall be constructed as a single integrated device and housed in a tamper-proof housing with tampering switches. Alarm signal shall be sent to local control panel/intelligent local controller when the housing is tampered.

10.2.8.2 MOVEMENT DETECTOR

10.2.8.2.1 General

Unless otherwise specified, the general design for movement detectors shall make reference to IEC 62642-1:2010, IEC 62642-2-2:2010, IEC 62642-2-3:2010, IEC 62642-2-4:2010 and 62642-2-5:2010 or other relevant recognised international standards. Movement detector in burglar

alarm and security system is to detect unauthorised intrusion. It shall employ various technologies such as passive infrared, ultrasonic, microwave and combination of the above.

Detectors shall be suitable for the environment and application and may incorporate more than one technology.

10.2.8.2.2 Components

The movement detection system shall comprise movement detectors, power supply, local control panel/intelligent local controller and other accessories, etc.

10.2.8.2.3 Performance Requirements

(a) Movement detector of passive infrared microwave verified type shall detect movement by passive infrared technology and microwave technology. An alarm signal shall be sent to the intelligent local controller/central control station if both of the passive infrared and microwave components in the sensor have been activated within a specified time.

(b) For the passive infrared component, the detectors shall keep constant monitoring of the 'thermal pattern' of the protected area. Any rapid alteration of the infrared energy within the protected area shall trigger the alarm of the passive infrared component. However, a slow and gradual change in temperature shall not trigger an alarm. The infrared beam shall not penetrate glass, thin wall or plastics.

(c) The microwave component shall keep constant monitoring of the protected area by detecting the Doppler shift of microwave emitted from the detector. The detector shall generate 'K' band microwave frequency of around 24 GHz and emit it as unmodulated electromagnetic field to the protected area or volume.

(d) The range of detection shall be adjustable.

(e) The electronic circuit of the detectors shall be protected against high radio frequency interference and shall be insensitive to thermal and optical source of interference.

(f) Indicator for trouble shooting shall be provided for easy identification.

(g) The detector shall be designed as a single integrated device and housed in a tamper-proof housing with tampering switches. Alarm signal shall be sent to local control panel/intelligent local controller when the housing is tampered.

SECTION 10.3

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 10.3.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

10.3.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-Section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

After connecting up, the system shall be field tested and tuned up to the required sensitivity by simulation of required alarm action and condition for every alarm device. The system performance in multi-alarm situation shall be tested by the simultaneous simulation of the required alarm action and condition for a group of randomly selected devices.

SUB-SECTION 10.3.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

10.3.2.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during Maintenance Period shall also comply with the specific requirements in this Sub-Section.

Operation, servicing and maintenance of the Installations, if specified, shall also refer to the equipment manufacturer's recommendations and specifications.

10.3.2.2 INSPECTION REQUIREMENTS DURING MAINTENANCE PERIOD

Quarterly inspection shall be carried out or at any time as instructed by the Supervising Officer.

All inspection activities shall be recorded in log book.

10.3.2.3 MAINTENANCE REQUIREMENTS

Maintenance services for the Installations shall be provided during the Maintenance Period. The services shall included: -

(a) 24 Hours Attendance of On-Call Maintenance and Emergency Repair Services

An emergency service team consists of technically qualified, skilled and experienced technicians shall be maintained for prompt attendance of emergency services at any time. The phrase 'at any time' shall cover 24 hours a day, 7 days a week throughout the year including Sundays and Public Holidays. Fault calls may be raised by the operational staff of the building /premise concerned, the Supervising Officer or his representatives verbally or in written form at any time.

Upon receipt of fault call, the emergency service team shall arrive at the site of incident within reasonable time, normally within 1 hour, to carry out emergency services. The emergency services shall include overtime works, all mechanical, electrical and electronic works and inspection, testing, adjustment, commissioning and cleaning which are found necessary to reinstate the safe and satisfactory working condition and operation order of the installation as soon as possible and within 24 hours.

(b) Quarterly Maintenance of System Equipment.

Maintenance services shall be carried out at any time as instructed by the Supervising Officer. The maintenance services may need to carry out outside normal working hours if required by the Supervising Officer.

(c) Replacement of Parts Due to Normal Wear and Tear

The replacement of parts due to normal wear and tear shall be included under the Works upon identify in the quarterly inspection or as requested by the Supervising Officer.

(d) Temporary Provisions

Temporary replacement for any damaged /defective equipment, part or component of the system shall be provided if they need to take away from the system for repair work.

10.3.2.4 SCOPE OF MAINTENANCE SERVICES

Maintenance services shall be carried out in sequence in according with the manufacturer's operation and maintenance manual and to the Supervising Officer's satisfaction as follows: -

(a) Electrical wiring, alarming, monitoring, sensing, detection, indication, operation, signal transmission/receiving devices and equipment and all remote/main circuits are in safe and satisfactory working condition and operation order.

(b) Each alarm device or manual call point at work station or within protective zone/area will instantly activate the common alarm circuit upon its operation.

(c) Activating the common alarm circuit will cause the automatic operation of the local and/ or remote alarm and successful transmission of the alarm signal to the security control centre via the remote alarm transmission system.

(d) The correct operation of security control consoles shall include correct display of device in alarm.

(e) The correct operation of all indicators including fault warning and of all alarm devices shall be checked and recorded.

(f) All sensing devices shall be tested in accordance with manufacturer's recommendation and shall be adjusted for satisfactory operation and alignment if necessary to suit the layout of the protected floor/area. Similarly, where lenses, optical/audio sending and/or receiving devices are fitted, they shall be properly cleaned and adjusted for alignment with proper material and tools.

(g) All camera lenses and monitor screens shall be cleaned and checked for overall clarity of the picture. All video cables and mains leads shall be checked for sound electrical connections. Controls and switches shall be checked and verified for correct and proper operation.

(h) All electrical and/or mechanical locks shall be examined for correct operation.

(i) The remote alarm transmission system to the security control centre shall be examined and tested according to proper procedures to be agreed with Commissioner of Police and with the management of the control centre.

PART 11 - LIFT, ESCALATOR AND PASSENGER CONVEYOR INSTALLATION

SECTION 11.1

INSTALLATION AND EQUIPMENT REQUIREMENTS

SUB-SECTION 11.1.1

GENERAL REQUIREMENTS

11.1.1.1 TRAVELLING CABLE

Travelling cables between the lift well and lift car terminal boxes shall be suspended by looping over reels or by suitable clamps and terminated at a suitable position that they will not be prone to damage by water seepage.

The construction of the travelling cables shall comply with EN 50214:2006 which in general shall fall within the following 5 types of cables:

Type	Maximum Speed Limit	Maximum Freely Suspended Length	Remark
Rubber-insulated & sheathed, flexible cable with 4 to 48 cores	1.6 m/s	35 m	Higher limits permissible if strain - bearing material is included
Rubber-insulated & sheathed, flexible cables with 3 to 18 cores	1.0 m/s	15 m	
PVC-insulated, and sheathed, flexible cables with 4 to 72 cores	No limit	No limit	
PVC-insulated and sheathed, flexible cables with 3 to 24 cores	1.6 m/s	35 m	Higher limits permissible if strain - bearing material is included
Rubber-insulated, flexible cables with 36 to 72 cores having strain - bearing centre	No limit	No limit	

Travelling cables shall be hung in the lift well, suspended from one end only, for sufficient time to avoid twisting or kinking before making final connections. Facility shall be provided on both car and well cable anchorages to permit each cable to be rotated to counter accumulated twist. Cables with 12 or more cores shall be used, and all cables that are to be grouped together shall be of the same size unless otherwise approved by the Supervising Officer.

11.1.1.2 EMERGENCY LIGHTS FOR THE CONTROL PANELS IN LIFT MACHINE ROOM

Emergency lights for control panels in the lift machine room of adequate illuminance shall be provided in the lift machine room. The illuminance at each control panel shall be not less than 50 lux. These lights shall be operated by batteries and shall be manually operated by a switch located at a convenient position inside the machine room.

11.1.1.3 BATTERIES AND CHARGERS

The batteries for each lift, escalator, passenger conveyor, powered vertical lifting platform and stairlift shall be capable of maintaining a supply to the connected emergency load for a minimum period of two hours. The batteries shall be of sealed, high rate maintenance free nickel-metal hydride type, or a type of better functions and performance and approved by the Supervising Officer and shall have a guaranteed life expectancy of at least 4 years. They shall not have any memory effect as to affect their usable life or performance. The nickel-metal hydride battery shall comply with IEC 61951-2:2017 where appropriate. The battery charger shall be compatible with the batteries used. The charger shall comply with EN 60335-2-29:2004+A2:2010 or IEC 60335-2-29:2016/AMD1:2019 and be capable of fully re-charge the batteries in not more than 12 hours.

11.1.1.4 VOLTAGE-DIP-RIDE-THROUGH DEVICE

The criteria set out in the Circular No. 16/2011 (Provision of Voltage-Dips Ride-Through Device issued to all Registered Lift/Escalator Contractors and Engineers) issued by the Electrical and Mechanical Services Department, the Government of the HKSAR shall be considered before proposing to install voltage-dip ride-through device on lifts and escalators.

11.1.1.5 POST VOLTAGE-DIP OPERATION

The post-voltage-dip-operation means for all lifts shall be provided to comply with the statutory codes and requirements.

11.1.1.6 LIFT RIDE QUALITY

The lift ride quality generally applies to passenger lifts with speed less than 8 m/s. For passenger lifts having speeds in the range of 6 to 8 m/s, a multiplier of 1.5 should be applied to the vibration limits. The requirements for judging the lift ride quality are stated in the following clauses.

Lateral and vertical vibrations of a lift car are the two main motion elements and the perceptible levels of which will affect the riding comfort perceived by the passengers. For passenger lifts with speed less than 6 m/s, the acceptable maximum peak-to-peak lateral vibration and vertical vibration are both 0.25 m/s^2. A multiplier of 1.5 should be used for the passenger lifts having speeds in the range of 6 to 8 m/s.

The acceptable equivalent sound pressure level without fan or air conditioning in operation is 55 dBA.

Acceleration/deceleration is the rate of change of vertical axis velocity. The acceptable maximum acceleration and deceleration are both 1 m/s^2.

Jerk is the rate of change of vertical axis acceleration and is the motion felt by the passengers. It is to compromise between high speed performance and passenger comfort. The acceptable maximum jerk is 4 m/s^2.

11.1.1.7 SAFETY REQUIREMENTS

Necessary safety precautions in carrying out maintenance and repair works of the Installations, in particular when any safety circuit is bypassed or interfered affecting the safety of the lift users, shall be made. At least two lift workers shall be deployed for carrying out the following lift works (other than for stairlifts and vertical lifting platforms):

(a) Attending any lift breakdown call;

(b) Releasing passengers trapped in a lift which stopped outside the unlocking zone;

(c) Manually releasing the brake of the traction machine of an electric lift, or operating the manual emergency lowering or ascending device of a hydraulic lift;

(d) Works in the lift pit;

(e) Maintenance of the counterweight assembly;

(f) Carrying out maintenance works, while the lift is in motion, which cannot be performed by the worker who is controlling the motion of the lift;

(g) Lubricating the suspension ropes;

(h) Inspecting the conditions of the car top sheave;

(i) Measuring the braking distance of electric traction lift;

(j) Disassembling and checking the machine brake;

(k) Testing the electrical safety device of the landing door or car door lock;

(l) Maintenance of anti-rebound device and switch;

(m) Maintenance of buffer;

(n) Maintenance of safety gear mechanism, speed reducing elements for ascending car overspeed protection means installed at bottom of lift car;

(o) Maintenance of electric safety chain at lift pit;

(p) Maintenance of the following components of a hydraulic lift: -

- safety gear, pawl and clamping devices;
- anti-creep device and hand pump;
- rupture valve, one way restrictor, manual lowering valve; and
- hose/ pipe work.

All actions taken and work done shall be recorded in the log book before the workers leave.

SUB-SECTION 11.1.2

ELECTRIC AND HYDRAULIC LIFT

11.1.2.1 GUIDES AND FIXING

Rigid steel guides shall be used for guiding lift cars and counterweights throughout their travel.

The strength of the guides, their attachments and joints shall comply with BS 5655-9:1985 or ISO 7465:2007 or EN 81-20:2014 or EN 81-50:2014 or other relevant international standards and be sufficient to withstand the forces imposed due to the operation of the safety gear and deflection due to uneven loading of the car; and

The guides shall have machined surfaces for rated speeds exceeding 0.4 m/s.

Guide brackets shall be provided at suitable intervals and shall be embedded into the walls enclosing the lift well or fixed to such walls by self-drilling anchor bolts as the standard practice for fixing guide rail brackets in reinforced concrete walls of 100 mm thick or more.

Wood or fibre blocks or plugs shall not be used for securing any guide brackets.

11.1.2.2 BUFFERS

Buffers shall be provided at the bottom limit of travel for cars and counterweights.

Energy accumulation type buffers shall only be used if the rated speed of the lift does not exceed 1 m/s.

Energy dissipation type buffers may be used whatever the rated speed of the lift.

11.1.2.3 COUNTERWEIGHTS

The counterweight shall be of metal and constructed from multiple sections, contained and secured within a steel frame, and shall equal to the weight of the complete car plus approximately 40% to 45% of the contract load.

At least, four guide shoes, capable of being easily renewed or having renewable linings shall be provided on the counterweight.

If there are pulleys on the counterweight they shall incorporate devices to avoid:

(a) the suspension ropes, if slack, leaving the grooves; and

(b) the introduction of objects between ropes and grooves.

11.1.2.4 SUSPENSION

11.1.2.4.1 Suspension Ropes

Cars and counterweights shall be suspended from steel wire ropes of best quality, the size and number being in accordance with EN 12385-5:2002. The factor of safety for the suspension ropes shall be not less than 12 in the case of traction drive with three ropes or more.

The suspension ropes shall be constructed to comply with EN 12385-1:2002, EN 12385-5:2002 or ISO 4344:2004 EDTN2 and shall have a life expectancy of at least 6 years for application on similar lifts. The suspension ropes shall be manufactured to ISO 9001:2000 by a reputable manufacturer. Relevant test certificates or test reports issued by organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS shall be submitted for approval. The test certificates or test reports specially referred to the ropes delivered to the Site shall be provided with an undertaking submitted. The documentary evidence to verify the place of manufacture and authenticity of the ropes delivered to the site or installed shall be provided.

11.1.2.4.2 Number of Ropes and Safety Factor

The minimum number of suspension ropes shall be two and they shall be independent. Where reeving is used the number to take into account is that of the ropes and not the falls.

The safety factor of the suspension ropes shall be at least:

(a) 12 in the case of traction drive with three ropes or more;

(b) 16 in the case of traction drive with two ropes; and

(c) 12 in the case of drum drive.

11.1.2.4.3 Minimum Nominal Diameter

The nominal diameter of the ropes shall be at least 8 mm.

11.1.2.4.4 Compensating Rope

For travels over 30 m, the compensation for hoisting ropes shall be provided. For lift speeds of 2.5 m/s or below, quiet operating metallic chains embedded in a sheath made up of plastic or similar material or other similar devices may be used as the means of compensation. For lift speeds above 2.5 m/s, compensating rope with tensioning pulleys shall be provided.

For lift speeds over 3.5 m/s, the compensating rope shall be equipped with anti-rebound devices.

11.1.2.4.5 Protection for Traction Sheaves, Pulleys and Sprockets

For traction sheaves, pulleys and sprockets, provisions shall be made according to Table 10 of EN 81-20:2014 to avoid: -

(a) the ropes/chains leaving the pulleys and sprockets, if slack;

(b) the introduction of objects between ropes/chains and pulleys/sprockets; and

(c) body injury.

The device used shall be constructed so that the rotating parts are visible, and inspection or maintenance operation will not be hindered. If they are perforated, the gaps shall comply with ISO 13857:2008. The dismantling shall be necessary only in the following cases:

(a) replacement of a rope/chain;

(b) replacement of a pulley/sprocket;

(c) re-cutting of the grooves.

11.1.2.4.6 Obstruction Switch

A safety device shall be provided to protect human and the equipment when the car or counterweight meets an obstruction when moving downwards.

The safety device shall not affect the movement of the lift car under either the inspection operation or the emergency electrical operation.

11.1.2.4.7 Motor Run Time Limiter

A safety device shall be provided to causing the de-energising of the motor.

11.1.2.5 TERMINAL STOPPING AND FINAL LIMIT SWITCHES

Each lift shall be provided with normal terminal stopping switches and final limit switches. They shall be positively operated by the movement of the car. These switches shall either be mounted on the car frame or in the lift well.

For single or two speed lifts either, the final limit switches shall:

(a) Open directly by mechanical separation of the circuits feeding the motor and brake, and provisions shall be made so that the motor cannot feed the brake solenoid; or

(b) Open, by an electrical safety device, the circuit directly supplying the coils of the two contactors, the contacts of which are in series in the circuits supplying the motor and brake.

In the case of DC variable voltage or AC variable speed lifts, the final limit switches shall cause the rapid stopping of the machine.

11.1.2.6 GUARDING

All dangerous parts shall be effectively guarded. Where applicable, components shall be inherently safe, obviating the need for external or removable guards.

Where two or more lifts are installed in a common lift well, the Building Contractor shall provide a partition either in the form of solid reinforced concrete or prefabricated wire mesh screen with earthing connection to separate each lift from an adjacent lift or its counterweight. The height of the partition shall be checked to ensure that it shall be erected from the lift pit to the full height of the lift well and across the whole depth of the lift well.

Counterweights shall be guarded by means of a rigid metal screen extending from a position 0.30 m above the lift pit floor to a position at least 2.50 m above the lift pit floor.

11.1.2.7 CAR FRAMES

Every lift car body shall be carried in a steel car frame sufficiently rigid to withstand the operation of the safety-gear without permanent deformation of the car frame.

The deflection of the members carrying the platform shall not exceed 1/1000 of their span under static conditions with the rated load evenly distributed over the platform.

At least four renewable guide shoes, or guide shoes with renewable linings, or sets of guide rollers shall be provided, two at the top and two at the bottom of the car frame.

For freight lift in markets and abattoirs, the bottom-supporting frame for car body shall be made of hot-dip galvanised mild steel or adequately protected against corrosion by epoxy paint coating system designed for marine application.

11.1.2.8 CAR ENCLOSURES

11.1.2.8.1 Non-combustible Materials

Lift cars, excluding linings, shall be constructed of non-combustible materials.

11.1.2.8.2 Car shall be Completely Enclosed

The car of every lift shall be completely enclosed by solid walls, floor and roof and shall, save for any opening affording normal access of users

thereto or for ventilation apertures or emergency exit not have any openings or open work panels in the sides.

The interior clear height of the car, i.e. height between the finished floor level and the underside of the false ceiling, shall be not less than 2.4 m.

11.1.2.8.3 Platform Loading

Car platforms shall be of framed construction. Platforms for passenger lift cars shall be constructed on the basis of rated load, this being evenly distributed. Platforms for freight/goods lift car shall suit the particular conditions of loading.

11.1.2.8.4 Internal Construction of Passenger Lift Car

Unless otherwise specified in the Particular Specification and/or on the Drawings, passenger lift car enclosure shall be of steel with 4 mm studded rubber floor to colour and pattern as approved by the Supervising Officer. The whole of the internal face of the car shall be of 1.5 mm thick hairline stainless steel sheet with/without standard etched pattern or mirror surface with/without standard etched finished stainless steel sheet as approved by the Supervising Officer. A stainless steel handrail shall be provided on three sides of the lift car, extended to within 150 mm of all corners and a stainless steel skirting panel approximately 100 mm deep shall be provided. Hairline finished stainless steel false ceiling with concealed fluorescent or Light Emitting Diode (LED) luminaries as approved by the Supervising Officer and ventilating fan complete with metal ceiling diffuser shall be provided. The layout of the false ceiling and lighting fittings shall be subject to the approval by the Supervising Officer.

The fan shall be of quiet running type having a noise level not greater than 55 dBA when measured at a distance of 1 m from the fan and it shall be capable of handling at least 20 air changes per hour of lift car volume, with car doors closed. The effective area of ventilation apertures situated in the upper part of the car shall be at least 1% of the available car area, and the same applies for any apertures in the lower part of the car.

11.1.2.8.5 Internal Construction of Freight/Goods Lift Car in Markets and Abattoirs

Unless otherwise specified, the complete enclosure of the lift car shall be constructed in stainless steel and as detailed below:-

(a) Car walls

All car wall panels shall be of 1.5 mm thick stainless steel sheet. The side and rear wall panels shall each be provided with three-equally-spaced full length lateral protective oak battens of 200 mm wide by 25 mm thick. The surface of the wood battens shall be covered with 1.0 mm thick stainless steel sheet fixed by stainless steel screws. The top battens shall be fixed at a height of 1100 mm above finished car floor level.

(b) Car roof

The car roof shall be of 1.5 mm minimum thickness stainless steel sheet. It shall be able to support the weight of two persons, i.e. to withstand a vertical force of 2000 N at any position without causing permanent deformation.

Ceiling lights shall be of recessed energy efficient type and be protected by stainless steel metal bars.

A recessed ceiling fan complete with heavy duty metal diffuser and capable of providing 20 air changes per hour in the car shall be provided. The fan when running shall have a noise level not greater than 58 dBA measured at a distance of 1 m from the fan.

The internal clear height of the car shall be not less than 2500 mm.

(c) Car floor

The car floor shall be constructed of stainless steel plate with 2 mm high multi-grip non-slip pattern, making a total thickness of 5 mm. The floor construction shall be in the form of a metal drain pan, the rear and side edges shall be folded up by 100 mm from the floor to form the drain pan. All joints and the corners of the pan shall be welded to prevent water leakage. The finished car floor level shall be made to fall to a drain outlet located at a rear corners position. A stainless steel drain water storage tank of not less than 0.035 m^3 holding capacity shall be provided at a suitable location under the drain pan to collect water from the drain outlet. The tank shall be completed with a mechanically operated automatic emptying device.

(d) Drain water storage tank

The drain water storage tank shall be constructed with 1.5 mm thick stainless steel and of sizes 350 x 350 x 300 mm(H) approximately. The tank cover of sizes 250 x 250 mm with stainless steel flat bar grating on top shall be removable to facilitate future maintenance and shall form part of the car floor. Holes of approximate 4 mm diameter shall be drilled through the cover for draining of water into the tank. A 25 mm dia. stainless steel pipe shall be provided with one end connected to the bottom of the tank and the other end left open-ended but controlled by a stop valve. The stop valve shall be kept close by a spring on one side and a roller connected to the other side. A metal bar of 450 mm long approximately shall be fixed at the bottom of the lift pit and when the lift reaches its lowest floor, the roller will be pressed by the metal bar which then open the stop valve and release the water collected in the tank into the lift pit. A float switch shall be provided in the water storage tank which upon operation shall transmit a signal to call for the car to descend to its lowest floor

position. Water collected in the pit will be pumped away by submersible pump provided by others.

(e) Control and indication

Car control buttons shall be the push/electronic touch button type as specified in this Sub-section.

Position indicators shall be of vandal resistant type securely mounted to the back of the faceplate which shall be of tamper-proof type. Legends shall be etched into stainless steel faceplate in black 13 mm high characters.

11.1.2.8.6 Internal Construction of Freight/Goods Lift Car

Unless otherwise specified, freight/goods lift cars shall be constructed in accordance to the requirements of Freight/Goods Lift Car in Markets and Abattoirs, except that the floor drain system is not required.

11.1.2.8.7 Internal Construction of Service Lift Car

Unless otherwise specified, the entire internal surfaces of the service lift car shall be 1.5 mm thick stainless steel sheet. A recessed energy efficient ceiling light shall be provided. A removable stainless steel shelf shall also be provided unless otherwise specified.

11.1.2.8.8 Maintenance Facilities

A 13A 3 pin switched socket outlet protected by residual current circuit breaker (R.C.C.B.) shall be provided on both the top and bottom of the lift car. The R.C.C.B. will be included in the Electrical Installation Work. A permanent lighting, suitably protected and separately switched, shall also be fitted on top of the lift car.

11.1.2.8.9 Car Illumination

Unless otherwise specified, every lift car shall be adequately illuminated by a minimum of two energy efficient luminaries with separate electronic ballast or LED luminaries as approved by the Supervising Officer. The illumination level shall not be less than 120 lux on the lift floor level and 150 lux minimum at the car controls. For accessible lift, the illumination level shall not be less than 150 lux on the lift floor level and at the car controls.

11.1.2.8.10 Emergency Lighting

Every lift car shall be provided with emergency lighting operated by a rechargeable battery supply. The lighting shall be automatically switched on in the event of failure of normal power supply to the lift. At least one of the energy efficient or LED luminaries shall be self-maintained emergency type with rechargeable batteries having a capacity sufficient to maintain the lighting for two hours upon failure of the normal lighting

supply. The charger shall be capable of fully re-charging the batteries in not more than 12 hours.

The emergency lighting shall be capable of ensuring the illumination level not less than 5 lux at the following points:-

(a) at each alarm initiation device in the car and on the car roof;

(b) in the centre of the car, 1 m above the floor;

(c) in the centre of the car roof, 1 m above the floor.

11.1.2.8.11 Emergency Alarm Device

An emergency alarm push button together with a buzzer (or an alarm bell), an intercom, an indicating light and a closed circuit television (CCTV) camera shall be provided in the lift car and be connected to the building management office or the caretaker's office, and the lift machine room, such that the person inside can speak to the building management office or the caretaker's office as the case may be.

In the building management office or caretaker's office with 24 hours attendance, there shall be a buzzer, indication light(s) (one for each lift) and an intercom connected to the lift car(s). A reset switch shall be provided for the buzzer and the indication light.

There shall be another buzzer (or alarm bell) connected to the alarm push button in the lift car provided at high level on the landing of designated point of entry.

The pattern of lift alarms shall be distinguishable from that of fire alarms and shall be of the following two-tone pattern:-

Low frequency:	600 Hz (±15%)	Duration: 600 ms (±20%)
High frequency:	920 Hz (±15%)	Duration: 300 ms (±20%)

The indication light in the lift car shall be for acknowledgement in the form of a blinking light adjacent to the intercom speaker. A notice 'When light blinks, it indicates your emergency call has already been received. Please be patient and wait for the rescue' (in English and Chinese) as approved by the Supervising Officer shall be provided next to the indication light.

The pressing of the emergency alarm push button inside the lift car shall actuate both buzzers and indication lights. The buzzer inside the car shall sound only when the emergency alarm push button is pressed. The emergency alarm push button shall have tactile marking of a bell and coloured yellow.

The electricity supply for these alarm devices and the system including the CCTV camera shall be backed up by rechargeable batteries and where

emergency power supply is available, be also fed by an emergency power supply.

11.1.2.8.12 Emergency Exits

Each lift car shall be provided with an imperforate emergency exit in the roof of minimum size 500 mm x 400 mm.

Panels for emergency exits shall: -

(a) be opened only from the outside;

(b) be clear of any apparatus mounted above the roof of the lift car;

(c) be capable of being opened, re-closed and re-locked without a key; and

(d) be provided with an electric safety device which will prevent operation of the lift when the panel is not locked, operate the buzzers (or alarm bells) and also cause the car top ventilation fan to stop.

11.1.2.9 CONTROL AND INDICATION IN CAR

11.1.2.9.1 Control Station in Car

Each lift car shall have a flush mounted control station comprising: -

(a) Call buttons with acceptance signals engraved in Arabic number to correspond with the landing served;

(b) An alarm push button with indicating light and buzzer, and with protection from being operated accidentally; the colour of this button shall be yellow;

(c) ‘door open’ and ‘door close’ push buttons;

(d) Audible and visible signals in connection with the overload device;

(e) Light switch, alarm reset switch, fan switch and cleaner's ‘Stop-switch’ keeping the car door open in the form of key switches or housed in a recessed metal box with hinged or sliding lid which will be key-locked; and

(f) Two-way intercom speaker.

All wordings in the control station shall be engraved in both English and Chinese characters. The floor number markings shall have suitable size, line thickness and colour contrast and shall be easily legible by users. The material for the control station shall be stainless steel with a thickness of

not less than 2.5 mm. The control station shall be fixed onto the car panel by stainless steel screws of secret-head type.

When the markings on the buttons are not easily legible by user due to inadequate contrast with the background of lift control panel, the following shall be incorporated:

(a) An identical floor number indication for call buttons and appropriate markings for other buttons shall be engraved in the panel beside to all buttons. The size of floor number indication shall be the same as the size of floor number on the call buttons. The colour of the floor number indication and its background shall be approved by the Supervisor Officer; or

(b) Back-lit type lift control button shall be installed. The changing colour back-lit LED control button illuminated on the character / symbol and the surrounding edges with contrasting colour before and after call acknowledgement shall be provided for intercom button, door opening button, and call buttons for the landing in all passenger lift cars. Illuminated back-lit button with single colour shall be provided for emergency alarm button. Tactile markings shall not be arranged with back-lit.

Information and samples of the indication plate and back-lit buttons shall be submitted to Supervisor Officer for approval.

11.1.2.9.2 Additional Control Station

For passenger lifts of 21 persons capacity or larger, and all accessible lifts, two car control stations, one on either side of the car doors, shall be provided such that one station shall have the above functions (a), (b) and (c) only and one station shall have all the functions (a) to (f).

Additional control stations in lift car shall be provided in case there is more than one car door.

11.1.2.9.3 Control Station Equipped with Attendant Control

For lifts equipped with attendant control, the control station shall also incorporate: -

(a) A non-stop button for the purpose of bypassing landing calls, but the calls shall remain registered until answered. This button shall be inoperative unless the lift is operated by an attendant; and

(b) A key-operated attendant control switch

The additional functions specified in this clause shall be provided in the Control Station.

11.1.2.9.4 Car Direction and Position Indicator

The direction indicators shall be of illuminated directional indicator with an illuminated area not less than 1125 mm^2 and height not less than 50 mm. The position indicator shall be of digital type display unless otherwise specified.

The characters on the position indicator shall have a minimum height of 50 mm and easy to read even from a wide angle of view and under an illumination level of 50 lux to 500 lux.

The indicators shall be securely mounted onto the back of faceplates.

Voice annunciator shall be provided for passenger lift, bed/passenger lift, accessible lift and freight lift to announce the floor due to be stopped. Unless otherwise specified, the announcement shall be in Cantonese, Putonghua and English. Voice synthesiser or similar device shall be submitted to demonstrate the quality of announcement and a voice tape shall also be submitted to verify the context of the announcement prior to installation.

11.1.2.9.5 Push/Electronic Touch Button

All push buttons except for cars in office buildings shall be vandal-resistant design and flush mounted construction. The control of buttons shall be equipped with contact-less function/feature (for one control station) unless otherwise specified in the Particular Specification. The contact-less function/feature for alarm button inside lift car shall be excluded and the function/feature shall be disabled for fireman's lift when the fireman's switch is activated.

Micro-movement push buttons shall be provided in place of vandal-resistant buttons for passenger lifts in office buildings and where specified in the Particular Specification. Electronic touch buttons are not preferred as they may not suit the visually impaired and blind people.

Both the halo and number of the button shall be illuminated in acknowledgement of the call. The halo and number shall be formed with flame retarding materials. Shock loads due to pressing of the button must be borne by the body of the unit and not by the contacts.

11.1.2.9.6 Inspection Control Station

A control station shall be fitted on the car roof and in the pit and it shall be so made that when in use:

- Switch lock or other similar device to lock the 'NORMAL/INSPECTION' switch to the 'Inspection' mode;

- it is not possible to control the car from any other position;

- the car will only travel at a speed not exceeding 0.63 m/s and not exceeding 0.3 m/s when the vertical distance above any standing area on car roof is less than 2.0 m (for the last 2 m);

- the car will not move until all safety devices are in, and remain in, the safe position; and

- the car will move only whilst two buttons are subjected to continuous pressure.

The control station shall comprise the following switches clearly marked:

- 'STOP' switch;

- 'NORMAL/INSPECTION' switch;

- directional inspection buttons, protected against accidental operation; and

- movement buttons, protected against accidental operations.

11.1.2.9.7 Information Display System

The information display system with colour Liquid Crystal Display (LCD) monitor(s) or similar slim type monitor(s) approved by the Supervising Officer for audio and video (AV) information display inside the lift car at the location(s) shall be supplied and installed as specified in the Particular Specification or Drawings, or as instructed by the Supervising Officer.

The system shall display the floor position, lift travelling direction, the lift status messages as well as floor directory and date/time. Separate car direction and position indicator(s) is/are not required but the provision of voice announcement shall still be complied with.

At least two sets of input ports in a popular system shall be provided in the Information Display System to exclusively allow other information providers to input other information signals such as, but not limited to, news, weather data etc. The necessary software and programming shall be provided to allow the smooth display of all the basic and other information mentioned above.

The monitor shall meet the following minimum technical requirements: -

Screen size	≥ 250 mm (10 inches) or as specified in the Particular Specification or Drawings, further or as instructed by the Supervising Officer
Protective coating	Anti-glare polariser, hard coat

Resolution	≥ 1920 X 1080 pixels, or as specified in the Particular Specification or Drawings, further or as instructed by the Supervising Officer
Video input interface	Analogue & Digital
Audio input	Stereo
Speakers	2 nos.
Control buttons & On-screen controls	normally disabled, only able to be enabled by authorised personnel
Electrical safety standard (including any associated adapter)	EN 62368-1:2014 or equivalent
Standard for electromagnetic emission/radiation	TCO'06 or its latest version

The following associated provisions shall be provided:

(a) all necessary audio & video equipment, data input stations and software;

(b) all necessary power supply, other than those specified to be supplied and installed by other parties in the Drawings or Particular Specification, to the monitor with an 'on/off' switch inside the service cabinet of the lift car operation panel;

(c) all necessary power and signal cables, conduits and trunkings, other than those specified to be done by other parties in the Drawings or Particular Specification, connected to the monitor;

(d) fibre optic cables (to be used as the traveling signal cables), or other types of cable specified in the Particular Specification or Drawings, or other types of cable approved by the Supervising Officer, and all necessary noise reduction and signal booster devices in order to eliminate the signal losses and noise to the monitor; and

(e) attendance and coordination with other parties for installation, testing & commissioning and maintenance of the complete information display system.

11.1.2.10 CAR AND LANDING DOORS

11.1.2.10.1 General Requirements

Each car entrance shall be provided with an imperforated car door which shall extend the full height and width of the car opening. The top track of the door shall not obstruct the car entrance.

All landing openings in lift well enclosures shall be protected by imperforated doors which shall extend the full height and width of the landing opening. The top track of landing door shall not obstruct the entrance to the lift car. Every such door shall have an FRR of not less than that of the fire barriers therein with regard to integrity, or not less than -/120/-.

The lift doors shall be provided and constructed to satisfy the criterion for integrity in accordance with BS 476 Part 20:1987 & Part 22:1987 (or EN 81-58:2003 or EN 1634-1:2014 + A1:2018 as appropriate) unless otherwise specified.

Any projections on or recesses in the exposed parts of the car doors or landing doors shall be kept to a minimum in order to avoid finger trapping between sliding parts of the door and any fixed part of the car or landing entrance.

For all automatic power operated horizontally sliding car doors, means shall be provided to minimise the risk of dragging the children's hands into the gaps between the car door panels and uprights.

The clearance between panels or between panels and any fixed part of the car or landing entrance shall not exceed 6 mm.

Sliding car and landing doors shall be guided on door tracks and sills for the full travel of the doors. The distance between the car and landing sills shall not exceed 35 mm.

The clear height of all entrances on car and landings shall not be less than 2 m.

11.1.2.10.2 Passenger Lift

Unless otherwise specified in the Particular Specification, the doors for passenger lifts shall be of metal construction, and the internal face of the car door shall be lined the same as the car. The doors shall be two panels, centre opening with automatic power opening and closing unless otherwise specified.

11.1.2.10.3 Bed/Passenger Lift

Unless otherwise specified in the Particular Specification, the doors for bed/passenger lifts shall be of similar construction as the passenger lift,

and shall be two speed, multi-panel, side opening with automatic power opening and closing. The car shall be equipped with an electronic door sensor which can detect an obstruction at the car entrances and controls the closing of the doors. This prevents the passenger, wheeled stretcher and wheeled chair from getting bumped by the closing doors, and relieves the user from holding down the OPEN button. The sensor shall scan for any object across the full height of the car entrance. The doors shall reverse immediately if the sensor detects any obstruction at the car entrances, and reverse operation is possible up to 2 times.

11.1.2.10.4 Freight/Goods Lift

Landing and car doors for freight/goods lift shall be of the construction as indicated in the Particular Specification and/or Equipment Schedule and shall be one of the following constructions:

(a) Manually operated, horizontally sliding doors

The doors shall be of stainless steel construction, robust for freight/goods lift use.

(b) Power operated, automatic, horizontally sliding doors

The doors shall be multi-panel of stainless steel construction, similar to those for passenger lifts, but strong enough for freight/goods lift use.

A timer shall be incorporated in the door opening circuitry to function as follows. Whenever the 'DOOR OPEN' button on the car control panel is pressed, the doors shall remain open for a pre-set period of time, adjustable by the timer between 2 and 10 minutes. By the end of the period, a buzzer shall sound prior to the closing of the doors. Pressing of the 'DOOR OPEN' button a second time shall set the timer for another period of time. However, pressing of the 'DOOR CLOSE' button on the same control panel shall cause the doors to close immediately. The doors shall not remain open for the pre-set period of time, but operate normally, unless the 'DOOR OPEN' button is pressed.

An instruction, in English and Chinese engraved on a 1.5 mm thick stainless steel plate notifying the user of the facility, shall be displayed conspicuously adjacent to the car control panel.

(c) Vertically bi-parting doors, manually operated or power closing

The doors shall be of stainless steel construction and shall only be used on freight/goods lifts which are generally accompanied by people and for vehicle lifts. They shall be vertically bi-parting, manually operated or power closing. For power closing doors, all the following conditions shall be fulfilled: -

(i) closing is carried out under the continuous control of the users;

(ii) the average closing speed of the door panels is limited to 0.3 m/s;

(iii) the car door is of perforated or mesh panel construction;

(iv) the car door is at least two thirds closed before the landing door begins to close; and

(v) the door mechanism shall be protected against unintentional access.

11.1.2.10.5 Finishes for Freight/Goods Lift in Markets and Abattoirs

For freight/goods lifts in markets and abattoirs, the landing doors, car doors, architraves, door sills, supporting frames, door head apron, and facia plate, etc., shall be of all stainless steel construction without ferrous metal backing.

11.1.2.10.6 Vision Panels for Freight/Goods Lift with Manually Operated Door

In order to ensure that the user before opening the door must be able to know whether the car is there or not, the landing doors shall be provided with one or more transparent vision panels conforming to the following conditions:

(a) the panel shall be made of an approved material or glass of a tempered or laminated type;

(b) minimum thickness of 6 mm;

(c) minimum area per landing door of 0.015 m^2 with a minimum of 0.01 m^2 per vision panel;

(d) the size and shape of the panel shall reject a sphere having a diameter of 100 mm or bigger;

(e) no part of the panel shall be at a height of less than 1000 mm above a lift landing; and

(f) width of at least 60 mm.

11.1.2.10.7 Service Lift

Unless otherwise specified in the Particular Specification, the doors for service lifts shall be manually operated, vertically bi-parting of 1.5 mm thick stainless steel construction.

11.1.2.10.8 Electrical Device for Proving the Car Doors Closed

Every car door shall be provided with an electrical switch which will prevent the lift car from being started or kept in motion unless all car doors are closed. A mechanical locking device shall also be provided such that the car door cannot be opened from the inside while the car is outside the unlocking zone.

11.1.2.10.9 Door Operator

The door operator shall open and close the car and landing doors in a safe, smooth and quiet manner and shall be able to achieve the door operating time as specified in the Particular Specification. The maximum closing force and kinetic energy shall comply with the requirements as stipulated in the Code of Practice on the Design and Construction of Lifts and Escalators issued by the Electrical and Mechanical Services Department, the Government of the HKSAR.

The door motor and drive shall be of AC motor with variable voltage variable frequency (VVVF) control unless otherwise specified in the Particular Specification. Other proven types of door motor and drive may also be used subject to the approval by the Supervising Officer.

11.1.2.10.10 Landing Door Locking Device

Every landing door shall be provided with an effective locking device so that it shall not normally be possible to open the door from the landing side unless the lift car door is in that particular landing zone.

It shall not be possible under normal operation to start the lift car or keep it in motion unless all landing doors are in the closed position and locked.

11.1.2.10.11 Door Locking Devices to be Inaccessible from Landing or Car

All door locking devices and door switches, together with any associated actuating rods, levers or contacts, shall be so situated or protected as to be reasonably inaccessible from the landing or the car.

11.1.2.10.12 Door Re-Opening Device

Door re-opening device shall be provided which shall automatically initiate re-opening of the door in the event of a passenger being struck (or about to be struck) by the door in crossing the entrance during the closing movement.

Dual function safety edge shall be used unless otherwise specified in the Particular Specification or as approved by the Supervising Officer. The requirements for dual function safety edge are as follows: -

(a) Dual function safety edge shall incorporate both mechanical and electronic type sensitive devices for providing automatically re-opening feature to the car door. When either one of the mechanical

and electronic type sensitive devices or both of them is/are actuated in the event of a passenger being struck (or about to be struck) by the door in crossing the entrance during the closing movement, re-opening of the door shall be automatically initiated;

(b) The dual function safety edge shall be installed at the leading edge of each car door panel. For centre opening doors the obstruction of either leading edge when closing will cause it to function;

(c) The mechanical device shall extend from not more than 25 mm above the sill (measured to the extended position of the protective device) to a minimum height of 1800 mm above the sill;

(d) The electronic device shall be of curtain type composed of not less than 24 infrared beams, or other technology specified in the Particular Specification or Drawings, or other technology approved by the Supervising Officer. The detection field of the curtain shall cover the entire car opening width and extend from not more than 25 mm above the sill to a minimum height of 1800 mm above the sill; and

(e) The electronic device shall be inoperative when the fireman mode of fireman's lift is activated.

Where specified in the Particular Specification or approved by the Supervising Officer, entirely mechanical type or electronic type safety edge may be accepted provided that it meets the above-mentioned requirement nos. (a) and (b) for both types of safety edges, requirement no. (c) for mechanical safety edge and requirement nos. (d) and (e) for electronic safety edge. However, dual function safety edge shall be used unless otherwise specified in order to cater for the elderly and disabled people.

11.1.2.10.13 'Door-Open' Alarm for Manually Operated Doors

For manually operated doors and power assisted doors, a 'door open' alarm shall be provided in the car to draw attention to a car or landing door which has been left open for an adjustable period up to 10 minutes.

11.1.2.10.14 Emergency Landing Door Unlocking Device and Key

Every landing door shall be provided with an emergency landing door unlocking device which, when operated by an authorised person with the aid of a key to fit the unlocking triangle as defined in EN 81-20:2014 or EN 81-50:2014, would open the landing door irrespective of the position of the lift car for rescue purpose. This unlocking key shall not be able to remain in the unlocked position with the landing door closed, when there is no action to unlock.

In the case of coupled car and landing doors, the landing doors shall be automatically closed by means of weight or springs when the car is outside the unlocking zone.

11.1.2.10.15 Inspection and Emergency Door in Lift Well

Where there is a long stretch of lift well without a landing door, an emergency door shall be provided at a distance apart not exceeding 11000 mm for evacuating the passengers. The inspection and emergency doors shall, unless otherwise specified, be provided by others, except item (e), and the party responsible for the work shall be well coordinated, to check and ensure that the doors provided comply with the following: -

(a) have minimum dimension 1800 mm x 500 mm with an FRR of not less than that of the fire barriers therein with regard to integrity, or not less than -/120/- for door used as emergency door, and minimum dimension 1400 mm x 600 mm with an FRR of not less than that of the fire barriers therein with regard to integrity, or not less than -/120/- for door used as inspection door;

(b) not open towards the interior of the lift well;

(c) be located in a position readily accessible to rescuers;

(d) be equipped with dual key-operated locks requiring the simultaneous operation of two designated keys for opening from the outside and capable of being reclosed and relocked without a key;

(e) be provided with an electrical safety device of such a type to secure that the lift cannot be set or kept in motion unless the door is fully closed; and

(f) bear on its outside surface a permanent notice in English and Chinese.

(g) be capable of being opened from inside the well without a key even when locked; and

(h) except for doors in the form of lift landing doors, bear on its outside face a prominent figure-type warning sign of size not less than 100 mm high and immediately above or next to the keyholes of such doors as shown below.

(i) Where the disposition of liftwell inspection and emergency doors can reduce the likelihood of inadvertent entry, a single locking

device operated by a designated key is acceptable. Typical examples are: -

- lift landing doors serving as the liftwell inspection and emergency doors; or

- liftwell inspection and emergency doors with their sills being 1 m or more above the adjoining floor.

11.1.2.10.16 Architrave

At each landing entrance, unless otherwise specified, architraves of 1.5 mm thick stainless steel of hairline or mirror finish or heavy gauge sheet steel profiled and spray painted to an approved colour shall be provided, as approved by the Supervising Officer. And filling (or grouting) as necessary shall be provided by others. All surfaces of architrave shall be formed true and gaps between sections will not be allowed. Bolts shall not be visible on the exposed surfaces of the architraves. The architraves shall extend to enclose the thickness of the enclosing front wall.

11.1.2.11 LANDING FIXTURES

11.1.2.11.1 Position and Construction

Unless otherwise specified in the Particular Specification a landing fixture will be mounted adjacent to the lift landing entrance for 'simplex' control lift and between the landing entrances for 'duplex' control lifts, or group supervisory control lifts.

This fixture shall consist of landing call push button(s) and illuminated call acceptance signal, with a stainless steel cover plate. The button(s) shall be of vandal-resistant design and flush mounted construction similar to the buttons inside lift car. The control of button(s) shall be equipped with contact-less function/feature unless otherwise specified in the Particular Specification. Micro-movement push buttons shall be provided for office buildings and where specified in the Particular Specification. Electronic touch buttons are not preferred as they may not suit the visually impaired and blind people.

11.1.2.11.2 Emergency Key Switch for Bed/Passenger Lift

An emergency key switch system comprising the following facilities shall be provided for bed/passenger lifts: -

- An on-off key switch above the landing fixture at each landing and on the lift car control station; and

- 'Emergency Use' indicator both in Chinese and English at each landing and on the lift car control station.

The emergency key switch shall be operated as follows: -

- When the key switch at the required landing is operated, the lift will immediately stop at the next floor in the direction in which it is travelling. Lift doors will remain closed and lift will immediately go to the floor at which the key switch has been operated. Should the lift be already travelling in the direction of the floor where the key switch has been operated the lift will go to that floor without stopping. At the same time of the key switch operation, an indicator will illuminate on the car control station, and on each landing to warn the passengers that the lift is required for 'Emergency Use' only;

- On arrival at the requesting floor the lift will stop, doors open and remain open until the same key is used to operate the key switch in the lift car. Should the key switch in the lift car is not operated for an adjustable period up to 5 minutes, the lift shall return to its normal operation;

- With the same key to operate the key switch in the lift car, the person requiring the lift will gain full control over the lift. The lift shall return to its normal operation when the key switch in lift car is returned to its ‘off’ position; and

- The key at each landing shall be of the spring-loaded type to ensure that the switch returns to ‘off’ position. The key in lift car shall be withdrawn at ‘off’ position only. The operation of key switch in lift car shall override the ‘on’ position of key switch at any landing. The ‘Emergency Use’ indicators shall remain illuminated until all the key switches are returned to their ‘off’ positions or when the pre-set period of time has been expired.

The emergency key switch shall not override the Fireman's Switch.

11.1.2.11.3 Direction and Position Indicator

Audible and visual direction indicators shall be provided on each landing. The indicator shall sound once for an arriving lift that is travelling upwards and twice for downwards. Audible signal shall be at least 58 dBA measured at 1 m from the landing door while the visual signal shall be an illuminated directional indicator with an illuminated area not less than 1125 mm^2 and the characters on the position indicator shall have a minimum height of 50 mm. The visual direction indicator shall have a minimum protrusion of 10 mm to give a better visual effect to the passengers waiting.

For automatic group supervisory control systems, illuminated position indicator shall be provided at the landing of the designated point of entry only unless otherwise specified. For all other automatic control systems, illuminated position indicator shall be provided at the landing of the designated point of entry and on all other landings unless otherwise specified.

11.1.2.11.4 Pre-Arrival Signal for Grouped Passenger Lifts

For group supervisory control of two or more lifts, the audible and visual signal provided for each passenger lift at each landing shall be activated before the arrival of each lift. The time between activation of the signal and the arrival of the lift shall not be less than 2 seconds.

11.1.2.11.5 Message Indicator for Passenger Lift

An illuminated indicator digital type display shall be provided for each lift except service lift at each landing to display messages such as 'Out of service', 'Overload', 'Full load', 'Used by firemen', 'On emergency service', 'This lift serves the following floors'. The indicator shall be able to display up to at least 32 messages. These messages shall be displayed alternatively in English and Chinese. The contents, display sequence and display patterns of these messages shall be on site programmable. The luminous intensity of the indicator shall be at least 3500 μcd. Message indicator is still required at each landing for each lift under group supervisory control when position indicator is not provided.

11.1.2.12 CAR CAPACITY AND LOADING

11.1.2.12.1 Passenger Lift

The available car area, rated load and number of passengers shall be determined from EN 81-20:2014 and EN 81-50:2014.

11.1.2.12.2 Bed/Passenger Lift to be Treated as Passenger Lift

To avoid the possibility of serious over-loading of bed/passenger lifts in hospitals, such lifts shall be treated as passenger lifts.

11.1.2.12.3 Freight/Goods Lift

Design calculations shall take into account not only the load carried but also the weight of handling devices which may enter the car.

11.1.2.12.4 Service Lift

A service lift shall have a rated load of not more than 250 kg.

11.1.2.13 LOAD PLATES, NOTICE BOARDS AND INSTRUCTIONS

A stainless steel plate engraving the rated load of the lift shall be fitted in each lift car in a conspicuous position. The rated load shall be given in persons and in kg.

The following stainless steel notice boards engraving conspicuously in both English and Chinese characters shall be provided and rigidly mounted: -

(a) The name of the company, telephone number and emergency instructions at the terminal landing lift lobby; and

(b) 'IN CASE OF FIRE DO NOT USE THE LIFT' with letter height of not less than 15 mm in each car and on each landing floor.

A board or suitable container for the necessary tools, together with clear instructions on the method for releasing the brake and moving the lift car in an emergency shall be positioned in the machine room in a conspicuous manner. It shall be stated on the board/container 'Emergency release operation shall only be undertaken by authorised person.'

11.1.2.14 SAFETY GEAR AND OVERSPEED GOVERNOR

Every lift other than a service lift shall be provided with a safety gear capable of operating in the downward direction and capable of stopping a fully laden car, or a counterweight or balancing weight, at the tripping speed of the overspeed governor, even if the suspension devices break, by gripping the guides and holding the car, counterweight or balancing weight there.

If accessible spaces do exist underneath the counterweight, the counterweight, as well as the car, shall be provided with safety gears.

Safety gears shall comply with the following general requirements: -

- The release of the safety gear on the car (or the counterweight or balancing weight) shall only be possible by raising the car (or the counterweight or balancing weight);

- Each safety gear shall be tripped by its own overspeed governor;

- The operation of the safety gear shall not cause the car platform to slope at more than 1 in 20 to the horizontal;

- Vibration of the car shall not in any case cause a safety gear to operate; and

- The tripping of safety gears by devices which operate electrically, hydraulically or pneumatically is forbidden.

Car safety gear shall be of the progressive type if the rated lift speed exceeds 1 m/s. It shall be of: -

- the instantaneous type if the rated lift speed does not exceed 0.63 m/s.

The safety gear of the counterweight shall be of the progressive type if the rated speed exceeds 1 m/s, otherwise the safety gear may be of the instantaneous type.

Overspeed governor shall be of the centrifugal type which shall operate the safety gear at a speed at least equal to 115% of the rated speed and in accordance with EN 81-

50:2014. The means for adjusting the overspeed governor shall be sealed after setting the tripping speed.

The motor control and brake-control circuits shall be opened before or at the same time as the governor trips and cause the lift motor to stop in compliance with EN 81-20:2014 and EN 81-50:2014.

The governor ropes shall not be less than 6 mm in diameter and shall be of flexible wire rope. The rope shall be tensioned by a tensioning pulley and the pulley (or its tensioning weight) shall be guided.

The breakage or slackening of the governor rope shall cause the motor to stop by means of an electrical safety device. The device shall be of bi-stable type requiring manual reset.

Ascending car overspeed protection means shall be type examined in accordance with testing process as described in Clause 5.7 of EN 81-50:2014 or other approved international standards. It shall be provided to a traction drive lift and shall act: -

- to the car; or

- to the counterweight; or

- on the rope system (suspension or compensating); or

- on the traction sheave.

If the ascending car overspeed protection means requires external energy to operate, the absence of energy shall cause the lift to stop and keep it stop. This does not apply for guided compressed springs.

Protection against unintended car movement of the lift car away from the landing with the landing door not in the locked position and the car door not in the closed position shall be provided. The unintended car movement protection means is regarded as a safety component and shall be type tested and examined in accordance with testing process as described in EN 81-50:2014, or other relevant international standards. It shall meet the requirements of Code of Practice on the Design and Construction of Lifts and Escalators and all its subsequent amendments if any and shall also conform to the following: -

- Micro-switch or similar mechanical type detecting device shall not be used as a means to detect the open/close status of lift doors; and

- Be tested and examined at least once annually after commissioning.

Where specified in the Particular Specification and/or shown on the Drawings, seismic operation control shall be provided to safeguard passengers from danger in the event of earthquake. Seismic detection sensors shall be installed in the lift machine room and other locations as specified or alternative proposal and approved by the Supervising Officer to detect the primary wave (P-wave) and secondary wave (S-wave) of an earthquake. The control operation shall be as follows: -

(a) When the seismic detection sensors detect the P-wave and/or low level of S-wave of an earthquake, the lift shall cancel all car calls and stop at the nearest landing in the direction of travel.

(b) When the seismic detection sensors detect the S-wave above the high setting, the lifts, which are located outside the express zone, shall cancel all car calls and stop at the nearest landing in the direction of travel.

(c) The lift in the express zone shall stop immediately once the seismic detection sensor detects the S-wave above the high setting. Unless there is operation of other safety device of the lift which can initiate an emergency stop and/or further lift operation will lead to a dangerous situation and/or there is a loss of electrical power and control, the lift shall re-start, after a preset adjustable time delay of 15 to 180 seconds, and travel with the lowest speed to the nearest landing in the direction for which the lift car moves away from the counterweight. The lift shall stop at the nearest landing. During the travel period, if any safety device of the lift operates or further lift operation will lead to a dangerous situation, the lift car shall stop.

(d) Audio and visual alarm indications shall be provided on the supervisory control panel for the actuation of the seismic detection sensors and the stopping/re-starting of the lift cars.

(e) The alternative acceptable seismic operation control arrangement and other additional means that can better safeguard passengers from danger or facilitate their rescue in the event of earthquake may be proposed for approval by the Supervising Officer.

11.1.2.15 OVERLOAD DEVICE AND FULL LOAD DEVICE

The overload shall be detected at the latest when the rated load is exceeded by 10% with a minimum of 75 kg. The overload device, when in operation, shall: -

(a) prevent any movement of the car;

(b) prevent the closing of any power operated door whether fitted to the car or to the landing at which the car is resting; and

(c) give audible and visible signals inside the car or at the car entrance for service lift.

The lift shall resume normal operation automatically on removal of the excessive load. The overload device shall be inoperative while the lift car is in motion.

Every lift other than a service lift shall be provided with a full load device having an adjustable setting range from 80% to 100% of the rated load and when operated, it shall by-pass all landing calls. When the load in the car is reduced, the car shall stop for landing calls as normal.

Overload device and full load device activated on floating car platform principle are NOT acceptable.

11.1.2.16 LIFT MACHINERY

11.1.2.16.1 Lift Motor

The motor shall be manufactured to operate for an unlimited period according to the expected duty of the lift. The AC motor may be supplied and controlled by static elements when AC variable speed system is specified.

Where specified in the Particular Specification and / or shown on the Drawings, high efficiency AC gearless permanent magnet synchronous motor shall be provided with high overall efficiency.

11.1.2.16.2 Bearing and Gear Case

Bearings shall be of the ball bearing type or sleeve ring type with oil ring bearings. Gear cases shall be provided with journal and thrust bearings suitable for the application.

11.1.2.16.3 Emergency Operation by Manual Device

For geared lift machines, the hoisting machine shall be provided with a smooth wheel which may be fitted to the shaft to move the lift car up or down by manual operation. The direction of movement of the car shall be clearly indicated on the machine.

If the wheel is removable, it shall be located in an easily accessible place in the machine room.

11.1.2.16.4 Emergency Operation by Electrical Switch

For gearless lift machines as well as machines where the manual effort to raise the car together with its rated load exceeds 400 N, an electrical switch for emergency operation shall be installed in the machine room.

For machines already fitted with manual operation wheel, the electrical switch for emergency operation shall also be installed, where technically feasible and available, for added protection.

The emergency electrical switch with directional push buttons protected against accidental operation shall be provided in the machine room such that when the emergency electrical switch is operated, the car can be moved up or down by applying constant pressure on the buttons. The car speed under the emergency operation shall not exceed 0.3 m/s.

The emergency electrical switch and its push buttons shall be so placed that the machine can readily be observed during operation.

Where emergency power supply is provided in the building for fireman's lift(s) and/or other lifts, the electrical switches for emergency operation shall be backed up by the emergency power supply. In case the capacity of emergency power supply is only sufficient for the fireman's lift(s), the electrical switches for emergency operation shall be disconnected from the emergency power supply during fire alarm mode and at the operation of the fireman's switch. The operation of the fireman's lift(s) shall not be affected in any case.

11.1.2.16.5 Electro-Mechanical Brake

Every lift machine shall be provided with a double brake system each of which is capable of stopping the machine when the car is downward travelling at its rated speed and with the load equivalent to 125% of rated load (150% of rated load in case of vehicle lift and 125% of total load for freight lift as described in of the Code of Practice on the Design and Construction of Lifts and Escalators). It shall also be fitted with a manual emergency operating device capable of having the brake released by hand while a constant manual pressure is required to keep the brake open.

If one of the brake sets of the double brake is not working due to failure of a component, a sufficient braking effort to decelerate, stop and hold the car, travelling downwards at rated speed and with rated load in the car and upward with empty car shall continue to be exercise. Solenoid plunger is considered to be a mechanical part.

11.1.2.16.6 RUN/STOP' Switch to be Provided where Lift Equipment is housed in Separate Compartment

Where lift equipment is housed in a compartment separated from the motor room or lift well, a switch shall be provided in that compartment which, when placed in the 'STOP' position, shall cause the lift to stop and refrain from being started until the switch is placed in the 'RUN' position.

11.1.2.16.7 RUN/STOP Switch to be Provided in Pit

A RUN/STOP switch shall be provided in each lift pit.

11.1.2.16.8 Stopping at the Nearest Landing

In addition to the home landing requirements, the lift shall automatically cancel all car calls and stop at the nearest landing floor in the direction of travel or designated floor with door open to release the passengers and with alarm in the supervisory control panel under the following fault conditions: -

(a) actuation of any of the safety device of respective lift which has not initiated an emergency stop;

(b) flooding of respective lift pit as detected by the water level sensor if any;

(c) breakdown of the ventilation fan in lift car; and

(d) actuation of the seismic detection sensor.

The nearest landing shall mean, as appropriate, the next available landing floor in the direction of travel, or a pre-designated nearest landing floor assigned for a lift car position in a direction of travel, or the nearest landing floor that a lift can practically stop at without jerk after deceleration.

The faulty lift shall not resume normal operation until positive reactivation. The ventilation fan, air conditioning and lighting of the faulty lift car shall be switched off and the lift door shall be closed after a preset adjustable period of time. Door open push button and safety edge shall however remain effective. Where there is "Out of Service" indication in the message indicator in the landing fixtures, it shall be turned on. Where required, the home landing key switch shall be able to bring an empty faulty lift to the landing at the designated point of entry after all passengers are released and the lift door is closed, if further lift operation will not lead to a dangerous situation. On arrival at the designated point of entry, the faulty lift shall however not resume normal operation until positive reactivation.

11.1.2.16.9 Move to the Nearest Landing after Emergency Stop

After an emergency stop, if there is no actuation of other safety and protection devices preventing the lift operation and further lift operation will not lead to a dangerous situation, the lift shall re-start automatically upon a preset delay for the following scenarios: -

(a) When the lift is brought to an emergency stop due to voltage dips, the lift shall restart within 60 seconds upon the restoration of normal power supply. The lift shall move to the nearest landing either one floor above or below and with door open to release the passengers. If there is no actuation of other safety devices, the lift shall resume normal operation within 5 minutes. If the lift does not restart and/or resume normal operation, an alarm shall be indicated in the supervisory control panel together with "Out of Service" indication in the message indicator in the landing fixtures; and

(b) When the lift is brought to an emergency stop due to power failure, the lift shall restart within 60 seconds upon the activation of emergency power supply. The lift shall move to the nearest landing either one floor above or below and with door open to release the passengers. If the lift does not restart and/or resume normal operation, an alarm shall be indicated in the supervisory control panel together with "Out of Service" indication in the message indicator in the landing fixtures; and

(c) When the lift is brought to an emergency stop due to the actuation of seismic detection sensors, the lift shall restart within 180

seconds and move to the nearest landing either one floor above or below and with door open to release the passengers. The lift shall however not resume normal operation until positive reactivation.

11.1.2.16.10 Automatic Rescue Device or Post-Voltage-Dip-Operation Means

An automatic rescue device or a post-voltage-dip-operation means shall be provided to resume the service of the lift from suspension following a power failure or voltage dip so that passenger(s) trapped in the lift can be released. The detailed requirements shall refer to the Code of Practice on the Design and Construction of Lifts and Escalators.

11.1.2.17 CONTROLLER

11.1.2.17.1 Construction

The controller shall be constructed in accordance with the general requirements of switchgear specified in the General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region, issued by the Building Services Branch, Architectural Services Department, the Government of the HKSAR and shall be mounted in a ventilated steel cubicle with hinged front doors and removable hinged rear panels (if necessary for maintenance at the rear side), in which all contactors, solenoids, relays, motor starting equipment etc., shall be fitted. All steel sheets shall be no less than 1.2 mm thick.

11.1.2.17.2 General Requirements

The controller shall comply with the general requirements as stated in EN 81-20:2014 and EN 81-50:2014, and in particular, the following features shall be included: -

(a) Materials used in the construction of the control equipment shall not support combustion;

(b) The components shall be mounted in a manner which will facilitate easy inspection, maintenance, adjustment and replacement. Wirings shall be terminated in such a way that the wires are not damaged. Accessible terminals suitably marked, shall be provided for incoming and outgoing cables;

(c) Control circuits at normal mains voltage shall be connected between phase and neutral and shall be supplied through double wound isolating transformer;

(d) Where rectifier is used it shall be of the full wave silicon type fed from a transformer;

(e) The control circuit shall be protected by suitably rated over-current circuit breakers or HRC fuses independently;

(f) The brake solenoid and any retiring cam shall operate on direct current; and

(g) Motors connected to polyphase AC power supplies shall incorporate means to prevent the motor from being energised in the event of phase failure.

11.1.2.17.3 Solid State Controls

Microprocessor-based control shall include the following features: -

(a) The system hardware shall be capable of supporting fully software based supervisory and motor control systems;

(b) Interruption of the electrical supply to the lift shall not affect the system memory or software;

(c) It shall be possible to change the supervisory control algorithm to meet a change in the use of the building by re-programming the instruction memory;

(d) It shall be possible to interrogate, by means of communication access/test points on the controller, the system operating functions by use of a portable unit using diagnostic routines;

(e) Visual indicators, e.g. LED'S, shall be provided on the controller to display information on the operational status of the lift; and

(f) Multiplexing techniques may be employed to reduce the number of trailing cables normally required, if considered cost effective to do so.

11.1.2.17.4 Provisions for Remote Monitoring of Lift

Remote monitoring system (RMS) shall be designed, supplied and installed under the Works. The RMS system shall be able to connect to the integrated Building Management System (iBMS) and/or Central Control & Monitoring System (CCMS) by others via commercially available communication protocol such as BACnet, Modbus etc. The lift status shall preferably be monitored in real-time.

The following output signals from the sensors of each lift installation or specified in the Particular Specification for the use of RMS of lift: -

General
- Normal/Fault status;
- Duty/Standby status;
- Power Supply Normal/ Fault status;
- Normal/ Essential Power status;
- Lift Car Alarm Pressed; and
- Up / Down status.

Remote Breakdown monitoring
- Start up machine Failure
- Lift Car Alarm
- Safety Devices Condition
- Door Operation Condition
- Power Source Failure of motor drive
- Intercom Power Supply Normal Status
- Controller Communication Failure

Remote Lift Performance monitoring
- Brake Performance
- Car/ Hall call Button Status
- Door Operation Status
- Speed Control Status
- Floor Zone Level Error Status
- Door Switch Status
- Load Detection Status
- Power Supply Status of Emergency Lamp System

Remote Data Collection
- Number of Start Up
- Running Distance
- Running Time
- Door Operating Count
- Number of Call Per Floor
- Running Amps [See Note]
- Running Line Voltage [See Note]
- Temperature inside outdoor lift shaft [See Note]
- Water leakage alarm at lift machine room [See Note]
- Energy consumption of lift, kWh [See Note]
- Regenerative Energy of lift, kWh [See Note]

This interface unit shall be located at the management office/caretaker's room next to the lifts monitoring panel unless otherwise specified on the Drawing or in the Particular Specification.

[Note: required if specified in the Particular Specification and/or on the drawings.]

11.1.2.18 AUTOMATIC CONTROL SYSTEM

11.1.2.18.1 Automatic Full Load By-Pass

To eliminate the inconvenience of having fully-loaded cars stop for landing calls, all lifts other than service lifts shall be equipped with a full load device which detects the load condition in the car and allow landing calls to be by-passed.

11.1.2.18.2 Automatic Push Button Control for Single Lift

Automatic push button control shall allow only one call to be registered at a time. The car answers one call before another can be registered. All car and landing doors must be properly closed before the car will respond to either a landing or car call. On stopping, a short period elapses during which no landing call is effective and priority is given to the car pushes to allow passengers to enter the car and register a car call.

If no car call is registered after the car stops at a floor and the car and landing doors remain closed then a landing call may be registered after an adjustable time delay of not more than 8 seconds, when the lift becomes free.

11.1.2.18.3 Down Collective Control for Single Lift ('Simplex' Control)

All calls shall be stored in the system and answered in sequence regardless of the order in which they are registered.

When travelling in the 'Up' direction, the car travels to the highest call, stopping at any intermediate floor for which a car call has been registered. On stopping for the highest call, preference is established for the 'Down' direction.

When travelling downwards the car stops for all car and landing calls that have been registered. When all calls have been answered, the car remains with doors closed at the floor to which it last travelled.

11.1.2.18.4 Down Collective Control for Two Inter-Connected Lifts ('Duplex' Control)

In addition to the features of 'Simplex Control', it shall also include the following control features.

When both cars are away from the landing of designated point of entry and all calls have been answered, one car will return automatically to the landing of designated point of entry and is referred to as the 'Next' car. The second car remains at the floor at which it last deposited passengers and is referred to as the 'Free' car. Both cars stand with doors closed.

With the cars standing with doors closed as described above the first landing call will be answered as follows: -

(a) for a landing call from the landing of designated point of entry, by the 'Next' car; and

(b) for any other floor landing call, by the 'Free' car.

With the 'Free' car answering calls, the 'Next' car will not start for 'Down' calls behind the 'Free' car until the 'Free' car is descending.

The passenger entering the ‘Free’ Car at the landing of designated point of entry would be able to register a call and travel to any destination. With both cars standing at the landing of designated point of entry with doors closed, the ‘Next’ car (i.e. the one that arrived first) will answer the first landing call. Directional preference should be maintained when a car stops for its last call until the doors close.

11.1.2.18.5 Directional Collective Control for Single Lift

All calls shall be stored in the system and answered in sequence regardless of the order in which they are registered.

When the car is travelling in a given direction it shall travel to the further-most call, answering any car call or landing call for the corresponding direction of travel.

Landing calls for the direction opposite to that in which the car is travelling shall be by-passed but shall remain stored in the system to be answered when the car returns in the opposite direction.

When the car stops for the last call in its direction of travel, preference is given to car call(s) for an adjustable period.

When all calls have been answered the car remains with doors closed at the floor to which it last travelled.

11.1.2.18.6 Directional Collective Control for Two Inter-Connected Lifts

In addition to the features as required in Directional Collective Control for Single Lift, it shall also include the following supervisory features.

When both cars are away from the landing of designated point of entry and all calls have been answered, one car shall return automatically to the landing of designated point of entry and is referred to as the 'Next' car. The second car remains at the floor to which it last travelled and is referred to as the 'Free' car. Both cars stand with doors closed.

With the cars standing with doors closed as described above, the first landing call shall be answered as follows: -

(a) for a landing call from the landing of designated point of entry, by the ‘Next’ car; and

(b) for any other floor landing call, by the ‘Free’ car.

With the ‘Free’ car answering calls, the ‘Next’ car shall not start for ‘Up’ calls or ‘Down’ calls behind the ‘Free’ car until the ‘Free’ car is descending. If the ‘Free’ car is delayed for a pre-determined time which is adjustable, the controller shall operate to dispatch the ‘Next’ car.

With both cars standing at the landing of designated point of entry with doors closed, the ‘Next’ car shall answer the first landing call.

The passenger entering the ‘Free Car’ at the landing of designated point of entry shall be able to register a call and travel to any destination.

11.1.2.18.7 Automatic Group Supervisory Control for 2-8 Inter-Connected Passenger Lifts

This group supervisory control system when specified in the Particular Specification shall incorporate a micro-computer or other similar solid state devices which continuously monitor the transportation demand and automatically adjust the group operation to suit the prevailing traffic pattern and to optimise passenger waiting time.

In the case of a fundamental change in the use or occupancy of the building, the system shall be re-programmable to cater for revised traffic pattern without inconvenient hardware modifications.

Control system features to be included are generally as described below but by no means exhaustive which may be either included as standard or specified elsewhere in the Particular Specification.

(a) Flexible service sectors

The lifts shall operate as an interconnecting collective group and the system shall arrange for cars to answer demands in accordance with priorities established by recording the time that calls have been registered. The lifts are to operate as completely flexible units and shall not therefore invariably make round trips, or park at specific floors, or operate to specified programmes, or in accordance with despatch times.

Landing calls shall be grouped into 'UP' and 'DOWN' sectors, the number of floors included in each sector depending on the anticipated traffic and the degree of priority to be accorded to the occupants of the floors. The priority of each sector shall be determined by the length of time that calls have been registered in the sector. It shall be possible to increase or reduce the priority of a sector by reducing or increasing the units of time for a sector.

When not answering calls, cars shall park with doors closed at the floor at which the last passenger is discharged. When a call is registered, the nearest parked car shall answer the call and when travelling to the floor at which the call is registered it shall by-pass calls in sectors through which it may have to pass. Should there be more than one call in sectors embracing several floors the car shall travel to the highest call in a 'DOWN' sector or the lowest call in an 'UP' sector.

When a car has answered all the landing calls in a sector to which it is assigned and the resulting car calls, it shall park at the final floor and become available for further assignment. When under normal condition of two way traffic, any car which has answered

the calls in its assigned sector and is not fully loaded, shall answer landing calls in the same direction in any sector through which it is passing while answering the car calls resulting from the assignment. The presence of an intense local demand shall be detected and additional cars assigned to this demand as required, provided always that elsewhere are of lower priority.

(b) Heavy 'Up' traffic

The heavy 'Up' traffic shall be detected through a load-weighing device and when cars loaded to 60% or more at the landing of designated point of entry two cars shall be assigned automatically to the landing of designated point of entry for a specific period. When lifts assigned to the landing of designated point of entry arrive, they shall stand with their doors in the open position with direction arrow illuminated. Cars not assigned to the landing of designated point of entry shall continue to answer demands elsewhere in the building in the normal manner.

(c) Heavy 'Down' traffic

When heavy 'Down' traffic is experienced, the condition shall be detected when downward travelling cars are loaded to 80% capacity. Under this condition the despatching system shall ensure that lift service is equally distributed through the building and fully loaded cars shall automatically bypass landing calls in order to prevent unnecessary stops.

(d) Light traffic

As traffic requirements diminish, cars shall complete their assignments and park with closed doors wherever they happen to be.

(e) Pre-arrival chiming system

(f) Traffic sentinel

An electronic detection system shall be incorporated to reduce the preset waiting time to landings and to supplement the operation of the door safety edge. After an adjustable period of time, the starting of the car shall be initiated immediately when the detection system detects that passenger movement across the threshold has ceased.

Should the sensor of the traffic sentinel be failed for an excessive period, the doors shall commence to close slowly after a pre-determined time delay.

(g) Car preference

It shall be possible to withdraw any car or cars from service for maintenance purposes or for attendant control by means of a key operated switch. Under this condition, other cars in the bank shall continue to answer calls in the system. If required, a car or cars shall be able to be withdrawn from the group and assigned to serve a selected floor/floors only.

(h) Car separation

An out-of-order car or cars shall be automatically separated from the group, while the remaining ones shall continue to operate under group supervision.

(i) Group operation of lifts under emergency power supply

Where a group of lifts are to be operated from the same emergency power source which is not sufficient to operate all the lifts at the same time, the automatic selector switch shall be provided such that upon the availability of emergency power, one lift at a time shall travel to and park at the landing of designated point of entry to release passengers. After all lifts are parked at the landing of designated point of entry, the emergency power supply shall remain connected to one of the lifts

In case where the group of lifts consists of fireman's lift(s), sufficient emergency power shall be available for the operation of the fireman's lift(s) and the sequential returning of the other non-fireman's lift(s) of the group to the designated point of entry at the same time. The operation of the fireman's lift(s) shall not be affected in any case.

The conduit/trunking facilities for the interconnections between different lift machine rooms will be included in the Electrical Installation Work where applicable. The interconnecting control cables shall be provided.

(j) Adjustment of lift control in different time slot / time schedule

Where specified in the Particular Specification and/or on the Drawings, the lift control shall be capable for adjustment to assign only one or two lifts for operation in different time slot. (i.e. night / holiday operation modes unless otherwise specified). The lift car not selected for operation shall be left idle in a parking mode and shall not respond to passenger calls. The summary table showing the mode of operation in different time slot shall be provided.

11.1.2.18.8 Destination Control System

The destination control system (DCS) shall be designed, supplied and installed, where specified in the Particular Specification and if required it

can register the designated floor via security card when passing through the security gates at main entrance.

Full Destination Control System, when specified, shall consist of hall operating panel in each landing, destination indicator inside lift cars, and lift identifier in lift lobbies etc.

Hybrid Destination Control System, when specified, shall consist of hall operating panel at main floor only, conventional lift call buttons shall be provided at all other landings, conventional lift call operating panel inside lift car shall be provided, lift identifier in lift lobbies etc.

11.1.2.19 POWER SYSTEM APPLICATION

11.1.2.19.1 Speed at and Below 1.75 m/s

For lift speed at and below 1.75 m/s, the power system shall be either DC geared variable voltage, or AC variable voltage (ACVV), or AC variable voltage variable frequency (ACVVVF) system, with levelling accuracy ± 10 mm. The motor rating shall be 180 starts per hour.

11.1.2.19.2 Speed above 1.75 m/s

For lift speed above 1.75 m/s, the power system shall be either DC gearless variable voltage, or AC variable voltage (ACVV), or AC variable voltage variable frequency system (ACVVVF) or permanent magnet synchronous (PMS) motor, with levelling accuracy of ±10 mm. The motor rating shall be 180 starts per hour.

11.1.2.19.3 Bed/Passenger Lift

The power system shall be either AC variable voltage (ACVV), or AC variable voltage variable frequency (ACVVVF), or DC variable voltage system. The lift shall be steady in acceleration and deceleration with a levelling accuracy of ±10 mm. The motor rating shall be 180 starts per hour.

11.1.2.19.4 Hydraulic Lift

Except where specified in the Particular Specification, all hydraulic lifts shall have a maximum speed not exceeding 0.5 m/s with levelling accuracy of ±5 mm. The hydraulic system shall be rated for at least 45 motor starts per hour.

11.1.2.19.5 Regenerative Power System

Regenerative power system shall be provided for lift rated speed of 1.5 m/s or above and rated load at 900 kg or above, power will be generated when lift car moves up on no load or moves down with full load.

11.1.2.20 ALARM BUZZER/BELL SYSTEM, SUPERVISORY CONTROL PANEL, INTERCOM SYSTEM, TELEPHONE AND CLOSED-CIRCUIT TELEVISION

11.1.2.20.1 Alarm Buzzer/Bell System

Where additional alarm device is specified in the Particular Specification and/or on the Drawings in addition to the system as specified in this Sub-section, all wiring, cabling work, buzzers (or alarm bells) and indicator board(s) in connection with all alarm system shall be provided as specified in this General Specification and the Particular Specification.

The alarm buzzers/bell and indicator board(s) shall also be connected to batteries.

The indicator board(s) shall have visual and audible alarms for all lifts and shall include a mute switch for silencing the alarm buzzer(s) / bell(s) and a reset switch to reset the alarm. The alarm buzzer(s)/bell(s), after muting, shall have audible signal again when there is a second alarm. The indication light(s) shall remain on until all alarms are cleared and reset at the indicator board(s).

11.1.2.20.2 Supervisory Control Panel

Where supervisory control panel is specified in the Particular Specification and/or Drawings, the installation work shall include the provision of all wiring and cabling work, visual and audible signal components, and controls for the supervisory control panel from all lifts to the supervisory control panel that is located in the caretaker's office or building management office as the case may be at the landing of designated point of entry unless otherwise specified.

The supervisory control panel shall include at least, but not exclusive, the following basic facilities: -

(a) In service/Out of service' LED lights for each lift;

(b) Floor/position indicators for each lift;

(c) Up/Down direction indicator arrows for each lift;

(d) System fault alarm buzzer / bell and LED indication lights;

(e) Mute button for alarm buzzer / bell and alarm reset button;

(f) Power on indicator;

(g) Lamp test button;

(h) Repeater master unit for an intercom system; and

(i) ‘Under Fireman control’ LED light for each Fireman's lift.

11.1.2.20.3 Intercom System for Passenger, Bed/Passenger and Freight/Goods Lifts

An intercom system, or similar device powered by the emergency battery supply shall be provided with wiring and cabling work for all passenger, bed/passenger and freight/goods lifts between the lift car and the lift machine room, and between the lift car and the building management office or the caretaker's office as the case may be. The intercom system shall comprise a 2-way speaker in each lift car station and master control station located in the lift machine room. A repeater master station with a 2-way speaker shall also be provided in the building management office or the caretaker's office as the case may be. The master control station shall have the following facilities: -

(a) A 2-way speaker to allow communication between lift cars and the master control stations;

(b) A master switch of spring return type to allow simultaneous communication between the master control stations and all lift cars; and

(c) Selective switches of spring return type to allow communication between any master control station and each lift car, one at a time.

The conduit/trunking facilities outside the lift machine room and lift well to the building management office or the caretaker's office will be included in the Electrical Installation Work or others.

11.1.2.20.4 Telephone

Where specified in the Particular Specification and/or on the Drawings, the recess cabinet in the lift car panel for the installation of a wall mounted type telephone set shall be provided. The door of the cabinet shall match with the control station panel and be boldly engraved 'Emergency Telephone' in red English and Chinese characters. The telephone set will be provided by others but the installation works shall be coordinated and the appropriate telephone cable(s) shall be provided from the lift car to a connection terminal at a location as specified in the Particular Specification and/or on the Drawings. The conduit/trunking facilities outside the lift machine room and lift well will be provided by others.

11.1.2.20.5 Closed Circuit Television

For all passenger lifts, bed/passenger lifts and freight lifts, the colour Closed Circuit Television (CCTV) system shall be provided with the following facilities: -

(a) a 2 Mega pixel IP-based fixed dome type CCTV camera shall be suitably mounted on the ceiling of the lift car;

(b) a colour CCTV monitor of HD-LCD/LED type or similar slim type approved by the Supervising Officer located at the lift machine room;

(c) a colour CCTV monitor of HD-LCD/LED type or similar slim type approved by the Supervising Officer located at the building management office or the caretaker's office or at a location as specified in the Particular Specification and/or on the Drawings;

(d) separate and independent lift travelling audio/video cable(s) for the CCTV system connecting between the CCTV camera installed in the lift car (with the corresponding power supply MCBs in the MCB boards in the lift machine room) and the CCTV monitor(s) respectively;

(e) a suitable CCTV camera mounting frame/provision on top of the lift car for the installation of the CCTV camera;

(f) a suitable CCTV monitor mounting frame/provision in the room as specified in the Particular Specification and/or on the Drawings for the installation of the CCTV monitor;

(g) all the conduit and trunking facilities inside the lift well and the machine room (conduit and trunking facilities outside lift well and lift machine room will be provided by others unless otherwise specified); and

(h) the following provisions are required when interfacing with the display monitor(s) of burglar alarm and security system is specified in the Particular Specification: -

- The supervisory control panel of lift/escalator/passenger conveyor installation shall be installed adjacent to the security control console. The exact location of the panel shall be subject to the Supervising Officer's direction on site; and

- Sub-clauses (c) and (f) above are no longer applicable. The installation of an independent set of CCTV display monitor adjacent to the security control console shall not be required. The images captured by the lift CCTV camera shall be displayed at the monitors of the security control console. The CCTV video signal and emergency alarm signal output connection sockets shall be integrated and provided on the supervisory control panel of lift/escalator/passenger conveyor installation for others to connect the signal output through appropriate plugs to the display monitors of the security control console based on the following conditions: -

  (1) the security control console will be supplied and installed by others;

  (2) the emergency alarm signal shall be the one from the emergency alarm bell inside each lift car and it

shall enable the security control console to immediately switch a monitor to display the lift car image on receiving such alarm;

(3) the CCTV video signal and emergency alarm signal output connection sockets on the lift supervisory control panel shall be CAT6/fibre optic/other compatible panel sockets;

(4) the associated connection plugs, which shall suit CAT6/fibre optic/other compatible panel sockets on the supervisory control panel of lift/escalator/passenger conveyor installation shall be provided and shall not be less than the sockets in quantity of the connection plugs required by the security control console;

(5) the CAT6/fibre optic/other compatible connection plugs and sockets shall be of 75 ohm impedance type, service voltage up to 500 V peak and frequencies up to 4000 MHz, and accept common RF cable;

(6) the video signal shall be 1.0 V p-p composite; and

(7) the video signal and alarm signal outputs shall be compatible with the security control console by providing all necessary built-in transducers/signal converter/interface device (the signal outputs to the security control console shall be either analogue or digital as specified in the Particular Specification).

In addition to the above requirements, the CCTV system shall also comply with the latest version of the General Technical Specification for Colour Closed Circuit Television System (Specification No. ESG14) issued by the Electrical and Mechanical Services Department, the Government of the HKSAR.

The CCTV system shall be supplied, installed and maintained by licensed security contractor or workers under the Security and Guarding Services Ordinance (Cap. 460).

11.1.2.21 FIRE SERVICE REQUIREMENTS

11.1.2.21.1 Fireman’s Lift

Where called for in the Particular Specification, Fireman's Lift(s) provided shall satisfy the following conditions: -

(a) Lift well openings shall be provided with automatic self-closing fire-resisting doors;

(b) It shall be of a minimum size of 1.35 m^2 net internal car floor area, with a minimum rated load of 680 kg;

(c) It shall be provided with a suitable control switch at the landing of designated point of entry to enable the Fire Services personnel to gain immediate control over the lift and return it to designated floor. When a Fireman's Switch is operated the lift shall return to the landing of designated point of entry without stopping for car or landing calls. Sole control of the lift shall then be rested in the car control station, and the Fire Services personnel need only take three simple steps to operate the lift:

- Press the desired floor button or 'door close' button continuously to close lift door and register call;

- On arrival at the desired floor, press 'door open' button continuously until lift doors are fully open; and

- If another floor is desired, press floor button of that floor.

On resetting the Fireman's Switch when the lift is at a floor other than the designated point of entry, the lift shall not resume normal operation and shall remain under fireman's lift operating mode until it returns to the designated point of entry and opens its door fully.

Once the Fireman's Switch is switched on and the Fire Services personnel have gained control of the fireman's lift, the lift shall remain under the exclusive control of fireman despite any power supply interruption or changeover from normal power supply to the secondary one, or vice versa, for the fireman's lift. All calls prior to the power supply interruption or changeover shall be automatically cancelled. The operation of the fireman's lift shall then be as follows: -

- In case the lift doors are not fully closed, on the re-establishment of power supply the doors shall automatically open if the lift stopped at a landing. The opening and closing of the doors shall be by pressing continuously the respective control buttons as under fireman's lift operating mode.

- In case the lift doors are fully closed, once the power supply has been re-established the lift shall immediately resume the fireman's lift operational control; or as alternative, return to the designated point of entry or the nearest landing below and resume the operational control.

(d) The electric fan on top of the lift car shall be stopped automatically upon the opening of the safety hatch;

(e) The speed of the lift car shall be such that it will reach the topmost discharge point of the building in not more than 1 minute, calculating from the time when the lift doors on the lowest discharge point are completely closed to the time when the lift doors at the topmost discharge point start to open; and

(f) The opening of the lift door shall not be less than 800 mm wide and 2000 mm high. The doors shall be fitted with power operated automatic self-closing device.

11.1.2.21.2 Fireman's Switch

The fireman's lift shall be provided with a suitable control switch, clearly indicated in English and Chinese as Fireman's Switch, at the designated point of entry to enable Fire Services personnel to gain control over the lift which, upon operation shall override the instructions registered and return to the designated point of entry as quickly as mechanically possible.

For easy identification of Fireman's lift which conforms to this standard, a red and white diagonal striped backing shall be provided behind the glass of the Fireman's switch.

The Fireman's Switch shall be of a type which does not require a key for operation. Where a two-button switch is used the operated button shall remain depressed to indicate which button is in operation. Where a toggle switch is used the 'down' position shall correspond to the 'on' position. The Fireman's Switch shall be located adjacent to the lift opening at the designated point of entry and shall be at a height of approximately 2000 mm above the floor level. Where two or more lifts are installed together, the switch shall be labelled such that there is no doubt as to which lift it controls.

11.1.2.21.3 Home Landing Operation

Every lift shall be provided with a facility to bring the lifts to the designated point of entry in case of fire by manually operated key switch installed at the designated point of entry or Building Management Office. The key switch shall also be used to bring the lift to the designated point of entry after normal office hours for parking with lighting, air conditioning and ventilation fan off and door close after releasing the passengers.

11.1.2.21.4 All Lifts to Return to Landing of Designated Point of Entry Upon Actuation of Fire Alarm System

Where specified in the Particular Specification and/or on the Drawings, the lift control shall be connected to the fire alarm system so that all lifts shall return to the landing of designated point of entry upon actuation of the fire alarm devices (other than smoke detectors) at the appropriate zone. Upon reset of the alarm system, the lifts shall only return to normal service after positive reactivation. In case the main power supply is also interrupted, the lift shall return in sequence to the landing of designated

point of entry, one at a time, upon availability of the emergency power supply.

11.1.2.21.5 Relevant Lifts to Return to Landing of Designated Point of Entry Upon Actuation of Fire Alarm System

Where specified in the Particular Specification and/or on the Drawings, the lift control shall be connected to the fire alarm system so that upon actuation of the fire alarm devices (other than smoke detectors) at the particular zone, all lifts serving that zone shall return to the landing of designated point of entry. Upon reset of the alarm system the lifts shall only return to normal service after positive reactivation. In case the main power supply is also interrupted, the lifts shall return in sequence to the landing of designated point of entry, one at a time, upon availability of the emergency power supply.

11.1.2.21.6 Refuge Floor

The doors of a fireman's lift, opening on to a Refuge Floor through a protected lobby shall not be opened until automatically released upon actuation of the Fireman's Switch, i.e. only the Fireman's Switch will have the capability of opening the lift doors at the Refuge Floor.

11.1.2.21.7 Notice

A permanent notice of prominent size indicating which is(are) the fireman's lift(s) by the words in English and Chinese 'FIREMAN'S LIFT' (消防升降機) and the floors served, shall be displayed adjacent to the Fireman's Lift at the landing of designated point of entry. The notice shall be made of at least 0.8 mm thick stainless steel sheet or other approved material with engraved red letters in English and Chinese.

11.1.2.22 REQUIREMENTS FOR BARRIER FREE ACCESS

11.1.2.22.1 General

The requirements for barrier free access shall be complied by all passenger lifts except those requirements specified only for the accessible lifts.

All passenger lifts shall comply with the Design Manual: Barrier Free Access 2008, PNAP APP-41 and subsequent amendments issued by the Buildings Department, the Government of the HKSAR.

Accessible lift(s), serving every floor, shall be provided in compliance with the Design Manual: Barrier Free Access 2008, PNAP APP-41 and subsequent amendments. All requirements for passenger lifts shall also be applicable to the accessible lift. The accessible lift car shall have minimum dimensions of 1500 mm x 1400 mm with a clear minimum door width of 850 mm unless otherwise specified or approved.

Unless otherwise specified, all passenger lifts shall suit the use by the elderly people in addition to the disabled people. The recommendations and guidelines as stipulated in the Design Manual: Barrier Free Access 2008, PNAP APP-41 and subsequent amendments issued by the Buildings Department shall be followed except with the approval of the Supervising Officer.

11.1.2.22.2 Lift Control Buttons

Essential lift control buttons such as the emergency alarm button, intercom button, door opening button, and call buttons for the landing in all passenger lift cars as well as call buttons at all the landings, shall not be lower than 900 mm or higher than 1200 mm above finished floor level. Braille and tactile markings shall be placed either on or to the left of the control buttons. Such markings shall be minimum 15 mm in height and 1 mm raised. All lift control buttons shall have a minimum dimension of 20 mm.

Control buttons shall be of micro-movement push button type and as specified in this Sub-section unless otherwise specified.

The graphics for tactile markings for 'Door Open', 'Door Close', 'Emergency Alarm', and 'Main Entrance Floor' shall be as shown in Figure 41 of the Design Manual: Barrier Free Access 2008, PNAP APP-41 and subsequent amendments unless otherwise specified. The tactile markings shall be of high contrasting colour background. The 'Main Entrance Floor' is the floor of the designated point of entry or as specified.

Where one of the lifts in a bank under group supervisory control is designated as the accessible lift, a separate call button for the accessible lift shall be installed on each floor to ensure that the accessible lift will stop at the called floor. Priority of attendance to the call for accessible lift shall be assigned to this button. This separate call button shall be identified with an approved Braille and tactile international symbol of accessibility on the floor panel. When floor buttons other than the separate call button are pressed, the accessible lift will be under the group supervisory control same as all other lifts in the same bank.

The accessible lift car shall have two lift control stations, one on either side of the car door.

11.1.2.22.3 Handrail

A tubular stainless steel handrail not less than 32 mm and not greater than 40 mm in external diameter shall be provided on 3 sides of all passenger lift cars, extending to within 150 mm of all corners. The handrail shall be not less than 30 mm or more than 50 mm clear of walls and other obstructions. The gripping surface of the top of the handrail shall be not less than 850 mm or more than 950 mm above the finished floor level.

11.1.2.22.4 Landing and Car Doors

On arrival of the passenger lift to a landing in response to a car call or landing call, the landing and car doors shall be opened automatically and be kept open for a pre-determined period before closing. This period shall be adjustable from 3 seconds to 30 seconds. The time period shall be suitably adjusted to allow sufficient time for wheelchair users or persons with a disability or the elderly to enter and leave the lift car. An audible signal shall be provided to signify the closing action of the doors. A sensitive door re-opening device shall be provided to automatically initiate the re-opening of the doors in the event that any obstacle is about to be struck by the doors in crossing the entrance during the closing movement. There shall be detection devices positioned at a height between 500 mm to 600 mm above the floor of the lift car as well as other heights. The landing and car doors shall be of automatic power operated horizontally sliding type.

11.1.2.22.5 Emergency Alarm Push Button and Intercom

There shall be an emergency alarm push button together with an indication light, a buzzer and an intercom inside all the lift cars such that the person inside can speak to the building management office or the caretaker's office as the case may be.

11.1.2.22.6 Door Jamb

Tactile and Braille floor designations shall be provided on the jambs on both sides of each lift entrance, by means of Arabic numerals, minimum 60 mm high, raised 1 mm, and at 1200 mm above the finished floor level.

11.1.2.22.7 Identification

The accessible lift and all lifts complying with same barrier free access requirements shall be identified by at least one international symbol of accessibility at each landing served by each lift. Where there is only one lift in the building or all the lifts in the building are designed for barrier free access, at least one international symbol of accessibility shall be provided at each lift lobby on the designated point of entry of the building.

Unless otherwise specified, the international symbols of accessibility for accessible lift shall be supplied and installed where there is only one accessible lift and only the accessible lift in the lift lobbies of all floors is required to have the international symbol of accessibility. For other cases or where there is more than one lift in any lift lobby required to have the international symbol of accessibility, the symbols will be supplied and installed by the Building Contractor unless otherwise specified.

Tactile warning tiles or similar shall be placed in front of the lift door of the accessible lift at each landing. Unless otherwise specified, tactile warning tiles will be provided by the Building Contractor.

The Building Contractor shall be coordinated to check and ensure that the requirements are complied.

11.1.2.22.8 Mirror in Accessible Lift

Where the dimension of accessible lift car are less than 1500 mm x 1400 mm with a size that does not allow a wheelchair user to turn around within the lift car conveniently, a mirror shall be provided inside the lift with a clear width not less than 850 mm and its bottom and top edges shall be not more than 300 mm and not less than 1800 mm above the floor of the lift car respectively. The size and location of mirror shall be made to facilitate a wheelchair user to check the conditions behind the wheelchair in reversing out of the lift and to see which level the lift has reached.

11.1.2.23 REQUIREMENTS FOR HYDRAULIC LIFT

11.1.2.23.1 Limitation of Use

Hydraulic lift shall not be applied for the purpose of passenger lift unless otherwise specified.

11.1.2.23.2 Drive System

(a) The lift car shall be driven by either direct acting or indirect acting (suspension) hydraulic system; and

(b) In case of direct acting system, the hydraulic ram shall be located either at the side, or the back. Unless otherwise specified, direct acting underneath the lift car is not acceptable.

11.1.2.23.3 Hydraulic Machinery

(a) General

Hydraulic equipment and piping shall be accessible and shall be mounted in a position that will not interfere with equipment adjustment or affect maintenance. All pressure and volume controls shall be so constructed that they are not adjustable outside the safe working range of the system of which they form a part.

(b) Manual emergency operation

Readily accessible manual devices for emergency operation shall be provided in the machine room.

(c) Anti-creep device

Provision shall be made to automatically return the car to the landing level at a speed not exceeding 0.15 m/s in the event of a leakage in the hydraulic system causing the car to move downward for more than 75 mm but within the unlocking zone.

(d) Ram

Ram shall have smooth cylindrical external surfaces and, if hollow, shall be of approximately uniform thickness. Grey cast iron or other brittle material shall not be used for rams or connecting links. Grey cast iron, where used in other parts of the ram assembly shall have a safety factor of not less than 10. Rams shall not be subjected to bending stresses or eccentric loading.

(e) Valves

The hydraulic system shall incorporate all the components necessary to ensure safety and to give smooth starting and stopping, and the control valves shall be adjusted to suit general passenger/goods traffic. A stopcock shall be provided between the control valves and the cylinder(s), and also between the reservoir tank and the pump if the pump is mounted outside the tank.

(f) Cylinders

Cylinders shall be so mounted that they are subjected only to axial loads. All necessary supports, and mountings of the cylinders shall be provided by the lift manufacturer, including covers for any boreholes. The neck of a cylinder shall incorporate an efficient gland, a wiper ring and a drainable cup to gather wiped oil.

(g) Suspended system

Where the car is suspended, the cylinders shall be solidly mounted on the building structure and the head of the ram adequately guided or supported to carry the rope pulley. A device shall be incorporated which will initiate the closing of the lowering valve in the event of the car being prevented from descending by an obstruction. The device may be either a low pressure switch in the hydraulic line or a slack rope switch.

(h) Pump and motor

The pump and pump motor shall be mounted on one robust bedplate or within the power unit assembly if it is suitably rigid. The motor pump and bearing(s) shall be so mounted and assembled that proper alignment of these parts is maintained under all normal operating conditions. The power unit shall be generously rated and shall operate with minimum noise and vibration. The unit shall be mounted on vibration insulators above the machine room floor. A silencer unit shall be fitted in the hydraulic system to minimise the transmission of pulsations from the pump to the car and the elimination of airborne noise. An oil filter shall be fitted on the pump inlet. A stopcock shall be provided to enable the filter to be cleaned or changed without significant loss of oil. The pump motor shall be of the single speed

squirrel cage or slip ring type and it shall run with minimum noise and vibration. It shall be capable of a continuous duty cycle of at least 45 motor starts per hour.

(i) Pipes

Rigid steel pipe shall be used. All welded joints shall comply with BS 2633:1987. Hydraulic piping shall be effectively isolated from the building structure to minimise the transmission of vibration.

(j) Design pressure

All cylinders, rams, pipes, valves, and fittings shall be designed such that under the forces resulting from a pressure equal to 2.3 times the full load pressure, a safety factor of at least 1.7 referred to the proof stress is assured.

(k) Oil storage tank

The tank shall have sufficient capacity to provide an adequate reserve to prevent the entrance of air or other gas into the system. A sight glass tube shall be provided for checking the oil level and the minimum level mark shall be clearly indicated. An oil level monitoring device shall be provided, and if operated, shall maintain a visual and audible signal in the control panel until the fault is rectified.

11.1.2.23.4 Suspension

Where the raising of the lift is achieved by the use of steel wire ropes interposed between the ram and the car, the steel wire ropes suspension shall be arranged in such a way that the cylinders impose only vertical loads on the building structure.

11.1.2.23.5 Transfer of Loads to Car Frame Guides

The car platform frame shall be so designed and constructed that all eccentric loads are transferred to the guides and not to the ram attachments.

11.1.2.23.6 Safety Gear

(a) Instantaneous car safety-gear shall not be fitted to direct acting hydraulic lifts. When any other form of car safety-gear is fitted to a direct acting lift, provision shall be made to absorb any impact loading at the cross-head due to the inertia of the ram and attachments; and

(b) All hydraulic cylinders shall be fitted with an integral or flange-bolted rupture valve which shall stop the descent of car cage.

11.1.2.23.7 Levelling

(a) Levelling accuracy

The control system shall be provided with a floor levelling device which shall automatically bring the lift car to a stop within ± 5 mm of level with any floor for which a stop has been initiated, regardless of the load or direction of travel.

(b) Re-levelling device

An automatic re-levelling device shall be provided which shall be arranged to automatically return the lift to the floor should the lift creep down from floor level for a distance not exceeding 75 mm.

11.1.2.24 REQUIREMENTS FOR SERVICE LIFT

11.1.2.24.1 Definition

Service lift means a permanent lifting equipment serving defined landing levels, comprising a car, the interior of which is INACCESSIBLE to PERSON on account of its dimensions and means of construction.

The car floor area shall not exceed a value determined from the table below:

Rated Load (kg)	Maximum Floor Area (m^2)
10	0.15
50	0.5
100	0.75
200	1
250	1

Neither the internal depth nor the internal width of the car shall exceed 1400 mm.

The overall internal height of the car shall not exceed 1200 mm.

The rated load shall not exceed 250 kg.

11.1.2.24.2 Lift Car and Method of Drive

Service lift cars shall be of rigid construction and totally enclosed except for service openings. The car shall not be made of inflammable materials. Two pairs of renewable guide shoes shall be fitted.

Unless otherwise specified, removable shelves shall be fitted inside the car and be so retained that they shall not be displaced by the movement of the car.

Cars shall be provided with imperforate doors to prevent goods projecting outside the car.

The method of drive for the lift shall be one of the following:

(a) by traction, i.e. sheaves and ropes; or

(b) by positive drive using drum and ropes without counterweights.

11.1.2.24.3 Guide

The car and counterweight shall each be guided by rigid guides.

Guides and their fixings shall be capable to withstand the application of the safety-gear (if provided) when stopping a fully loaded car or counterweight.

11.1.2.24.4 Buffer

Buffers shall be provided under all cars and counterweights.

A lift with positive drive shall be provided with additional buffers on the car top to function at the upper limit of travel.

The buffers used shall be one of the following types:

(a) spring;

(b) rubber; or

(c) resilient plastic.

11.1.2.24.5 Counterweight

Counterweights shall be of metal. A metal frame shall be provided to prevent their displacement.

In the case of drum drive, there shall be no counterweight.

11.1.2.24.6 Suspension

Cars and counterweights shall be suspended by means of round strand steel wire ropes. The factor of safety of suspension ropes shall not be less than 10.

The minimum number of suspension ropes shall be two and they shall be independent. The diameter of sheaves or pulleys shall not be less than 30 times the rope diameter.

11.1.2.24.7 Safety Gear

Safety gear tripped by an overspeed governor shall be provided for the car where:-

(a) the rated capacity is 250 kg;

(b) accessible spaces exist beneath the lift well; or

(c) gross car roof area equals to or greater than 0.37 m^2.

Where there is an accessible space beneath the well, the counterweight shall be equipped with safety gear.

11.1.2.24.8 Load Plate and Warning Notice

A load plate giving the contract load of the lift in kg shall be fixed in a prominent position at each landing entrance.

A warning notice in both English and Chinese bearing the words 'Persons are forbidden to enter the lift car or enclosure' as approved by the Supervising Officer shall be prominently fixed at each landing entrance.

11.1.2.24.9 Car and Landing Door

All landing openings in the lift well shall be protected by doors. Every car or landing door shall be provided with an electric safety device which shall prevent the lift from being operated when any car or landing door is open.

It shall not be possible during normal operation to open a landing door unless the car is in the unlocking zone.

The landing doors shall be provided with the facility of being unlocked from outside with the aid of a special purpose key provided for use only by a competent lift worker.

11.1.2.24.10 Terminal Stopping Switches

Service lifts shall be provided with terminal stopping switches to stop the car automatically at or near the terminal service levels.

11.1.2.24.11 Instructions for Emergency Operation

In the machine room or the interior of the machine enclosure, a framed notice of reasonable size shall be provided with detailed instructions to be followed in the event of lift breakdown particularly concerning the use of the device(s) provided for manual emergency movement and the unlocking key for landing doors. Details of the framed notice shall be approved by the Supervising Officer.

The direction of movement on the car shall be clearly indicated on the machine.

11.1.2.25 REQUIREMENTS FOR MACHINE-ROOM-LESS LIFT

11.1.2.25.1 Definition

A machine-room-less lift is a lift installation where all its driving machinery and safety components are installed inside the lift well and the requirement for a lift machine room is not necessary.

11.1.2.25.2 Statutory Requirements

The machine-room-less lift shall be of a type approved by the Electrical and Mechanical Services Department, the Government of the HKSAR.

When the proposed machine-room-less lift does not comply fully with the statutory codes and requirements, all necessary submissions to the relevant authorities shall be prepared and arranged for applying exemptions/modifications of the requirements, and where applicable provide all necessary information and assistance to the Supervising Officer for applying such exemptions/modifications.

The early submissions shall be made in order to obtain all the necessary approvals matching with the project programme.

In addition to the new construction requirements, the requirements in statutory regulations and codes shall be checked to ensure that all the necessary exemptions/modifications including those related to maintenance and safety requirements to suit the machine-room-less lift installation are included in the submissions to the relevant authorities.

The adequate maintenance facilities and safety measures shall be incorporated, so that the operational safety and reliability of machine-room-less lift shall not be lower than the lift with machine room, and are to the approval of the Electrical and Mechanical Services Department, the Government of the HKSAR and the Supervising Officer.

The confirmation from a Registered Lift Engineer under the Contract shall be provided in writing that any future maintenance, repair, major alteration, replacement, examination and testing of the machine-room-less lift can be carried out inside the lift well safely and without difficulty, complying with all the occupational safety and health requirements of the Labour Department, the Government of the HKSAR.

11.1.2.25.3 Specific Requirements

Unless specific requirements on alternative arrangement are, machine-room-less lift shall comply with all the requirements for electric lift installation as detailed in other sections of this General Specification.

In the absence of lift machine room, the provision of a lift equipment room by Building Contractor is essential and shall be planned in order to house all the equipment of machine-room-less lift located outside the lift well.

All the controls, devices, panels and facilities of machine-room-less lift located outside the lift well shall be housed centrally in the lockable lift equipment room outside the lift well. Where there is no lift equipment room provided by the Building Contractor as specified in the Particular Specification and/or shown on the Drawings, the lockable lift equipment cabinet shall be installed with hinged doors for housing all such controls, devices, panels and facilities of machine-room-less lift outside the lift well.

Position of the lift equipment room/cabinet shall be as stipulated in the Particular Specification and/or on the Drawings, or alternative proposed and approved by the Supervising Officer. It shall be near or adjacent to the lift well and near to the overspeed governor and motor brake as required in (b) below. The lift equipment room/cabinet shall be accessible by authorised person only.

Locating the lift equipment cabinet at the lift lobby of the occupied floor should be avoided, and where it is unavoidable it shall be positioned and constructed to minimise the disturbance and obstruction to the occupants during maintenance and inspection. The frequency and details of maintenance and inspection work at the lift equipment cabinet shall be submitted so that the occupants of the occupied floor can be consulted where necessary.

The lift equipment cabinet shall be provided and constructed from stainless steel frame and stainless steel sheet of minimum 1.5 mm thick with finishes approved by the Supervising Officer unless otherwise specified. It shall be of adequate size for housing all the equipment including the tools.

The door(s) of lift equipment room/cabinet shall not open towards the control panel or other devices installed inside the room/cabinet and shall be fitted with a lock that can be opened without a key from inside (for room/cabinet accessible by people) and can be locked without a key from outside. It shall bear on the outside face a notice in English and Chinese in letters and characters not less than 25 mm high as follows:

UNAUTHORISED ACCESS (OPENING) PROHIBITED
LIFT EQUIPMENT ROOM (CABINET)
CLOSE AND LOCK THIS DOOR
不得擅進 (打開)
升降機設備室 (櫃)
請關閉並緊鎖此門

The following specific requirements for machine-room-less lift shall also be complied with:-

(a) Maintenance, repair, major alteration, replacement and examination of the overspeed governor and machine shall be able to be carried out on the car roof safely and without difficulty;

(b) Both the overspeed governor and motor brake shall be able to be observed through a window of the control panel provided outside the lift well or by an inspection door at the lift well provided by the Building Contractor. The design of the position and dimensions of such inspection door shall be submitted and approved by the Supervising Officer;

(c) Tripping and re-setting of the overspeed governor shall be able to be remotely controlled outside the lift well, in the lift equipment room/cabinet, or where required at a position approved by the Supervising Officer;

(d) The motor brake shall be able to be remotely released outside the lift well, in the lift equipment room/cabinet or where required at a location approved by the Supervising Officer;

(e) When the counterweight buffer is completely compressed, the over-travel of the lift car above the upper terminal landing floor level shall not exceed a dimension that will hinder the release of passengers in a safe manner;

(f) Sufficient energy efficient lighting shall be provided for illumination of the overspeed governor, motor brake and machine in the lift well;

(g) The electro-mechanical brake shall be capable of stopping/holding a fully laden machine-room-less lift car traveling downward at its rated speed and with the load equivalent to 125% of the rated load. The safety gear shall be capable of stopping/holding a fully laden machine-room-less lift car traveling downward at the tripping speed of the overspeed governor, even if the suspension devices break;

(h) Lift machinery drive when placed inside the lift well shall be of low-fire-risk construction so that the fire hazard and fire risk in the lift well shall not be increased when compared with a lift with machine room, and the fire resistance period required for the lift well shall not be affected;

(i) Intercom system in lift machine room and CCTV monitor in lift machine room shall be installed in the lift equipment room or cabinet;

(j) The platforms and works areas inside the lift well shall be adequate and able to support the weight of at least two persons and additional tools and equipment for carrying out the maintenance and repair.

11.1.2.25.4 Control Panel

Position of the control panel shall be as specified in the Particular Specification and/or shown on the Drawings, or alternative proposal and approved by the Supervising Officer. When the control panel is located outside the lift well, it shall be placed in the lift equipment room or in the lockable lift equipment cabinet provided. Hinged front doors and removable hinged rear panels are not required. When the control panel is located inside the lift well, it shall be located at a position that will enable the lift maintenance personnel to carry out inspection and maintenance work in a safe and efficient manner. All necessary working platform and access to the control panel shall be provided.

11.1.2.25.5 Provisions for Rescue of Passengers

Machine-room-less lift shall be provided with emergency electrical switch and push button installed outside the lift well with the same functions and provisions as required for electric and hydraulic lift. The emergency electrical switch and push button shall be installed in the lift equipment room/cabinet, together with clear instruction of its use.

To cater for power failure and breakdown of the lift car, in addition to the provision of emergency electrical switch and the controls for releasing the brake as required for electric and hydraulic lift, the following facilities shall be provided and be readily available for use by the rescue personnel:

(a) Car lifting tool for moving the car in case it is stuck; and

(b) Weights for adding to the car in case of balanced loading condition where the car cannot be moved by releasing the motor brake, or other means to move the lift car as approved by the relevant Authorities and the Supervising Officer.

A suitable lockable container for storage of the above facilities, together with clear instructions on the method for releasing the brake and moving the lift car in an emergency, shall be provided and placed inside the lift equipment room/cabinet. The container shall bear on the outside face a notice ‘Emergency release operation shall only be undertaken by authorised person’.

11.1.2.25.6 Fire Resisting Construction

The lift machinery of machine-room-less lift is located inside the lift well. The fire resistance period of lift well shall comply with the Code of Practice for Fire Safety in Buildings 2011 and subsequent amendments issued by the Buildings Department. Lift machinery of machine-room-less lift shall be of low-fire-risk construction/type. The presence of lift machinery in lift well shall be checked with confirmation to the Supervising Officer that it does not increase the fire hazard and fire risk in the lift well so that the fire resistance period of lift well is not required to be increased to align with the fire resistance period requirement of lift machine room. Where necessary and agreed by the Supervising Officer,

approval for exemptions/ modifications of the statutory codes and requirements shall be obtained from the relevant authorities. In particular, lift well constructed from glass and other low fire resistance material shall be checked to ensure its compliance with the relevant codes and requirements.

11.1.2.25.7 Energy Efficient Lift

Machine-room-less lift shall be energy efficient type using high efficiency gearless drive such as permanent magnet synchronous (PMS) motor or better and approved. The detailed supporting quantitative information shall be provided to substantiate the higher energy efficiency of machine-room-less lift as compared with other conventional energy efficient lift with equivalent functions and performance.

SUB-SECTION 11.1.3

ESCALATOR AND PASSENGER CONVEYOR INSTALLATION

11.1.3.1 STEPS/PALLETS

11.1.3.1.1 Step/Pallet Demarcation

The surface of the steps/pallets shall be horizontal at all positions exposed to passenger.

The nominal width of steps/pallets shall be 1000 mm unless otherwise specified.

Yellow lines of 25 mm width shall be marked on both sides and front of the leading/trailing edges of the steps of the escalator. For passenger conveyor, yellow lines of 25 mm width shall be marked on both sides of the pallets only.

Yellow lines shall be durable and of wear resistant materials to show demarcation between comb and cleat.

11.1.3.1.2 Integral Die-Cast Aluminium Step Tread, Pallet and Step Riser

The step treads and pallets shall be of die-cast aluminium with closely spaced cleats designed to provide a secure foothold, the latter being grooved parallel to the travel of the steps to mesh with the comb teeth at the entrance and exit. For escalator, step risers shall also be of die-cast aluminium integral with the step treads and shall include vertical cleats designed to pass between the cleats of the tread on the adjacent steps thus providing a combing action with minimum clearances.

11.1.3.1.3 Rollers

Each step/pallet shall be supported on four rubber or synthetic material tyred ball bearing rollers, grease sealed for life and so mounted that tilting and rocking of steps/pallets is prevented whilst ensuring smooth quiet operation in service.

11.1.3.1.4 Traction

Traction to the steps/pallets shall be by means of two endless roller chains.

11.1.3.1.5 Dimensions of Step/Pallet

The depth of any step/pallet in the direction of travel shall not be less than 400 mm.

For escalator, the rise of any such step shall not be more than 240 mm.

11.1.3.1.6 Clear Height above Step/Pallet

The clear height above the steps/pallets at all points shall not be less than 2300 mm.

11.1.3.1.7 Flat Steps for Escalator

There shall be at least a length of two complete steps i.e. 800 mm at either end of the escalator travelling horizontally from the comb line.

11.1.3.2 STEP/PALLET CHAINS

11.1.3.2.1 Step/Pallet Chain

The steps/pallets shall be driven by at least 2 steel link chains of which at least one shall be located at each side of the step/pallet.

The step chains shall be of endless roller type and modular construction. Each module shall comprise not more than 4 rollers.

11.1.3.2.2 Materials

The step/pallet chains shall be made of high tensile steel links with hardened and ground pins, unless otherwise specified.

11.1.3.2.3 Quiet Operation

The rollers shall accurately engage with the drive sprockets to ensure smooth and quiet operation.

11.1.3.3 TRACKS

11.1.3.3.1 Curved Section

All the curved sections of the tracks shall be manufactured in steel or aluminium pressure die-castings.

11.1.3.3.2 Straight Section

The straight sections of the tracks shall be of steel or aluminium extrusions. The tracks forming both running surfaces and guards over the trailing rollers shall essentially be channels or of such formation as to prevent derailing.

11.1.3.3.3 Design

The entire tracking system shall be so designed that in the unlikely event of a step chain breaking, there shall be no likelihood of the steps lifting out of place.

11.1.3.4 LANDING PLATE

11.1.3.4.1 Landing Plate

Floor landing plates shall be provided over the openings to give access to the mechanism for maintenance purpose. These landing plates shall be of stainless steel or wear resistant aluminium alloy which shall afford a secure foothold. All associated supports and fixing bolts of the landing plate shall be firmly and securely tightened. Safety device for floor landing plates shall be provided. Alternative material will not be accepted without the prior approval of the Supervising Officer.

11.1.3.4.2 Landing Gap

The gap between the balustrade exterior panelling and the wall or obstacle shall not exceed 75 mm.

11.1.3.4.3 Tactile Warning Strips

Tactile warning strips are required at the top and bottom ends of an escalator or at both ends of a passenger conveyor. Unless otherwise specified, the tactile warning strips will be provided by the Building Contractor. The installation details shall be coordinated with the Building Contractor to check and ensure that the requirements are complied.

11.1.3.5 COMBS

11.1.3.5.1 Combs

Combs shall be provided at both landings and shall be of wear resistant aluminium alloy with anti-slip pattern.

11.1.3.5.2 Comb Teeth Section

The comb teeth sections shall have fine pitch teeth to allow the cleats of the step tread to pass them with a minimum of clearance. The comb teeth sections shall be made of synthetic resin, metal or equivalent material.

Each such comb teeth sections shall be such that: -

- it is adjustable horizontally and vertically; and
- sections forming the same are readily removable in case of emergency.

The teeth of every comb teeth section shall be so meshed with and set into the slots of the step tread and pallets. For escalator, the points of such teeth are always below the upper surface of such tread surface.

11.1.3.6 BALUSTRADING

11.1.3.6.1 Balustrades

Solid balustrades shall be installed on each side of the escalator/passenger conveyor and shall consist of the following components:

(a) Skirting

The skirting panels shall be vertical and constructed of smooth hairline finish stainless steel with thickness of not less than 2 mm. Embossed, perforated or roughly textured materials shall not be used.

(b) Interior profile

The interior profile shall be of smooth hairline finish stainless steel with thickness not less than 2 mm. The interior profile and the balustrade interior panelling shall have an angle of inclination of at least 25o to the horizontal.

(c) Interior and exterior panelling

Both the interior and exterior panelling shall be of smooth hairline finish stainless steel with thickness of not less than 1.5 mm. If glass balustrade is specified, the glass shall be of a laminated safety glass and shall have sufficient mechanical strength and rigidity. The glass panels shall be at least 6 mm thick.

When specified in the Particular Specification, Lighting shall be provided along and underneath the handrails except for slim type balustrade decking design and stainless steel type balustrade decking design when specified in the Particular Specification.

(d) Balustrade decking

The decking shall be of stainless steel or extruded aluminium, polished and anodised in natural colour. The decking is to be situated under the handrail and forms the top cover of the balustrade panelling. Appropriate measure shall be provided to discourage people from sliding along the decking.

(e) Extended newel

The newel including the handrails shall project beyond the root of the comb teeth by at least 600 mm in longitudinal direction.

11.1.3.6.2 Dress Guard

Dress guards of brush bristles type shall be provided along the full length of the lower part of the skirting panels.

Brush bristles type dress guard shall be made of nylon filaments. The nylon filaments shall not support combustion and shall be durable and with flagged ends to give a soft face and be securely held within a pressed steel holder. The assemblies shall be easily removed when replacement is necessary. It shall consist of anodised aluminium carrier which is suitable for the escalator/passenger conveyor sidewall. The bottom of the carrier shall have chamfer angle to eliminate trapping of feet, trolley wheels and parcels, etc. The carrier shall be fixed onto the skirting panel by secret fixings which are concealed by the filaments but are easily removable.

11.1.3.6.3 External Cladding

The external cladding of the undersides and sides of the escalator/passenger conveyor shall be of hairline stainless steel and provided unless otherwise specified. The cladding materials shall have a FRR of not less than half an hour.

11.1.3.6.4 Guard for Adjacent Building Obstacles and Criss-Cross Escalators

Where building obstacles and on criss-cross escalators can cause injuries to passengers riding on escalators, appropriate preventive measures shall be taken. In particular, at floor intersections and criss-cross escalators, a set of vertical obstruction guard shall be provided and placed above the balustrade decking

For vertical building obstacles or columns, unless other approved preventive measures (e.g. buffer protection surfaces) are taken, fixed guards shall be installed. The fixed guards would not be required if the vertical building obstacle or column has a radius of curvature of not less than 300 mm. The part of the vertical building obstacles or columns facing the escalator shall form part or whole of a smooth continuous surface extending from at least 100 mm below the top of the handrail to a height of at least 2100 mm above the step, pallet or belt of the escalator.

The position of the obstruction guards shall be such that it can effectively prevent injuries to the passengers. The guard shall be of light and durable material such as plastic as approved by the Supervising Officer.

It is not necessary to comply with the requirements as mentioned in this Clause when the distance between the edge of the handrail and any obstacle is equal to or greater than 600 mm.

When specified in the Particular Specification, for the rise of escalator is greater than 15 m or the escalator to the next lower floor level with vertical difference greater than 15m. Shelter wall shall be installed at both sides of the escalator with a height of at least 1800 mm from newel to newel, except the portions where there is no danger of people falling from the escalator.

If the guard shall be fixed on building obstacle or decoration panel, it shall be installed by Building Contractor.

11.1.3.6.5 Distance between Balustrade Interior Panelling

The horizontal distance (measured right angles to the direction of travel) between the balustrade interior panelling lower points shall always be equal to or less than the horizontal distance measured at points higher up.

The maximum distance between the balustrade interior panelling at any point shall be smaller than the distance between handrails. This requirement can be disregarded for escalators with handrails centralised with balustrade interior panelling.

11.1.3.7 HANDRAILS

11.1.3.7.1 Rubber Handrail

The handrails shall be in luminous contrast with the background and constructed of multi-layered canvas with the exposed surface covered with smooth black abrasion resistant rubber which shall be vulcanised into an endless loop.

11.1.3.7.2 Speed

The handrails shall move in the same direction and substantially at the same speed as the steps. The speed of the handrail is permitted to deviate from the speed of the steps, pallets or belt within the limits of 0% to +2%.

11.1.3.7.3 Safety Guard

Safety guards shall be provided where the handrails enter and leave the escalator/passenger conveyor newels to prevent pinching of fingers and hands.

In addition to being protected by the automatic operation of the handrail entry safety guard, the point of entry of the handrail into the newel shall be so configured as to prevent the pinching of fingers, hands or other objects. Handrail entry designs which form part of the continuous profile of the balustrade decking or which are considered by the Supervising Officer as vulnerable to the pinching of fingers, hands or other objects are not accepted.

11.1.3.7.4 Handrail Guide

The handrail guides shall be in specially formed section to allow easy movement of the handrail but properly shaped as to retain the handrail always in its place.

11.1.3.7.5 Width of Handrail

The width of the handrail shall be between 70 mm and 100 mm.

11.1.3.7.6 Handrail Clearance

The horizontal distance between the outer edge of the handrail and walls, adjacent criss-cross escalators or other obstacles shall under no circumstances be less than 200 mm or 80 mm (for a continuous smooth wall) and shall be maintained to a height of at least 2100 mm above the steps, pallets or belt of the escalator/passenger conveyor.

The vertical distance between the handrail and step nose, pallet surface or belt surface shall not less than 900 mm and not exceed 1100 mm.

11.1.3.7.7 Concealed Type Self-Cleaning Devices

The handrails shall be equipped with automatic concealed type self-cleaning devices unless otherwise specified in the Particular Specification. Selection of self-cleaning devices shall best be done by verification of their capability and effectiveness in the disinfection. The self-cleaning devices shall be compatible with the escalators and shall not interfere with the operation and maintenance of the escalators.

11.1.3.8 TRUSS

11.1.3.8.1 Construction

The structural steel truss shall be a rigid steel fabricated structure and shall be capable of carrying a full complement of passengers together with mechanism of the escalator/passenger conveyor the balustrades and the weight of exterior covering. The supporting structure shall be designed in a way that it can support the dead weight of the escalator/passenger conveyor plus a passenger weight of 5000 N/m². The factor of safety used in the design of structural members of the escalator/passenger conveyor trusses shall not be less than 5 based on static load.

11.1.3.8.2 Step/Pallet Chain Breaking

The entire tracking system shall be so designed that in the unlikely event of a step/pallet chain breaking, there shall be no likelihood of the steps/pallets lifting out of place.

11.1.3.8.3 Machinery Space

For escalator, the upper section of the truss shall contain the drive machine and shall be fitted with a trap door. In cases where several drive machines are placed along the length of an escalator/passenger conveyor, suitable means of access to the drive machines shall be provided.

The structural integrity of the trap door and all associated supports and fixing bolts shall be firmly and securely tightened. Safety device for trap door shall be provided.

11.1.3.9 LUBRICATION

11.1.3.9.1 Lubrication

Effective means for lubricating the bearings and moving parts as required shall be provided with easy access.

Oil pump shall be provided for the automatic lubrication of steel chains.

11.1.3.9.2 Oil Pan

Oil tight drip pans shall be provided for the entire length of the escalator/passenger conveyor to contain any waste and lubricants within the truss. Where necessary, the oil tight drip pans shall be removable to give access to both the machinery space and the return station for maintenance.

11.1.3.10 DRIVING MACHINERY

11.1.3.10.1 Independent Driving Machine

Each escalator/passenger conveyor shall be driven by at least one machine of its own.

11.1.3.10.2 Reduction Gear

The driving machine shall incorporate a reduction gear system employing worm gear, planetary gear or other proven gear types.

(a) Worm gear system

The driving machine shall incorporate a worm reduction gear with a vertical flange-mounted motor or other proven design. It may be connected by chain or other proven means to the main drive shaft of the escalator/passenger conveyor. The worm shaft and worm wheel shall be housed in a substantial cast iron housing which shall also hold the lubricant.

(b) Planetary gear system

The motor, planetary gears and brakes shall be fully enclosed and form a unique, compact no-chain unit. Motor and bearings shall have life-time lubrication.

11.1.3.10.3 Motor

The motor shall be integrally mounted, AC squirrel cage, three phase induction motor of continuous rating, reversible type with high starting torque and low starting current and specially designed for escalator/passenger conveyor application. Variable voltage and variable

frequency (VVVF) control and soft starting shall be employed as the motor control and the starting method of the motor drive respectively.

Other proven motor types may also be used subject to the approval by the Supervising Officer.

11.1.3.10.4 Speed

The rated speed of the escalator shall not be more than 0.75 m/s and 0.5 m/s for an escalator with an angle of inclination not exceeding 30° and 35° with rise not more than 6 m from the horizontal respectively.

The rated speed of passenger conveyor shall not exceed 0.75 m/s. However, this rated speed may be increased to 0.9 m/s maximum provided that: -

(a) the width of the pallets or the belt does not exceed 1100 mm; and

(b) at the landings, the pallets or the belt move horizontally for a length of at least 1600 mm before entering the combs.

Where specified in the Particular Specification and/or on the Drawings, a key switch shall be provided in or near the control panel to adjust the speed manually and on step/ continuous basis.

11.1.3.10.5 Bearing

The motor shall be fitted with grease lubricated ball bearings.

11.1.3.11 BRAKING

11.1.3.11.1 Electro-Mechanical Brake

Each escalator/passenger conveyor shall be provided with braking that is mechanically applied and electrically held off type of sufficient capacity to efficiently bring the escalator/passenger conveyor to rest with uniform deceleration when travelling at full contract speed in either direction.

11.1.3.11.2 Auxiliary Brake

Escalators and inclined passenger conveyors shall be equipped with auxiliary brake(s) acting immediately on the non-friction part of the driving system for the steps, pallets or the belt (one single chain is not considered to be a non-friction part), if

(a) the coupling of the operational brake and the driving wheels of the steps, pallets or the belt is not accomplished by shafts, gear wheels, multiplex chains, two or more single chains; or

(b) the rise exceeds 6000 mm;

(c) the operational brake is not an electro-mechanical brake; and

(d) they are 'Public Service Escalators' as defined in the Code of Practice on the Design and Construction of Lifts and Escalators.

11.1.3.11.3 Handwinding

Provision shall be made for handwinding the escalator/passenger conveyor in either direction, and shall be suitably marked for "UP" and "DOWN" operation. Crank handles and perforated wheels are not permitted. Instructions for handwinding devices in English and Chinese shall be displayed prominently in the driving station. If the handwinding device is detachable, it shall not be accessible to unauthorised persons. The handwinding device shall be painted yellow.

11.1.3.11.4 Stopping Distances

Rated Speed	Stopping distance between
0.50 m/s	min. 200 mm and max. 1000 mm
0.65 m/s	min. 300 mm and max. 1300 mm
0.75 m/s	min. 350 mm and max. 1500 mm

The stopping distance for an unloaded escalator shall be close to the minimum value, while for a downward moving loaded escalator it shall be close to the maximum value.

The stopping distances for unloaded and loaded passenger conveyors shall be between the following values:

Rated Speed	Stopping distance between
0.50 m/s	min. 200 mm and max. 1000 mm
0.65 m/s	min. 300 mm and max. 1300 mm
0.75 m/s	min. 350 mm and max. 1500 mm
0.90 m/s	min. 400 mm and max. 1700 mm

The stopping distance for an unloaded passenger conveyor shall be at such a value in the range to achieve smooth retardation.

For escalators/passenger conveyors with intermediate speeds the stopping distances are to be interpolated.

The stopping distances shall be measured from the time the electric stopping device is actuated.

11.1.3.12 FOOTLIGHTS AND STEP/PALLET LIFTS UNDER LANDINGS

11.1.3.12.1 Footlight

Footlights shall be provided on either side of the interior of the skirting at both landings and energy efficient or LED luminaries shall be used. The

intensity of illumination shall be not less than 50 lux for indoor; or shall be not less than 15 lux for outdoor escalators or passenger conveyors at the landings, measured at floor level.

11.1.3.12.2 Step/Pallet Lights under Landings

Energy efficient or LED luminaries shall be provided underneath landings to illuminate the clearance between steps/pallets, steps/pallets and skirting, steps/pallets and comb, at the horizontal steps portion of the escalator. The colour of these lights shall be green.

11.1.3.12.3 Replacement of Lamp

Facility shall be incorporated for the easy replacement of lamp.

11.1.3.13 MOUNTING FACILITIES

11.1.3.13.1 Mounting Facilities

Except those builder's work as mentioned in Part 1 of this General Specification to be carried out the Building Contractor, all other supports and mounting facilities, e.g. R.S.J. beams, mounting brackets, bearing plates, etc. required for the installation of the escalator/passenger conveyor shall be provided.

11.1.3.14 SAFETY DEVICES

11.1.3.14.1 Safety Device

(a) Emergency stopping devices

Emergency stop devices shall be placed in conspicuous and easily accessible positions at or near to landings of the escalator/passenger conveyor. For escalators with rise above 12000 mm, and for passenger conveyors with a length of the treadway of more than 40000 mm, additional emergency stopping devices shall be installed.

Permanent label both in English and Chinese for emergency stopping device should be provided.

(b) Broken step/pallet chain device

The broken chain safety device shall be incorporated as part of the tension carriage, and they shall operate if the bottom sprocket moves unduly in either direction in the event of either both step/pallet chains breaking or becoming unduly lengthened due to wear of the pins, or tension in either chain dropping below a pre-determined value.

(c) Broken drive chain device

A device shall operate for breakage of the chain between the driving machine and the escalator/passenger conveyor main drive shaft. Auxiliary brake if provided shall also operate.

(d) Broken step/pallet device

If any part of the step/pallet is sagging so that meshing of the combs is no longer ensured, switching off shall be operated at a sufficient distance before the comb intersection line to ensure that the step/pallet which has sagged does not reach the comb intersection line. The control device can be applied at any point of the step/pallet.

(e) Broken handrail device

Broken handrail devices shall be situated inside both balustrades at the lower end of the incline, which shall be actuated if either or both handrails break.

(f) Non-reverse device

A non-reversing device shall be arranged to prevent a travelling escalator/passenger conveyor to slow unduly or attempt to reverse its direction of travel. The escalator/passenger conveyor shall be stopped once the device is operated and it shall only be started again by the key operated switch.

(g) Comb obstruction device

A comb obstruction device shall be provided to stop the escalator/passenger conveyor and maintain stationary in the case of foreign objects being trapped at the point where the steps, pallets or the belt enter the comb.

(h) Skirting switches

Skirting switch shall be provided to stop the escalator/passenger conveyor and maintain stationary in the case of foreign objects being trapped between skirting and steps/pallets.

(i) Handrail entry device

Handrail entry device shall be installed at the point of entry of the handrail into the newel to prevent the pinching of fingers, hands or other objects. The escalator/passenger conveyor shall be stopped and maintain stationary upon operation of this handrail entry device.

(j) Phase protection relay

A phase protection relay shall be provided to stop the escalator/passenger conveyor and maintain stationary in the case of absence of control voltage or loss of one phase of the voltage.

(k) Overspeed governor

Escalator/Passenger conveyor shall be equipped with an overspeed governor in such a way that it will stop the escalator/passenger conveyor and maintain stationary before the speed exceeds a value of 1.2 times the rated speed.

Escalator/Passenger conveyor excluding non-inclined passenger conveyor shall be stopped and maintain stationary by the time the steps/pallets or the belt change from the preset direction of travel.

(l) Motor protection relay

Motors directly connected to the mains shall be protected by a motor protection relay against overload by means of automatic circuit breakers with manual reset which shall cut off the supply to the motor in all live conductors.

When the detection of overload operates on the basis of temperature increase in the windings of the motor, the circuit breaker may be closed automatically after sufficient cooling down has taken place. The escalator/passenger conveyor shall be stopped once the device is operated and it shall only be started again by the key operated switch.

(m) Landing plate device

Safety device should be provided for floor landing plates or trap doors, which shall be activated for stopping the escalator/passenger conveyor when the floor landing plates or trap doors are not in the original position.

(n) Missing step device

Monitoring device should be provided at each driving and return station under the floor landing plates or comb plate, which shall be activated for stopping the escalator/passenger conveyor when any missing step is detected and prevent missing step emerging from the comb plate.

11.1.3.14.2 Operation of the Safety Device

The operation of any one of these safety devices shall cause the electrical supply to the driving motor to be disconnected and the electro-mechanical brake to be operated thus bringing the escalator/passenger conveyor to rest.

11.1.3.15 CONTROL

11.1.3.15.1 Control Station

Control station shall be provided at both landings newel, which shall contain an emergency stop switch, two key operated direction switches, an audio alarm switch and if specified a foot light switch. The station shall be so positioned as to enable any person operating any of the switches to afford a full view of the escalator/passenger conveyor.

The emergency stop switch shall be push button type with a red button and shall be suitably protected against accidental operation. But the directional starting switch shall be of the key-operated spring off type.

All control switches shall be provided with clearly engraved markings both in English and Chinese.

11.1.3.15.2 Provision for Remote Monitoring of Escalator/Passenger Conveyor

The remote monitoring system (RMS) shall be designed, supplied and installed. The RMS system shall be able to connect to the Central Control & Monitoring System (CCMS) by others via commercially available communication protocol such as BACnet, Modbus, etc. The escalator/passenger conveyor status shall preferably be monitored in real-time.

The following output signals from the sensors of each escalator/passenger conveyor installation or specified in the Particular Specification for the use of RMS of escalator/passenger conveyor: -

- Normal/Fault status;
- Duty/Standby status;
- Power Supply Normal/ Fault status;
- Normal/ Essential Power status; and
- Emergency stop button activated.
- Up / Down status;
- Water level High / Low status at escalator pit [See Note];
- Running Hour;
- Running Amps [See Note]; and
- Running line voltage [See Note].

This interface unit shall be located at the management office/caretaker's room next to the escalator/passenger conveyor monitoring panel unless otherwise specified on the Drawings and/or in the Particular Specification.

[Note: Where specified in the Particular Specification and/or on the drawings.]

11.1.3.15.3 Service-on-demand Escalator/Passenger Conveyor Control

Where specified in the Particular Specification and/or on the Drawings, the service-on-demand control shall be provided for escalators/passenger conveyors which shall be actuated by means of contact mat, motion sensor or other presence detection devices. Light ray sensor and contact mat shall be arranged at least 1300 mm and 1800 mm (from the outer edge of the contact mat) before the comb intersection line respectively. The length of the contact mat in the direction of travel shall be at least 850 mm. Contact mat reacting to weight shall respond before the load reaches 150 N, applied to a surface of 25 cm^2 at any point. Construction measures shall discourage circumvention of the control elements. The escalator/passenger conveyor shall start automatically from stop or crawl speed upon detection of personnel movement within the landing zone of the escalator/passenger conveyor. The escalator/passenger conveyor shall start to move or accelerate before the person walking reaches the comb intersection line.

Motion sensors shall be installed at the exit of the service-on-demand escalator to detect whether there is any passenger approaching the escalator in opposite direction. Upon detection of passenger approaching in the opposite direction, the escalator shall immediately start up and run in the predetermined direction for an adjustable period of not less than 10 seconds. Concurrently audible signal shall be provided to alert the passenger not to step onto the escalator.

The escalator/passenger conveyor shall be stopped or reduced to a crawl speed automatically after a preset period of time (which shall be adjustable) which shall be at least the anticipated passenger transfer time plus 10 seconds after the passenger has actuated the automatic starting device. The stopping of the escalator shall be gradual with no jerk.

A clear visible signal system shall be provided at both ends indicating to the user whether the escalator/passenger conveyor is available for use, and its direction of travel. Electronic signage display shall also be provided at each of the ingress/egress points of escalators/passenger conveyors in order to notify the users of the travel direction.

The service-on-demand control and associated components for outdoor escalator/passenger conveyor shall be of weatherproof construction. The design shall be ‘fail-safe’ such that in case of the failure of the service-on-demand control or any of its detection devices and sensors, the escalator/passenger conveyor shall continue to operate normally without stopping.

11.1.3.16 CONTROLLER

The controller shall be a self-contained unit containing all the necessary electromagnetic switchgears including a residual current circuit breaker, local control push buttons, DC power supply, etc.

The controller shall be located in the truss at the upper landing for escalator and in the truss at landing for passenger conveyor, and provision shall be made for easy access for maintenance.

The controller shall be fitted inside a dust proof 1.2 mm thick stainless steel cabinet.

11.1.3.17 MAINTENANCE FACILITIES AND NOTICES

11.1.3.17.1 Machinery Space Lighting

A permanent light, suitably protected, will be provided in the machinery space included in the Electrical Installation Work, and which can be switched without passing over or reaching over any part of the machinery.

11.1.3.17.2 Switched Socket Outlet

A 13A 3 pin switched socket outlet will be included in the Electrical Installation Work in each escalator/passenger conveyor machinery space. The socket outlet will be fitted adjacent to the light switch.

11.1.3.17.3 Emergency Stop Switch in Machinery Spaces

A stop switch for the machinery shall be provided in each machinery space where means of access to the space is provided.

The stop switch shall:

(a) be of the ‘push-to-stop, pull-to-run’ type; and

(b) having the switching positions marked unambiguously and permanently marked ‘STOP’.

EXCEPTION: A stop switch needs not be provided in a machinery space if the main switch is located therein and close to the machinery.

11.1.3.17.4 Notice on the Access Door

On each access door to the machinery space in both landings a notice of durable materials with the inscription of the following message in English and Chinese shall be fixed:

‘Machinery space - danger, access prohibited to unauthorised persons’.

11.1.3.17.5 Marking of Escalator/Passenger Conveyor

At least at one landing, the name of the manufacturer & the manufacturer's serial number shall be indicated, visible from outside.

11.1.3.17.6 Notice for Automatic Start

In the case of escalators/passenger conveyors starting automatically, a clearly visible and audible signal system, e.g. road traffic signals, shall be provided indicating to the user whether the escalator/passenger conveyor is available for use, and its direction of travel.

11.1.3.17.7 Notice near Entrances of Escalator/Passenger Conveyor

The following notices for the user shall be fixed in the vicinity: -

(a) Small children must be held firmly;

(b) Dogs must be carried;

(c) Stand facing the direction of travel; keep feet away from sides;

(d) Hold the handrail;

(e) Transportation of bulky and heavy loads not permitted; and

(f) Baby carriage not permitted.

Whenever possible, these notices shall be given in the form of pictographs. The minimum size of the pictographs shall be 80 x 80 mm.

Where there is an accessible lift providing alternative access route for persons with a disability, a sign posted at the entry of the escalator for indicating the alternative access route shall be provided. The sign will be provided by the Building Contractor and installed at the appropriate location according to the requirements unless otherwise specified.

11.1.3.18 ALARM BUZZER/BELL

11.1.3.18.1 Alarm Buzzer/Bell

An alarm buzzer/bell shall be supplied and installed in the machinery space which shall be sounded when any emergency safety device operates.

11.1.3.18.2 Type of Alarm Buzzer/Bell

The pattern of the alarms shall be distinguishable from that of fire alarms and shall be of the following two-tone pattern:

Low frequency:	600 Hz (±15%)	Duration: 600 ms (±20%)
High frequency:	920 Hz (±15%)	Duration: 300 ms (±20%)

Where specified in the Particular Specification and/or on the Drawings, the alarm buzzers/bells shall be impact resistant, suitable for conduit

entry. Alarm buzzers/bells for outdoor installation shall be weatherproof to IP65.

11.1.3.18.3 Audio Indicator for Disabled

Escalators and passenger conveyors are not considered part of a barrier-free route. However, where specified in the Particular Specification and/or on the Drawings, audio indicator shall be provided in the escalator and passenger conveyor for providing clear and consistent signal for going up / down or moving forward indication at both ends to assist persons with visual impairment to use the escalators and passenger conveyors. Adequate warning and guarding shall be provided alongside and at each end of the escalators and passenger conveyors.

11.1.3.19 REQUIREMENTS FOR WEATHER-PROOF ESCALATORS OR ESCALATORS IN MARKETS

11.1.3.19.1 Protection against Weather

The escalator(s) shall be protected by a canopy or other similar structure constructed by the Building Contractor.

11.1.3.19.2 Protection against Corrosion

(a) Truss and metal work of escalator

The entire truss and metal work of the escalator other than moving parts shall be hot-dipped galvanised or adequately protected against corrosion by epoxy paint coating system designed for marine application.

The galvanising to the truss and metal work of the escalator shall not be carried out until all welds for steelwork, cutting, sawing, drilling and forming holes are completed. If small areas of the galvanised coating were unavoidably damaged by welding, cutting or by rough treatment during transit or erection, they shall be made good in accordance with General Specification for Buildings.

The surface of the completed truss and metal work shall be prepared and treated in accordance with the epoxy paint coating manufacturer's recommendation. All rust and dirt on the surface of the truss and metal work shall be removed by wire brushing and the truss and metal work shall be thoroughly degreased by degreasing solvent prior to application of any paint coating.

The number, thickness and method of application of paint coating shall be in accordance with the epoxy paint coating manufacturer's recommendation but in any case at least three coats of epoxy paint coating system primer shall be applied followed by at least three

coats of finishing epoxy paint coating. Each coat of paint shall be thoroughly dried before application of the next coat.

All the above-mentioned degreasing and painting process shall be carried out at the factory and painting of truss and metal work at site is not permitted without prior approval except for touching up of damaged paint coating during installation at site.

Welding carried out on site on the truss or any metal work that will damage the protective paint coating is not permitted unless prior approval is given. Where rust appears on the parts of the truss or metal work due to damage of paint coating, it must be thoroughly removed by wire brush, degreased and followed by application of the same number of paint coatings as in the factory to the satisfaction of the Supervising Officer.

Information on the epoxy coating system including details of surface preparation, method of application, number of coatings and samples of paints shall be submitted for approval prior to manufacture.

(b) Moving parts

Moving parts of the escalator including step driving chains, sprocket gears, steps, etc. which require greasing or oiling and any metal components which for functional reasons, shall not be painted.

These parts shall be constructed of corrosion resistant materials such as stainless steel or heavily electroplated with corrosion resistant materials such as nickel or chromium. These moving parts shall be adequately lubricated all the time by automatic oilers and suitably protected from water entering into the escalator interior.

All ball or roller bearings such as those installed on the step driving chain, driving mechanism shall be of the sealed type.

11.1.3.19.3 Lubrication

Automatic oilers shall be provided for chain lubrication and operated in pre-determined period. Device for separation of oil and water shall be provided if the lubrication system is of re-circulating type.

11.1.3.19.4 Driving Machine

The driving motor shall have a degree of protection of at least IP54. Watertight cover shall be provided on all bearings.

11.1.3.19.5 Electrical Wirings and Accessories

All exposed wiring terminals, junction boxes, switches, etc. shall have a degree of protection of at least IP54.

11.1.3.19.6 Drainage

The effective drainage facilities for the escalator shall be provided. A permanent drain point will be provided by the Building Contractor at the bottom of the escalator pit. An additional drain point at the upper pit of an escalator shall be provided if found practicable so that water can be collected and directed to the nearest drain pit provided by others. An alarm giving a warning of flooding at the lowest escalator pit shall be provided.

11.1.3.19.7 Water Level Switch at Bottom Landing Machine Pit

A water level switch shall be provided at the bottom landing machine pit and provide alarm signal to the escalator/passenger conveyor monitoring panel in the event water collected in pit reaches a pre-determined level.

11.1.3.20 AUDIBLE DEVICE OF ESCALATOR FOR THE VISUALLY IMPAIRED

Where specified in the Particular Specification and/or on the Drawings, a device generating audible "ticking" signals shall be provided for each escalator to enable the visually impaired to distinguish between escalator steps moving towards and away from them. The device shall also enable the visually impaired to distinguish between adjacent escalators with steps moving in different directions.

(a) The driving unit of the audible device shall be housed in a rigid enclosure and mounted inside the escalator machine pit. The speakers of the device shall be flush mounted at the skirting or balustrade interior panelling of the upper and lower landings of each escalator and at the left hand side facing the escalator;

(b) The sound level of the audible "ticking" signal emitted by the speaker of the audible device at each landing shall be adjustable, with a maximum output of 70 dB, such that changes can be effected at no cost to the Employer to suit operational needs after completion of the Works. For outdoor escalators, automatic timer-controlled volume adjusting device shall be provided to produce two pre-set volume levels respectively for day and night operation modes;

(c) Frequency of the "ticking" sound shall be adjustable from 70/minute (step moving towards the visually impaired) to 800/minute (steps moving away from the visually impaired). The frequency of the "ticking" sound shall be automatically reversed when the direction of step movement of the escalator is reversed; and

(d) The audible device shall be disabled manually if required.

11.1.3.21 SAFETY REQUIREMENTS

Necessary safety precautions in carrying out maintenance and repair works of the Installations, in particular when any safety circuit is bypassed or interfered affecting the safety of the escalator users, shall be made. At least two escalator workers shall be deployed for carrying out the following escalator works:

(a) Carrying out maintenance works, while the escalator is in motion, which cannot be performed by the worker who is controlling the motion of the escalator;

(b) Manual lubricating chains; and

(c) Disassembling and re-assembling the machine brake.

All actions taken and work done shall be recorded in the log book before the workers leave.

SUB-SECTION 11.1.4

POWERED VERTICAL LIFTING PLATFORM INSTALLATION

11.1.4.1 DEFINITION AND SPECIFIC REQUIREMENTS

11.1.4.1.1 Definition

The powered vertical lifting platform installation shall be a platform lift for providing vertical transportation between two/three fixed levels for mobility impaired persons.

11.1.4.1.2 Statutory Requirements

The vertical lifting platform proposed shall be of a type approved by the Electrical and Mechanical Services Department, the Government of the HKSAR.

All necessary submissions for applying modifications/exemptions from relevant government departments shall be prepared and arranged, where applicable. All cost incurred shall be included in the Contract.

The vertical lifting platform shall comply with the Design Manual: Barrier Free Access 2008, PNAP APP-41 and subsequent amendments issued by the Buildings Department, the Government of the HKSAR unless otherwise specified.

The vertical lifting platform shall comply with the requirements of powered vertical lift platform as stipulated under Circular No. 3/2014, 3/2014A, 11/2016 and 4/2019 issued by the Electrical and Mechanical Services Department, the Government of the HKSAR.

11.1.4.1.3 Specific Requirements

The following specific requirements shall be complied with:

(a) The rated loads of vertical lifting platforms shall not be more than 500 kg;

(b) The rated speed shall be at least 0.02 m/s and not exceed 0.15 m/s;

(c) The clear platform floor area shall be at least 1100 mm x 1500 mm and not exceed 2 m^2;

(d) The clear door/gate width shall be at least 900 mm;

(e) The vertical travel shall not exceed 7000 mm; and

(f) The operation type shall be either attendant-operated or self-operated as specified in the Particular Specification and/or on the

Drawings. Where it is not specified, the vertical lifting platform shall be constructed for self-operated;

In case the maximum vertical travel of the vertical lifting platform installation exceeds 1980 mm, the installation shall also comply with the following additional requirements:

- The lift well shall be made up of four side walls and a floor. The height of enclosure shall be of minimum 2500 mm above the upper landing or with full height to the ceiling; and

- A ventilation louvre of not less than 0.15 m^2 net free area shall be provided at the lift well for lifting platforms where the lift well of which is not required to contribute to the protection of the building against the spread of fire.

11.1.4.2 LIFT WELL

11.1.4.2.1 General Provisions

The platform, ram, leadscrew, guides and suspension of a powered vertical lifting platform shall be installed in a lift well.

When the lift well is required to contribute to the protection of the building against the spread of fire, it shall be totally enclosed and comply with the relevant provisions of Building (Planning) Regulations (Chapter 123), Building (Construction) Regulations (Chapter 123), the Code of Practice for Building Works for Lifts and Escalators 2011, and the Code of Practice for Fire Safety in Buildings 2011 and subsequent amendments issued by the Buildings Department, the Government of the HKSAR.

When the lift well is not required to contribute to the protection of the building against the spread of fire, it does not need to be totally enclosed. The walls of the lift well shall be formed from non-fire rated panels which have a mechanical strength such that when a force of 300 N being evenly distributed over an area of 500 mm^2 in round or square section, is applied at right angles to the wall, at any point, from the inside of the lift well towards the outside, the wall shall: -

(a) resist without any permanent deformation; and

(b) resist without elastic deformation greater than 10 mm.

The enclosure of the powered vertical lifting platform shall be imperforate.

11.1.4.2.2 Materials

The surface of the enclosure frame shall be adequately protected against corrosion by factory applied corrosion resistant treatment designed for indoor/outdoor application. The enclosure panels shall be made of Grade

316 mirror stainless steel/hairline stainless steel/baked powder coated steel/ baked powder coated steel frame with transparent panels and or plastic blind panel or material having equivalent functions or performance as approved by the Supervising Officer.

11.1.4.2.3 Lighting

The enclosure of the vertical lifting platform installation shall be illuminated to at least 50 lux using a separately fused lighting supply independent of the vertical lifting platform installation power supply. The separately fused lighting system will be included in the Electrical Installation Work.

11.1.4.2.4 Requirements of Different Vertical Rise Travel

The lifting platform shall be provided with a mechanical blocking device in the lift pit such that when the mechanical blocking device is set to operate the running of the lifting platform drive nut will be stopped by means of an electrical safety device.

The mechanical blocking device shall be capable of supporting the platform with its rated load and obstructing the platform from descending to below 1000 mm as measured from the floor, for lifting platforms having a travel exceeding 1100 mm to allow works in the lift pit to be safely carried out. Where the travel of the lifting platform exceeds 600 mm but does not exceed 1100 mm and the maintenance and checking of components can be performed within the lift well while the lifting platform is fully descended, the requirement of mechanical blocking device can be omitted. Otherwise, the vertical clearance below the platform by application of the mechanical blocking device shall be not less than 500 mm.

If the travel of the lifting platform exceeds 1100 mm but does not exceed 1980 mm, the enclosure forming the lift well shall terminate at a height of not less than 1100 mm above the upper landing.

If the travel of the lifting platform does not exceed 1100 mm, enclosure other than for the platform underside protection is not required.

Skirt guard shall be provided instead of rigid enclosure for lifting platform the travel of which does not exceed 600 mm to prevent hazard due to the descending platform. The lifting platform shall allow maintenance and checking of its components when the platform is fully descended.

Where hydraulic ram is used for the raising and lowering of the lifting platform, insertion of the ram into the ground or other structural cavity shall be avoided, unless otherwise specified in the Particular Specification and/or on the Drawings and approved by the Supervising Officer.

11.1.4.2.5 Lift Pit/Ramp

A lift pit/ramp/pit drainage will be provided by the Building Contractor for the power vertical lifting platform installation. If a pit is not available, ramps shall be fitted on the platform access edges incorporating a step greater than 15 mm height. They shall have an inclination, which shall not be greater than 1:12 on a vertical rise above 100 mm. A step up to 15 mm high is permissible at the leading edge of any ramp.

11.1.4.3 LIFTING PLATFORM CARRIAGE

11.1.4.3.1 General Requirements

The lifting platform carriage shall comprise a solid floor panel, kicker plates, toe guards and solid side panels. Within the carriage there shall be an easy grip handrail, control station and necessary lighting.

The platform shall be of sufficient mechanical strength for the designed purpose and shall have slip resistant surfaces. The sill of the platform or the landings shall be coloured to contrast with the landing floor surface at the entrance.

11.1.4.3.2 Handrail

An ‘easy grip bar’ handrail of cross-sectional dimensions between 32 mm and 40 mm extending up to 150 mm away from corners. The handrail shall be installed with its top at 900 mm as measured from the finished floor level and with the clearance between the gripping part and the side panel maintained at not less than 30 mm and not more than 50 mm. The vertical distance between the grip bar and the control buttons should not be less than 100 mm.

11.1.4.3.3 Emergency Lighting at Platform

An emergency light shall be provided at the platform of at least 1 W energy efficient lamp fed by an automatically rechargeable battery supply which shall be capable of operating the emergency light for at least 2 hours in case of an interruption of the normal power supply. This emergency lighting shall come on automatically upon failure of the normal power supply. The electricity supply for the emergency lighting shall be fed from the batteries.

11.1.4.4 LANDING DOORS/GATES

11.1.4.4.1 Entrance

Lift well entrance shall be protected by landing door or gate as specified in the Particular Specification and/or on the Drawings. The clear access height onto and over the platform shall not be less than 2000 mm. The clear width of the entrances shall not be less than 900 mm. Landing door

sills shall be provided in accordance with the Code of Practice for Building Works for Lifts and Escalators 2011 issued by the Buildings Department, the Government of the HKSAR.

11.1.4.4.2 Door/Gate

In order to prevent roll away of a wheelchair, the platform with travel less than 1980 mm shall be protected by a gate of at least 1100 mm in height at landing entrance, and if the travel is more than 1980 mm, the platform shall be protected by a door of at least 2000 mm in height at landing entrance.

Doors/Gates shall be made of Grade 316 mirror stainless steel/hairline stainless steel/baked powder coated steel/aluminium or material having equivalent functions or performance as approved by the Supervising Officer. Doors/Gates shall be single or 2-door design and be operable by application of a low level manual effort and conform to the following: -

(a) they are self-closing but can be stable in open position;

(b) do not open into the lift well;

(c) require a force to open them which is not more than 30 N at the handle;

(d) provided with a vision panel when the door/gate is made of non-transparent material and is over 1100 mm in height, the bottom edge of the vision panel shall be located between 300 mm and 900 mm above the floor level of the landing;

(e) the vision panel shall be made of an approved material or glass of a laminated type/tempered type and with minimum thickness of 6 mm and a width of at least 60 mm;

(f) the size and shape of the vision panel shall be such that it will not permit the passage of a sphere having a diameter of 100 mm, have a minimum glazed area per landing door of 0.015 m^2 with a minimum of 0.01 m^2 per vision panel; and

(g) if they are of glass, visual markings between 1400 mm and 1600 mm above the floor shall be provided. Door panels made of glass shall comply with ISO 9386-1 or EN 81-41:2010.

11.1.4.4.3 Door/Gate Lock

Door/Gate lock with mechanical and electrical interlocks shall be of a type approved by the Electrical and Mechanical Services Department, the Government of the HKSAR.

Interlocking features shall perform the following requirements: -

(a) Entrance door/gate lock shall be closed properly before the vertical lifting platform installation starts to move;

(b) Powered vertical lifting platform installation shall stop moving if the doors/gates are not closed and locked properly; and

(c) An unlocking key or other special service tool shall be required for opening the doors/gates in case of emergency.

11.1.4.5 GUIDES AND DRIVE SYSTEM

11.1.4.5.1 General Requirements for Guides

The guides and guide fixings shall be of sufficient strength and rigidity to stop the lifting platform at its maximum safe working load on application of a safety gear or clamping device.

The lifting platform shall each be guided by at least two rigid steel guides throughout the travel which can ensure that the clearances between the edges of the lifting platform and the lift well walls/enclosure or between platform and landing door sill shall not exceed 20 mm.

11.1.4.5.2 Drive System

Each lifting platform shall have at least one machine of its own. Every machine, jack, pulley and other similar equipment connected with the lifting platform shall be so supported and fixed as to prevent it from becoming loose or being displaced.

Electro-hydraulic drive for powered vertical lifting platform shall consist of a hydraulic pump unit, drive motor, gear box, guides, electro-mechanical brake with spokeless wheel for emergency manual operation, overspeed governor, safety gear (not required for rack and pinions, screw and nut driven vertical lifting platform), controller, main power switch and other accessories.

The hydraulic pump unit comprising a pump, motor, oil tank, control valves and electrical control shall be housed in a separate control panel outside the lift well. The hydraulic pump shall be driven by a 220 V AC motor.

The controller and their associated equipment including the drive unit of a hydraulic powered vertical lifting platform shall be installed close to the lift well. If they are installed in a room, it shall be dedicated for the vertical lifting platform and be made accessible only to authorised persons for activities such as maintenance, inspection, testing and rescue. Where the travel of the lifting platform does not exceed 1980 mm, the equipment shall be installed inside the enclosure forming the lift well provided that emergency lowering and raising of the lifting platform can be accomplished from outside the enclosure.

11.1.4.5.3 Hydraulic Control Device

Hydraulic control devices shall be incorporated into the hydraulic circuit with details as follows: -

(a) Shut-Off Valve

Installed in the circuit which connects the cylinder(s) to the non-return valve and the down direction valve(s).

(b) Non-Return Valve

Installed in the circuit between the pump(s) and the shut-off valve. Capable of holding the vertical lifting platform installation with the rated load at any point when the supply pressure drops below the minimum operating pressure. The closing of the non-return valve shall be effected by the hydraulic pressure from the jack and by at least one guided compression spring and/or by gravity.

(c) Pressure Relief Valve

Connect to the circuit between the pump(s) and the non-return valve. The hydraulic fluids shall be returned to the tank. To limit the pressure to 140% of the full load pressure.

(d) Down Direction Valve

It shall be held open electrically. Closing of which shall be effected by the hydraulic pressure from the jack and by at least one guided compression spring per valve.

(e) Rupture Valve

Where required, rupture valve shall be capable of stopping the vertical lifting platform installation in the downward movement, and maintaining it stationary, in the event of failure of any part of the hydraulic circuit.

(f) One-way Restrictor

Where required, one-way restrictor shall prevent the speed of the vertical lifting platform with rated load in downward movement exceeding the rated speed downwards by more than 0.15 m/s.

(g) Filters

In the circuit between the tank and the pump(s), and in the circuit between the shut-off valve and the down direction valve(s) shall be accessible for inspection and maintenance.

(h) Pressure Gauge

Connect to the circuit between the non-return valve or the down direction valve(s) and shut-off valve. Gauge shut-off valve shall be provided between the main circuit and the connection for the pressure gauge.

(i) Reservoir

The hydraulic oil reservoir shall be of a closed construction incorporating a covered filler, a breather, a filter and a level gauge for checking the level of the hydraulic fluid in the reservoir.

(j) Manual Lowering Operated Valve (Emergency)

Installed in a circuit allowing the vertical lifting platform installation, even in the case of power failure, to be lowered to the lower landing where the passenger can leave the platform.

11.1.4.6 OPERATION CONTROL SYSTEM

11.1.4.6.1 Control System

Control system shall be designed to be fail-safe. Control station completed with an on / off key switch shall be positioned at each lift entrance for easy operation by the attendant.

3 sets of 'operating key' for attendant-operated type/'common key' for self-operated type for the key-operated switch of the vertical lifting platform installation shall be provided.

Control buttons shall be located at a height not less than 900 mm and not more than 1200 mm above platform or finished floor level. All control buttons shall have a minimum dimension of 20 mm while the hold-to-run button should be of a minimum dimension of 50 mm. Braille and tactile markings shall be placed either on or to the left of the control buttons. Such markings shall be in Arabic numerals and / or symbols. Tactile markings shall have a minimum dimension of 15 mm high and be raised 1 mm minimum. The tactile marking of the push buttons for the main entrance floor shall be identified with a symbol in a star shape. The emergency alarm push button shall be in a tactile bell shape. Tactile markings and control buttons shall be in luminous contrast with the background. If tactile markings are provided on the left of the control buttons, both of them shall be in luminous contrast with the background. If tactile markings are provided on the control buttons, then apart from the background, they shall also be in luminous contrast with one another.

In case of power failure or emergency, the competent person shall be able to operate the manual (emergency) valve to lower the vertical lifting platform installation to the lower landing where the passenger can leave the platform.

11.1.4.6.2 Landing Control Station

Landing control station shall be provided adjacent to each lift entrance and shall incorporate the following features:-

(a) Constant pressure operated control buttons to call in the vertical lifting platform installation;

(b) Key-operated switch to activate/deactivate the control system of the vertical lifting platform installation; and

(c) Call bell button to call an attendant.

11.1.4.6.3 Platform Control Station

Platform control station shall be provided on the platform carriage and shall incorporate the following features:-

(a) 24V DC constant pressure operated control buttons for UP and DOWN directions to operate the vertical lifting platform installation;

(b) Key-operated switch to activate/deactivate the control system of the vertical lifting platform installation;

(c) Emergency stop button of the 'push-to-stop', 'pull to run' type to stop the vertical lifting platform installation; and

(d) Call bell button to call an attendant.

11.1.4.6.4 Notice and Marking of Powered Vertical Lifting Platform

Conspicuous instruction plates and direction labels shall be displayed to state the user guide, procedure of normal operation and manual (emergency) operation. The labels shall be of stainless steel with characters/letters engraved in English and Chinese. The size, arrangement and wording of the labels shall be submitted to the Supervising Officer for approval prior to ordering.

The rated load in person and kilograms; vertical lifting platform installation number; name and telephone number of the maintenance service company, and emergency instructions shall be engraved in English and Chinese in a stainless steel notice plate permanently fixed inside the installation or on the side of the lift entrance.

The rated load shall also be indicated on a sign installed at a prominent position next to the platform control station.

11.1.4.6.5 User Guide and Operation Manual

User guide and operation manual containing operating instructions, general information and warning notices in English and Chinese in compliance with the requirements of the Electrical and Mechanical Services Department, the Government of the HKSAR shall be provided and affixed at a conspicuous location at the vertical lifting platform installation. The guide and the manual shall be laminated with plastic protective sheets.

11.1.4.7 SAFETY DEVICES

11.1.4.7.1 Safety Devices

Safety devices of the vertical lifting platform installation shall include but not limited to the following:-

(a) Mechanical blocking device with an electric switch shall be provided which detects the operation of the mechanical blocking and disables the operation of the vertical lifting platform installation;

(b) Pressure relief valves shall be fitted in the hydraulic drive system to prevent the possibility of system over loading and over pressure;

(c) Rupture valve and/or restrictor shall be fitted and be capable of stopping the platform in downward movement in case of failure;

(d) Manual (emergency) operating valve shall be fitted to lower the platform to the lower landing in case of power failure. A hand-pump which causes the platform to move in the upward direction shall be permanently installed for every vertical lifting platform installation whose platform is fitted with a safety gear or a clamping device;

(e) Slip resistant floor covering on the Powered Vertical Lifting Platform Installation shall be provided;

(f) Positively operated safety switches on all safety systems shall be provided;

(g) Door/Gate lock with mechanical and electrical interlocks shall be provided to ensure that the vertical lifting platform installation cannot be operated until the entrance doors are fully closed;

(h) An ‘easy grip bar’ handrail shall be fixed on one or more non-entrance sides of the platform; and

(i) An overload/device shall be provided to prevent the power operated doors from closing and the platform from moving. It shall give audible and visual signals at the platform entrance.

11.1.4.8 CALL BELL SYSTEM, SUPERVISORY CONTROL PANEL, INTERCOM SYSTEM AND CLOSED-CIRCUIT TELEVISION SYSTEM

11.1.4.8.1 Call Bell System

Where call bell system is specified in the Particular Specification and/or on the Drawings, the work shall include the provision of all wiring and cabling work, visual and audible signal components, controls for the call bell system from the vertical lifting platform to the call bell panel at the location as specified on the Drawing and/or in the Particular Specification.

A call bell system comprising emergency alarm push button together with a buzzer and a yellow indicator for acknowledgement shall be provided at the platform carriage and at each lift entrance and call bell panel shall be located at the management office/caretaker's room next to the vertical lifting platform monitoring panel unless otherwise specified on the Drawing and/or in the Particular Specification.

Call bell panel shall be made of stainless steel and include a call bell, on/off key switch, green 'power supply healthy' indicator, red 'call location' indicator, re-set button, lamp test button. A 13A socket of emergency power supply adjacent to the call bell panel will be included in the Electrical Installation Work.

Wiring diagram shall be provided and located inside the call bell panel for reference.

The cable containment facilities from the lift shaft at the landing of designated point of entry to the position of the call bell panel will be included in the Electrical Installation Work.

11.1.4.8.2 Supervisory Control Panel

Where supervisory control panel is specified in the Particular Specification and/or on the Drawings, the work shall include the provision of all wiring and cabling work, visual and audible signal components, controls for the supervisory control panel from the vertical lifting platform to the supervisory control panel at the location as specified in the Particular Specification and/or on the Drawings.

The supervisory control panel shall include at least, but not exclusive, the following basic facilities:-

(a) 'In service / Out of service' LED lights;

(b) On/off key switch;

(c) System fault alarm buzzer / bell and LED indication lights;

(d) Mute button for alarm buzzer / bell and alarm reset button;

(e) Power on indicator; and

(f) Lamp test button.

The cable containment facilities from the lift shaft at the landing of designated point of entry to the position of the supervisory control panel will be included in the Electrical Installation Work.

11.1.4.8.3 Intercom System

Where the maximum vertical travel of the vertical lifting platform installation exceeds 1980 mm, an intercom system shall be provided.

An intercom system, or similar device powered by the emergency supply with wiring and cabling work, shall be provided for the vertical lifting platforms between the lift car and the call bell panel completed with intercom. The intercom system shall comprise a 2-way speaker in the vertical lifting platform station and the call bell panel integrated with intercom system located at the management office/caretaker's room unless otherwise specified on the Drawing and/or in the Particular Specification. The integrated call bell panel shall have the following facilities: -

(a) a 2-way speaker to allow communication between lift cars and the call bell panel;

(b) a switch of spring return type to allow simultaneous communication between the call bell panel and all lift cars; and

(c) Selective switches of spring return type to allow communication between the call bell panel and each lift car, one at a time.

The cable containment facilities from the lift shaft at the landing of designated point of entry to the position of the call bell panel integrated with intercom system will be included in the Electrical Installation Work.

11.1.4.8.4 Closed Circuit Television System

Where the maximum vertical travel of the vertical lifting platform installation exceeds 1980 mm, closed circuit television (CCTV) system shall be supplied, installed and commissioned.

11.1.4.9 BATTERY POWERED OPERATION AND FIRE EMERGENCY SERVICE

11.1.4.9.1 Battery Powered Operation

In case of power failure, the vertical lifting platform installation shall be automatically switched over to the battery powered operation to allow the passenger to travel to the exit landing at entrance level and leave the platform. The platform shall then park at that landing until normal power is resumed. When normal power is resumed, the vertical lifting platform

installation shall be automatically switched back from battery powered to normal power supply.

Battery charging shall be carried out at points where the vertical lifting platform is expected to be stationary between journeys. Usually this is at each end of the rail. If the vertical lifting platform installation is stopped at a position, there shall be alarm indications to the passenger and at the location as specified on the Drawings and/or in the Particular Specification.

11.1.4.9.2 Fire Emergency Service

The vertical lifting platform installation shall be provided with a facility to integrate with the fire service system of the building. Fire signal dry contact will be provided by other at a point near to the lift control panel. The parked lifting platform shall be isolated from operation when a fire service signal is received. If the signal is received when the vertical lifting platform installation is in use, the installation shall remain in operation with all safety provisions in proper functioning until it travels to a destined landing for exit and then isolated from operation.

11.1.4.10 REQUIREMENTS FOR WEATHER-PROOF POWERED VERTICAL LIFTING PLATFORM INSTALLATION

11.1.4.10.1 Protection against Weather

The vertical lifting platform(s) shall be protected by a canopy or other similar structure constructed by the Building Contractor.

11.1.4.10.2 Protection against Corrosion

(a) Structural steel work of vertical lifting platform

The structural steel work of the vertical lifting platform other than moving parts shall be hot-dipped galvanised or adequately protected against corrosion by epoxy paint coating system designed for marine application.

The surface of the structural steel work shall be prepared and treated in accordance with the epoxy paint coating manufacturer's recommendation. All rust and dirt on the surface of the truss and metal work shall be removed by wire brushing and the truss and metal work shall be thoroughly degreased by degreasing solvent prior to application of any paint coating.

The number, thickness and method of application of paint coating shall be in accordance with the epoxy paint coating manufacturer's recommendation but in any case at least three coats of epoxy paint coating system primer shall be applied followed by at least three coats of finishing epoxy paint coating. Each coat of paint shall be thoroughly dried before application of the next coat.

All the above-mentioned degreasing and painting process shall be carried out at the factory and painting of structural steel work at site is not permitted without prior approval except for touching up of damaged paint coating during installation at site. The paints use for touch up at site shall be submitted for the approval of the Supervising Officer. The volatile organic compound (VOC) content, in grams per litre, of all paint and primer shall not exceed the prescribed limit under the Air Pollution Control (Volatile Organic Compounds) Regulation or the limit set by EPD, whichever is more stringent.

Welding carried out on site on the structural steel or any metal work that will damage the protective paint coating is not permitted unless prior approval is given. Where rust appears on the parts of the structural steel or metal work due to damage of paint coating, it must be thoroughly removed by wire brush, degreased and followed by application of the same number of paint coatings as in the factory to the satisfaction of the Supervising Officer.

Information on the epoxy coating system including details of surface preparation, method of application, number of coatings and samples of paints shall be submitted for approval prior to manufacture.

(b) Moving parts

All moving parts or components of the vertical lifting platform including door hinges, roller spindles, etc. which require greasing or oiling and any metal components which for functional reasons, shall not be painted.

These parts shall be constructed of corrosion resistant materials such as stainless steel or heavily electroplated with corrosion resistant materials such as nickel or chromium. These moving parts shall be adequately lubricated and suitably protected from water entering into the vertical lifting platform interior.

11.1.4.10.3 Driving Machine

The driving machine shall have a degree of protection of at least IP54. Water-tight cover shall be provided at all bearings. All bearings installed on the driving mechanism shall be of the sealed type.

11.1.4.10.4 Electrical Wirings and Accessories

All exposed wiring terminals, junction boxes, switches, etc. shall have a degree of protection of at least IP54.

11.1.4.10.5 Drainage

The flooding alarm device for the vertical lifting platform shall be provided. A permanent drain point/sump pit will be provided by the Building Contractor at the bottom of the vertical lifting platform pit.

An alarm giving a warning of flooding at the vertical lifting platform pit coupled with a timer to stop the vertical lifting platform after a preset time shall be provided.

SUB-SECTION 11.1.5

STAIRLIFT INSTALLATION

11.1.5.1 GENERAL REQUIREMENTS

11.1.5.1.1 General

The stairlift shall be of a type approved by the Electrical and Mechanical Services Department, the Government of the HKSAR.

Platform carriage shall be provided for a stairlift installation to support the platform on the guide rails and direct the platform up and down the guide rail system. The platform carriage shall be provided with handrails to the passenger for easy grabbing. The platform shall be finished with non-slip platform deck and ramp surfaces.

The platform shall negotiate vertical and horizontal bends and landing transitions smoothly without transfer of the passenger. A smooth start/stop shall be provided when entering/departing landing zone.

The clear height above the platform shall be not less than 2 m long its whole journey.

Ramps provided at the platform access edges shall be minimum 150 mm high.

Kick plate(s), minimum 150 mm in height, shall be provided at non-access side(s).

A removable lockout cover shall be provided for the folded platform.

3 numbers of 'Common Key' for the key-operated switch shall be provided.

11.1.5.1.2 Technical Features

Ramps shall be fitted to the platform access edges, when folded up, to prevent accidental wheelchair roll off. The ramps shall be raised and lowered electrically; operated in sequence only when the platform is unfolded and at rest at a landing. Drive system shall be electrically and mechanically interlocked with the ramps to prevent the stairlift from moving unless the ramps are raised and to prevent the ramps from lowering during the stairlift travelling.

Folding and unfolding of the platform shall be electrically operated. Means of folding and unfolding the platform shall be able to be operated manually in case of malfunction or power failure.

Key-operated switches at the operation call stations at all landings shall be provided to permit the stairlift's operations, including calling and

sending functions, to become effective only when the respective key-operated switch is in the 'On' position. Control system shall comply with requirements of EN 81-40:2008, ICC/ANSI A117.1:2017, ASME A17.1:2019 or equivalent IEC standards.

The power system shall not, by injection of undesirable waveforms into the electrical installation, adversely affect the connected electricity supply system and/or the electricity supply to other users or consumers.

11.1.5.1.3 Drive Mechanism

Drive system including components of the drive motor, gear box, electro-mechanical brake with spokeless wheel for emergency manual operation, overspeed governor, safety gear (not required for screw and nut driven stairlift), controller, main power switch and other accessories shall be contained within a lockable drive system cabinet such that no moving parts are exposed to cause potential danger. The cabinet shall be made up of stainless steel or other durable materials as approved by the Supervising Officer.

The drive shall be equipped with built-in thermal overload and short circuit protections. When the door of drive cabinet is opened for servicing, the power supply to the drive system shall be automatically cut off unless all the live conductors and contacts of the drive system are protected or inaccessible.

Drive mechanism shall be one of the following types:

- Suspension;
- Rack and Pinion;
- Chain and Chainwheel; and
- Screw and Nut.

Smooth starting and stopping of the stairlift installation are required. The stairlift installation shall turn around smoothly during the travel along curved section of the rail.

11.1.5.1.4 Safety Features

Provisions of the safety features for the stairlift installation shall include but not limited to the following: -

(a) The main control key-operated switch installed at all operation call stations and on the carriage shall be provided to allow the operation of the control switches. The control switches shall be effective only when the key is in the 'On' position. The key shall be removable only from the 'Off' position;

(b) The ramps fitted to the platform access edges shall be operated automatically. Before any movement of the stairlift, the ramps shall be in the raised position. The ramps shall remain in the raised position whenever the stairlift is not at landing. Bi-directional

pressure sensors shall be fitted to the ramps to stop the movement of the stairlift when the wheelchair rolls against the ramp or the ramp comes to contact with an obstacle. The sensors shall also operate when the platform is in the folded position. The stairlift shall stop within 25 mm of travel after the first contact with an obstacle;

(c) Sensitive surfaces in full size shall be fitted under the platform and the platform carriage, and in areas where there are potential shearing, crushing, trapping or abrading hazards to stop the movement of the stairlift when the surface comes to contact with an obstacle. The stairlift shall stop within 25 mm of travel after the first contact with the obstacle;

(d) Emergency stop buttons of the 'push-to-stop, pull-to-run' type shall be provided at the platform carriage and the operation call stations at all landings to deactivate the stairlift installation manually;

(e) Two safety barrier arms in length of full width of the platform shall be fitted to the platform access sides for stability of the passenger. Position of the lowered arms shall be at height between 800 mm and 1,100 mm above the platform. The arms shall be mechanically locked down in the lowered position when the stairlift is not at landing. The arms shall be raised up only at landing position;

(f) Final limit switches shall be provided at the uppermost and the lowest landings to prevent the movement of the stairlift travelling beyond its normal stopping positions. Activation of the switches shall disconnect the power supply to the motor in the direction of travel. The switches shall be adjusted to maintain level tolerance within 13 mm regardless of load size or direction of travel. The switches shall be designed to withstand possible abuse from adverse domestic cleaning activities;

(g) Audio-visual Bystander Alert Devices including an audio chime and flashing amber strobe shall be provide to alert the bystander when the platform is in motion or in unfolding at intermediate landing position(s);

(h) Fault control interlock shall be provided to prevent the stairlift from travelling when there is a fault;

(i) Security lock shall be provided to prevent unauthorised unfolding and accidentally unfolding of the platform; and

(j) In the event of power failure or fault, electro-mechanical brake of the stairlift installation shall be able to be manually released by the use of the spokeless wheel or other approved means. The stairlift installation shall then be able to be raised or lowered to the nearest landing.

11.1.5.1.5 Display of Information

User guide and operation manual containing operating instructions, general information and warning notices in English and Chinese in compliance with the requirements of the Electrical and Mechanical Services Department, the Government of the HKSAR shall be provided and affixed at a conspicuous location at the stairlift installation and the management office respectively. The guide and the manual shall be laminated with plastic protective sheets.

Rated load in person and kilograms, stairlift number, name and telephone number of the service company, and emergency instructions shall be engraved in English and Chinese in a plastic notice plate permanently fixed to the platform.

11.1.5.1.6 Design Responsibilities

The installation work shall be well coordinated with the relevant parties as necessary on the site.

The design of stairlift installation and selection of equipment and components including the matching with the components of other interfacing installations shall be provided.

The selection of the proper, correct and consistent components shall be provided to match the system proposed in order to meet all the requirements specified. In the event that these requirements cannot be met due to the use of improper, incorrect or inconsistent components, all such components shall be replaced and shall re-design the stairlift installation, all to the satisfaction of the Supervising Officer. All extra costs thus incurred shall be included in the Contract.

11.1.5.1.7 Structural Steel

The manufacturer confirmation of the material of structural steel work shall be provided as required by the Supervising Officer.

11.1.5.1.8 Guide Rails

Rigid steel guide rails shall be used and welded or securely fixed to supporting steel structure fixed directly to the structural members of the building. Guide rails shall run in parallel to the direction of staircase flight and landings throughout the travelling distance.

11.1.5.1.9 Travel Control

The travel control comprises red-lamp indicator, control switches for calling and sending, directional control switches, emergency stop button and a key-operated switch. Large directional control switches shall be provided so that people with disabilities can operate the stairlift installation with ease. Constant pressure is required to operate the control

switch. Only when the red-lamp signals are cleared, the stairlift is ready to operate.

11.1.5.1.10 Electrical Works

The electrical works shall comply with the following requirements.

The control circuit voltage shall not exceed 50 V. All wiring and electrical parts which are accessible without using any tools shall be at a potential of not exceeding 24 V.

All secondary wiring shall be completed with numbered ferrules for identification which shall be carried out in a neat and systematic manner and terminated at a terminal board at the junction of small wiring and the incoming cables.

Electrical motors shall comply with IEC 60034-1:2017 and shall be of such size and type to adequately drive the equipment under all normal conditions of service without overloading. Insulation shall be of minimum Class F to IEC 60085:2007 for tropical conditions.

Motor starters shall be rated to intermittent class 0.1, 60% on-load factor and utilisation category AC-3 in accordance with BS EN IEC 60947-4-1:2019, or equivalent. Suitably rated thermal overload relays shall be incorporated into each starter circuit with inherent single-phase protection. Each starter shall incorporate fuse protection.

Each starter for the motor shall comply with BS EN IEC 60947-4-1:2019, or equivalent, and shall be provided with an adjustable motor overload protection device and under-voltage release suitable for the motor load and having manual resetting facilities. Direct-on-line starters shall be used for motors smaller than 3.8 kW. For motors over 3.8 kW, star-delta starters shall be used instead.

11.1.5.2 OPERATION CALL STATIONS

11.1.5.2.1 General Requirements

Operation call stations shall be located at all landings, mounted on the adjacent wall or integrated into the driving box, and be safely away from the flight path of the stairlift such that the stairlift can be safely and conveniently unfolded.

The operation call station shall be user-friendly and shall incorporate but not limited to the following features: -

(a) Indication lamp to indicate power supply is ‘On’;

(b) Indication lamp to indicate the activation of call station;

(c) Indication lamp to indicate fault signals;

(d) Emergency stop button shall be provided;

(e) Call for help push button with protection from being operated accidentally together with a buzzer and an indication lamp shall be provided;

(f) Indication lamp to indicate the position of the stairlift. [Note: If the whole journey of the stairlift installation can be observable at any one landing, this requirement may be omitted as determined by the Supervising Officer.];

(g) Constant pressure operated control switches for calling and sending the stairlift. [Note: If the whole journey of the stairlift installation cannot be observable at any one landing, this requirement will be omitted. However, for self-operated stairlift installation, the whole journey of the stairlift shall be designed and made to be observable by the passenger at either upper, intermediate and lower landing to allow it to be self-operated.]; and

(h) Constant pressure operated control switches for folding and unfolding the stairlift. [Note: The control switch for carrying out folding and unfolding functions may be combined with the control switch for carrying out calling and sending functions.].

For self-operated stairlift installation only, the control panel on the platform carriage shall be user-friendly and shall incorporate but not limited to the following features: -

- Indication lamp to indicate power supply is 'On';

- Indication lamp to indicate the activation of call station;

- Indication lamp to indicate fault signals;

- Emergency stop button;

- Emergency alarm push button in yellow with protection from being operated accidentally together with an alarm and an indication lamp; and

- Constant pressure operated control switches for moving the stairlift.

11.1.5.2.2 Control & Operation for Attendant-operated Stairlift Installation

A plug-in hand-held attendant control unit with flexible cord in suitable length for manoeuvring shall be provided to allow an attendant to control a moving stairlift while walking next to it. Two additional hand-held attendant control units shall be supplied together with the installation.

Emergency stop buttons shall be provided at the attendant control unit, operation call stations at all landings and on the platform carriage.

Key-operated switch shall be provided to activate/deactivate the control system of the stairlift installation.

Labels shall be provided to assist the attendant in using the attendant control unit and the operation call station. The labels shall be of stainless steel with characters/letter engraved in English and Chinese. The arrangement and wordings of the labels shall be approved by the Supervising Officer prior to ordering.

11.1.5.2.3 Control & Operation for Self-operated Stairlift Installation

Where specified in the Particular Specification and/or on the Drawings, self-operated stairlift(s) shall be provided in lieu of attendant-operated stairlift(s).

Operation call stations for self-operated stairlift(s) shall be located at a height not less than 900 mm and not more than 1200 mm above the finished floor level at landings. The operation call stations shall be located at convenient positions away from the whole flight path of the stairlift such that the stairlift being called by the passenger can be safely unfolded at the landing being served.

Emergency stop buttons shall be provided at the operation call stations at all landings and on the platform carriage.

Key-operated switch with common key system as approved by the Electrical and Mechanical Services Department, the Government of the HKSAR shall be provided to activate/deactivate the control system of the stairlift installation.

Labels shall be provided to assist the passenger and the public in using the operation call station and the control panel on the platform carriage. The labels shall be of stainless steel with characters/letter engraved in English and Chinese. The arrangement and wordings of the labels shall be approved by the Supervising Officer prior to ordering.

11.1.5.3 FIRE EMERGENCY SERVICE

11.1.5.3.1 General Requirements

When specified in the Particular Specification and/or on the Drawings, the stairlift installation shall comply with the requirements stipulated in this Section.

The stairlift installation shall be provided with a facility to integrate with the fire service system of the building. The parked stairlift shall be isolated from operation when a fire service signal is received. If the signal is

received during the stairlift is in use, the stairlift shall remain in operation until it travels to a terminal landing.

In case of power failure, the stairlift installation shall be automatically switched over to battery powered operation to allow the passenger to continue the travel. When the normal power is resumed, the stairlift installation shall be automatically switched back from battery powered to normal power.

The battery supply shall be capable of being isolated by use of a switch or plug fitted to the platform carriage which shall be accessible and operable without using a tool. Battery terminals and charge contacts shall be physically protected against short circuit.

11.1.5.3.2 Batteries and Chargers

In addition to the requirements stipulated in Sub-section 11.1.1, the batteries and chargers shall comply with the following requirements.

A separate compact cabinet securely fitted in the carriage structure for storage of backup batteries and automatic charger shall be provided for battery powered operation. The battery cabinet shall be ventilated. The batteries shall not emit fumes during normal operation or during charging.

The battery charger shall not damage or overcharge the batteries, even after long period on charge. If the battery cabinet is fitted to the platform carriage, battery charging shall be carried out at each end of the guide rail. If the platform carriage is stopped at a position out of the reach of the charge contacts, there shall be indications to the passenger and the management office.

The battery capacity shall facilitate, when the batteries are fully charged, the stairlift to complete at least 5 upward and 5 downward continuous journeys under full load without charging.

11.1.5.4 REQUIREMENTS FOR OUTDOOR/WEATHER-PROOF TYPE STAIRLIFT INSTALLATION

11.1.5.4.1 General Requirements

All outdoor stairlifts and stairlifts specified to be weather-proof in the specifications or on the drawings shall be constructed in accordance with the following requirements.

The driving motor shall have a degree of protection of at least IP54. Water-tight cover shall be provided. All exposed wiring terminals, junction boxes, switches, etc. shall have a degree of protection of at least IP54.

All bearings installed on the driving mechanism shall be of sealed type.

The structural steel work of the entire stairlift installation other than moving parts shall be hot-dipped galvanised or adequately protected against corrosion by factory applied epoxy paint coating system designed for marine application.

Moving parts of the stairlift installation shall be constructed of corrosion resistant materials such as stainless steel; or heavily electroplated with corrosion resistant materials such as nickel or chromium; or other corrosion resistant materials as approved by the Supervising Officer. These moving parts shall be adequately lubricated all the time and suitably protected from water that enters into the stairlift interior.

11.1.5.4.2 Painting Process

The number, thickness and method of application of paint coating shall be in accordance with the epoxy paint coating manufacturer's recommendation, but in any case at least three coats of epoxy paint coating primer shall be applied followed by at least three coats of finishing epoxy paint coating. Each coat of paint shall be thoroughly dried before the application of next coat.

The surface of the completed structural steel work shall be prepared and treated in accordance with the epoxy paint coating manufacturer's recommendation. All rust and dirt on the surface of the work shall be removed by wire brushing and shall be thoroughly degreased by degreasing solvent prior to the application of any paint coating.

All the above-mentioned degreasing and painting process shall be carried out at the factory. Painting of structural steel work at Site is not permitted without prior approval from the Supervising Officer except for touching up of damaged paint coating during installation at site.

Information on the epoxy coating system including details of surface preparation, method of application, number of coatings, and samples of paints shall be submitted for approval prior to manufacture.

11.1.5.4.3 Welding

Welding carried out on Site on the structural steel or any metal work that will damage the protective paint coating is not permitted unless prior approval is given. Where rust appears on the parts of the structural steel or metal work due to damage of paint coating, it must be thoroughly removed by wire brush, degreased and followed by application of the same number of paint coatings as in the factory to the satisfaction of the Supervising Officer.

SECTION 11.2

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 11.2.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

11.2.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

11.2.1.2 HOT RUN TEST FOR LIFT

24-hour hot run test for lift installation shall be carried out to identify any irregularities and undertake the corresponding remedial works before handover. A method statement with detailed description shall be submitted to the Supervising Officer for approval prior to the commencement of the hot run test. In general, the lift shall run 4 hours continuously each session times 6 sessions from the main landing to the topmost landing during the hot run test. The lift shall stop at every landing and the lift door ON/OFF operation shall perform as the same as normal operation. Prior to the hot run test, car decoration, car floor and floor finishes shall be completed for all the landings. Test with dummy load is not required, unless stated in the Particular Specification.

11.2.1.3 INSPECTIONS REQUIRED BY AUTHORITY

Mandatory inspection, examination and testing shall be carried out and submitted to the Supervising Officer the test and examination certificates as shown in the Appendices of Testing and Commissioning Procedure for Lift, Escalator and Passenger Conveyor Installation in Government Buildings of Hong Kong Special Administrative Region.

The completion of testing and commissioning and, if applicable, the associated statutory inspections by EMSD is one of the major considerations for certifying completion and handing over of the complete installation. Certificates in the specified forms as stipulated in the Lifts and Escalators Ordinance (Cap. 618) and signed by a Registered Lift/Escalator Engineer shall be submitted to the Supervising Officer upon completion of the installation.

SUB-SECTION 11.2.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

11.2.2.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during Maintenance Period shall also comply with the specific requirements in this Sub-section.

Operation, servicing and maintenance of the Installations, if specified, shall also refer to the equipment manufacturer's recommendations and specifications.

11.2.2.2 RESPONSE AND ATTENDANCE TO EMERGENCY AND FAULT CALLS

Emergency, fault and complaint calls arising from defective work materials and/or system operation during the Maintenance Period shall be attended at any time. The phrase 'at any time' shall cover 24 hours a day, 7 days a week throughout the year including Sundays and Public Holidays. Fault calls may be raised by the operational staff of the building /premise concerned, the Supervising Officer or his representatives verbally or in written form at any time.

All defects leading to fault or breakdown of the equipment and/or system shall be rectified within 24 hours.

The emergency services shall include overtime works, all mechanical, electrical and electronic works and inspection, testing, adjustment, commissioning and cleaning which are found necessary to reinstate the safe and satisfactory working condition and operation order of the installation as soon as possible and within 24 hours. Upon receipt of an emergency services call, the emergency services team shall arrive at the site of incident within reasonable time normally within 1/2 hour to carry out emergency services.

If any passenger is death or injured as reported, the Registered Lift/Escalator Engineer shall arrive at the site within two hours to conduct detailed investigation of the incident and examination of the lift/escalator thoroughly.

Detailed investigation to any reportable lift or escalator incidents, including failure of the main drive, breakage of any suspension rope, failure of overspeed governor, safety gear, overload device, interlocking device of the lift door or brake, failure of escalator brake, step chain, drive chain, or safety equipment shall be carried out. The report shall be submitted to EMSD within 7 days. The process for reporting, tracking, and investigating incidents involves the checking of staffing, performance, and documentation, and tracking of investigations on process safety incidents and the trending of incident investigation data to identify recurring incidents.

11.2.2.3 MAINTENANCE SERVICES DURING MAINTENANCE PERIOD

In addition to the routine inspection, servicing and maintenance, commissioning and re-adjust the equipment/systems to meet the actual operation conditions and to test the installations to meet statutory requirements including the submission of test reports and certificates shall be carried out.

The additional works shall include, but not limited to, the following: -

(a) any repairs necessary to maintain the installation in good and safe working order at all times;

(b) carrying out periodic inspections, tests, repairs, adjustments and maintenance of the installation during the Maintenance Period;

(c) supplying all lubricants, cleaning materials, rope preservatives etc.;

(d) replacing all burnt out lamp bulbs/tubes/LED of correct rating;

(e) renewing the suspensions ropes for lift installation at no additional cost to the Employer due to normal wear and tear as per the judgement by the Registered Lift Contractor/Engineer and/or manufacturer's recommendation for maintain an adequate factor of safety and/or as required based on the replacement criteria in the statutory codes and circulars issued by the Electrical and Mechanical Services Department, the Government of HKSAR and/or as required in the maintenance schedule specified in this Section of the General Specification; and

(f) providing, repairing or replacing at no additional cost to the Employer such mechanical and electrical parts of the installation necessary for the safe and normal operation of the installation.

When a suspension rope needs to be replaced, other suspension ropes on the same sheave or in the same set shall also be replaced complying with the requirements in the statutory codes and circulars issued by the Electrical and Mechanical Services Department, the Government of HKSAR.

Maintenance schedule for each type of Installations shall be submitted to the Supervising Officer for approval before the certified completion of the Works. The maintenance schedule shall be prepared base on both manufacturer's recommendations and the statutory requirements according to the schedules stipulated in this Sub-section.

11.2.2.4 NOTES ON ENTRY OF LOG BOOK

For passenger entrapment call, two or more lift workers shall be deployed to attend the scene to release the passengers trapped in the lift. At least one of the lift workers attending the fault calls shall be a Registered Lift Worker and he/she shall record the actions taken in the log book before he leaves the scene.

In all cases, Registered Lift/Escalator Contractors/Engineer/Workers must fill in log book in accordance with the latest requirements as stipulated in the statutory codes.

The specified form of log book for lifts and escalator shall be referred to Circular No. 10/2018 issued by the Electrical and Mechanical Services Department, the Government of the HKSAR.

11.2.2.5 MAINTENANCE SCHEDULE FOR ELECTRIC PASSENGER, FREIGHT, GOODS AND SERVICE LIFTS

Schedule No.		Description of Job	Frequency
1	(a)	Top up lift machine gearbox and lubricate bearings.	Weekly
	(b)	Check brake for correct mechanical action. Ensure linings and drums are free from oil or grease. (See Note 1)	Weekly
	(c)	Clean overspeed governor and lubricate.	Weekly
	(d)	Inspect bearings of drums, sheaves and pulleys. Lubricate.	Weekly
	(e)	Inspect motor/generator/exciter commutators and slip rings operating under working conditions and stationary. Lubricate bearings.	Weekly
	(f)	Clean, inspect and adjust controller contacts, interlocks and dashpots. Lubricate. Observe and adjust operation sequence and timing of contactors.	Weekly
	(g)	Clean floor selector, check action and adjust. Lubricate drive gear.	Weekly
	(h)	Top up counterweight guide shoes lubricators.	Weekly
	(i)	Clean up lift well as necessary. Clean pit. Inspect condition of lift well enclosure. The photographs shall be submitted in size of not less than 4R and also in electronic format of resolution not less than 12 megapixels (i.e. jpeg, tiff) for the conditions of each lift installation inspected. The photographs in electronic format must be sharp, clear, good brightness and contrast and clearly marked with the respective venues, lift number, and date of record for easy identification.	Weekly
	(j)	Clean guides and lubricate where applicable.	Weekly
	(k)	Check limit switches, direction switches and their operating devices. Ensure rollers and spindles are free to rotate. Lubricate.	Weekly

Schedule No.		Description of Job	Frequency
	(l)	Inspect car exterior and clean car top. Top up car guide shoe lubricators. Inspect tensioning devices for correct adjustment. Clean and inspect door operating gear and check for oil leaks. Lubricate.	Weekly
	(m)	Check door locks for safe operation. Ensure rollers and spindles are free to rotate. Lubricate. (See Note 2)	Weekly
	(n)	Check that car and landing doors operate freely and bottom tracks are clear of debris.	Weekly
	(o)	Ride in car, observe and record irregularities in starting, stopping and general running.	Weekly
	(p)	Check for correct operation: - Car controls, car door switches, door re-opening device, emergency stop, alarm bell and intercom system. Inspect condition of car interior and floor covering. Observe levelling accuracy.	Weekly
	(q)	Test operation of landing buttons, indicators and fireman switch.	Weekly
	(r)	Ensure the normal operation of CCTV System	Weekly
2	(a)	Inspect lift machine gearing and bearings. Ensure keys and fixing bolts are secure.	Monthly
	(b)	Inspect brake coupling and linings for wear. See that keys and fixing bolts are secure. Check that brake release gear and hand winding wheel are readily available.	Monthly
	(c)	Check drums, sheaves and pulleys for visible cracks, ensure keys and fixing bolts are secure. Inspect bearings and sheave grooves. (See Note No. 3)	Monthly
	(d)	Check condition of wire ropes (including suspension ropes). Ensure wire ropes are evenly tensioned. (See Note No. 4)	Monthly (new wire ropes shall be checked fortnightly for at least 2 months after installation)

Schedule No.		Description of Job	Frequency
	(e)	Inspect overspeed governor for wear. Ensure keys and fixing bolts are secure.	Monthly
	(f)	Extract dust from interiors of motors and generators. Inspect bearings, ensure fixing bolts are secure.	Monthly
	(g)	Inspect floor selector bearings. Check connections and flexes. Inspect driving rope, tape or chain for wear and correct tension.	Monthly
	(h)	Inspect and operate by hand the slack rope switch, safety-gear switch, broken tape or rope switch and overspeed governor switch.	Monthly
	(i)	Inspect guides for wear and ensure fixings are secure.	Monthly
	(j)	Check counterweight clearances for rope stretch. Inspect rope equaliser. Ensure main tie bolts are secure. Inspect guide shoes for wear and 'float'. Ensure filler weights are properly positioned and secure. Check safety-gear for guide clearance and free movement.	Monthly
	(k)	Open, clean and inspect limit switches, direction switches. Inspect fixed ramps and inductor plates.	Monthly
	(l)	Ensure spring buffers are secure. Clean oil buffers and top up. Check for oil leaks.	Monthly
	(m)	Inspect conditions of landing and car sill nosings and check car clearance. Inspect lock beaks, door rollers and spindles for wear. Inspect door inter-connecting wires or chains for wear and correct tension.	Monthly
	(n)	Ensure car frame bolts are secure. Check guide shoes for minimum 'float'. Ensure car body is secure in frame. Check safety-gear for guide clearance and free movement. Check tension of safety rope. Inspect door operating mechanism for wear and ensure driving sprockets, keys and fixing bolts are secure. Ensure that the 'pick-up' between car and landing doors is correctly aligned. (See Note 5)	Monthly

Schedule No.		Description of Job	Frequency
	(o)	Open, clean and inspect car controls, floor switches, door switches. Check action of emergency opening and movable floor. Inspect car lighting.	Monthly
	(p)	Inspect travelling cables and their anchorages.	Monthly
	(q)	Open, clean and inspect landing button boxes and ensure that they and any indicator boxes are securely fixed.	Monthly
3	(a)	Open, clean and inspect landing door locks. (See Note 6)	Three monthly
	(b)	Carry out electrical discharge test for on emergency lighting, batteries and battery charger for 1 minute at the 10-hour discharge rate.	Three monthly
	(c)	Inspect and operate by hand the ascending car overspeed protection device switch and rope break protection device.	Three monthly
4	(a)	Renew wire ropes (including suspension ropes) (See Note 4)	
	(b)	Test overspeed governor, safety gear, ascending car overspeed protection device, uncontrolled car movement protection device and rope break protection device on no load.	(i) After major repair or major replacement that affects the operations of the device. (ii) Every year
	(c)	Test overspeed governors, safety gear, ascending car overspeed protection device, uncontrolled car movement protection device and rope break protection device on full load.	(i) After major repair or major replacement that affects the operations of the device. (ii) Every 5 years
	(d)	Test by simulation of overload device.	Every year
	(e)	Test by simulation of homing key switch.	Every year

Schedule No.	Description of Job	Frequency

Note

The attention of all personnel engaged on lift maintenance services is drawn to the need for the proper observance of all safety rules, regulations and statutory requirements. It is essential that all apparatuses are rendered, and kept, safe during servicing operations. Protective clothing and other safeguards shall be worn or used by the maintenance personnel. All defects in tools, steps, ladders and other items are to be reported immediately and the equipment shall not be used until the fault is rectified.

The lubricants used shall be of the brands and grades recommended by the component manufacturer or their approved equivalents. Ensure adequate lubrication, but avoid excessive. Spillage shall be wiped off. Oily rags or waste shall be removed

The following items are general guidance for the proper maintenance of the lift installation. These items are by no means exhaustive. The maintenance personnel shall follow all instructions and guideline as recommended by their relevant manufacturer.

1. A brake operating solenoid shall be adjusted to the shortest stroke that will expand the brake bands equally with minimum clearance, consistent with free running of the brake drum.

2. It is essential that a lift will not operate with a car or landing door open, and that landing doors are kept locked except when a car is standing at that floor.

3. (a) Wear on rope grooves of sheaves shall not be such as to cause rope slip.

   (b) All grooves must be equal, i.e. all ropes shall sit to the same depth.

   Sheave grooves shall only be allowed to be re-cut once to satisfy the above conditions.

4. Wire ropes (including suspension ropes) shall be renewed when any one of the following conditions exists: -

   (a) Where undue stretching occurs after the initial stretch has taken place;

   (b) There is corrosion/rust or extensive rouging;

   (c) There is birdcaging of strands;

   (d) The rope has been damaged;

   (e) The rope is more than six years old;

   (f) Suspension ropes should be replaced before breakage in order to keep the lift in safe working order. Therefore, suspension ropes should be replaced

immediately based on the replacement criteria, but not limited to, the following: -

Rope Conditions	Rope Replacement Criteria	
	6-strand x 19 rope 6-strand x 25 rope	8- or 9- strand x 19 rope 8- or 9- strand x 25 rope
Reduction in diameter	10%	10%
No. of broken wires randomly distributed among the outer strands	>24 per rope lay	>32 per rope lay
No. of broken wires randomly distributed among the outer strands when severe rusting or extensive rouging of the rope is observed	>12 per rope lay	>16 per rope lay
No. of broken wires concentrating in one or two outer strands	>12 per rope lay	>16 per rope lay
No. of broken wires concentrating in one or two outer strands when severe rusting or extensive rouging[1] of the rope is observed	>6 per rope lay	>8 per rope lay
No. of adjacent broken wires in one outer strand	>4 and the no. of broken wires per rope lay >12	>4 and the no. of broken wires per rope lay >16
No. of adjacent broken wires in one outer strand when severe rusting or extensive rouging of the rope is observed	>2 and the no. of broken wires per rope lay >6	>2 and the no. of broken wires per rope lay >8

[1] Where rouging exists for more than a cumulated rope length of 1 m within a hoisting rope for an installation with a travel not more than 30 m, or a cumulated rope length of 3 m within a hoisting rope for an installation with a travel exceeding 30 m should also be regarded as severe rusting or extensive rouging of the rope

(g) The discard criteria of lift manufacturer, the discard criteria of rope manufacturer, whichever are more stringent;

(h) If any rope on a sheave needs to be replaced, all other ropes on that sheave shall be replaced. When one wire rope of a set has been damaged during installation or acceptance testing prior to being subjected to lift service, it is permissible to replace a single damaged rope with a new rope provided the following requirements are met: -

- The wire rope data for the replacement rope should correspond to the wire rope data of the certificate of the original set of ropes.

- The ropes of the set in question should not have been shortened since their original installation.

- The tension of the new replacement rope should be checked and adjusted as necessary at fortnightly intervals over a period of not less than two months after installation. If the tolerance in the rope tension cannot be maintained within the limits specified by the lift

manufacturer after six months, the entire set of suspension ropes should be replaced.

- The replacement rope should be provided with the same type of suspension rope fastening used with the other ropes.

- The diameter of the replacement rope, under tension, should not be varied from the remaining ropes by more than 0.5% of the nominal diameter of the rope. The diameter of the ropes should be measured according to the method specified by the lift manufacturer. If the lift manufacturer does not specify the measuring method, the one specified in the international standard ISO 4344 should be followed.

(i) The minimum car and counterweight runby and clearances should be maintained when new suspension ropes are installed or when existing suspension ropes are shortened. The minimum clearances should be maintained by any of the following methods.

- Limit the length that the ropes are shortened.

- Provide blocking secured in place at the car or counterweight strike plate. The blocking should be of sufficient strength to withstand the reactions of buffer engagement without permanent deformation. If wooden blocks are used to directly engage the buffer, a steel plate should be fastened to the engaging surface or should be located between that block and the next block to distribute the load upon buffer engagements.

- Provide blocking secured in place under the car and/or counterweight buffer of sufficient strength to withstand the reactions of buffer engagement without permanent deformation

5. Where a power limiting device is incorporated in the door operating mechanism, it shall be clear of the safety edge and operate at a force not exceeding 150 N when the door is obstructed.

6. Door locks are to be examined internally at least once every six months (except if fitted with transparent covers, permitting observation of working parts and no defects are apparent). The opening up and internal examinations are to be carried out in sequence and spread evenly over the period.

Remarks: The word ‘Door’ in the Schedule means any sliding or hinged part which gives access to the car or lift well enclosure.

11.2.2.6 MAINTENANCE SCHEDULE FOR HYDRAULIC LIFTS

Schedule No.		Description of Job	Frequency
1	(a)	Inspect ram and cylinder, adjust gland, lubricate.	Weekly
	(b)	Check control, pilot and levelling valves and adjust. Lubricate.	Weekly
	(c)	Inspect control rope and chain, rope gripper and terminal stops.	Weekly
	(d)	Inspect bearings of sheaves and pulleys. Lubricate.	Weekly
	(e)	Clean, inspect and adjust controller contacts, interlocks and dashpots. Lubricate. Observe and adjust operation sequence and timing of contactors.	Weekly
	(f)	Clean floor selector, check action and adjust. Lubricate drive gear.	Weekly
	(g)	Clean guides. Top up lubricators.	Weekly
	(h)	Clean up lift well as necessary. Clean pit. Inspect condition of lift well enclosure.	Weekly
	(i)	Check levelling switches. Ensure rollers are free to rotate.	Weekly
	(j)	Check that doors operate freely and bottom tracks are clear of debris.	Weekly
	(k)	Inspect car exterior and clean car top.	Weekly
	(l)	Observe and record irregularities in starting, running and stopping of the lift.	Weekly
	(m)	Check for correct operation: - car controls, car door switch, alarm bell and intercom system. Inspect condition of car interior and floor covering.	Weekly
	(n)	Check action of landing buttons and indicators.	Weekly
	(o)	Check door locks for safe operation. Ensure rollers and spindles are free to rotate. Lubricate. Check that emergency door release key is readily available. (See Note 1)	Weekly
	(p)	Ensure the normal operation of CCTV System	Weekly

Schedule No.		Description of Job	Frequency
2	(a)	Ensure that keys and fixing bolts of sheaves and pulleys are secure and check for visible cracks and corrosion. Inspect bearings and rope grooves.	Monthly
	(b)	Check condition of wire ropes (including suspension ropes). Ensure wire ropes/suspension chains are evenly tensioned. Clean and lubricate. (See Note 2)	Monthly (new wire ropes shall be checked fortnightly for at least 2 months after installation)
	(c)	Ensure ram head bolts and cylinder fixing bolts are secure. Check for visible signs of corrosion. Check action of air release cock and anti-syphonic valve.	Monthly
	(d)	Ensure pipework, joints, bolts and fixings are visibly sound and free from corrosion and leaks. Check stop valve. Inspect oil reservoir and pump.	Monthly
	(e)	Open, clean and inspect: control valves, pilot and levelling valves. Check overrun and cut-off devices. Check over-load relief valve.	Monthly
	(f)	Inspect pump motor when operating and stationary.	Monthly
	(g)	Inspect floor selector bearings. Check connection and flexes. Inspect driving rope, tape or chain for wear and correct tension.	Monthly
	(h)	Inspect safety gear switch and operate it by hand.	Monthly
	(i)	Check counterweight clearances for rope stretch. Ensure main tie-bolts and filler weights are secure. Check guide shoes for wear and ‘float’.	Monthly
	(j)	Inspect ‘Jigger’ counterweight assembly for visible signs of corrosion. Ensure fixings are secure. Check guide shoes for wear and ‘float’.	Monthly
	(k)	Inspect travelling cables and their anchorages.	Monthly
	(l)	Inspect guides for wear and ensure fixings are secure. Check spring buffers.	Monthly
	(m)	Inspect condition of landing and car sill nosings and check car clearances. Inspect lock beaks, door rollers and spindles for wear.	Monthly

Schedule No.	Description of Job		Frequency
	(n)	Ensure car frame bolts are secure. Check guide shoes for wear and 'float'. Ensure car body is secure in frame. Check safety gear for running clearance and free movement. Check tension of safety rope.	Monthly
	(o)	Open, clean and inspect car controls, door switches and levelling switches. Check operation of emergency opening. Inspect car lighting.	Monthly
	(p)	Open, clean and inspect landing button boxes and ensure that they and any separate indicator boxes are securely fixed.	Monthly
	(q)	Open, clean and inspect landing door locks. (See Note 3)	Monthly
3	(a)	Carry out electrical discharge test for on emergency lighting, batteries and battery charger for 1 minute at the 10-hour discharge rate.	Three monthly
4	(a)	Renew wire ropes (including suspension ropes). (See Note 2)	
	(b)	Test safety gear on no load.	(i) After major repair (ii) Every year
	(c)	Test safety gear on full load.	(i) After major repair or major replacement that affects the operation of the device. (ii) Every 5 years

Note

The attention of all personnel engaged on lift maintenance services is drawn to the need for the proper observance of all safety rules, regulations and statutory requirements. It is essential that all apparatuses are rendered, and kept safe during servicing operations. Protective clothing and other safeguards shall be worn or used by the maintenance

personnel. All defects in tools, steps, ladders and other items are to be reported immediately and the equipment shall not be used until the fault is rectified.

The lubricants used shall be of the brands and grades recommended by the component manufacturer or their approved equivalents. Ensure adequate lubrication, but avoid excessive. Spillage shall be wiped off. Oily rags or waste shall be removed.

The following items are general guidance for the proper maintenance of the lift installation. These items are by no means exhaustive. The maintenance personnel shall follow all instructions and guidelines as recommended by their relevant manufacturer.

1. It is essential that a lift will not operate with a car or landing door open, and that landing doors are kept locked except when a car is standing at that floor.

2. Wire ropes (including suspension ropes) shall be renewed in accordance with Clause 4 of Note for the maintenance schedule for electric passenger, freight, goods and service lifts.

3. Door locks are to be examined internally at least once every six months (except if fitted with transparent covers, permitting observation of working parts and no defects are apparent). The opening up and internal examinations are to be carried out in sequence and spread evenly over the period.

Remarks: The word 'Door' in the Schedule means any sliding or hinged part which gives access to the car or lift well enclosure.

11.2.2.7 MAINTENANCE SCHEDULE FOR ESCALATORS AND PASSENGER CONVEYORS

Schedule No.	Description of Job		Frequency
1	(a)	Check the clearance between the steps/pallets/belts and the skirt guard to ensure adequate clearance.	Weekly
	(b)	Inspect bearings of drums, pulleys and all moving parts. Lubricate.	Weekly
	(c)	Clean down the machine room as necessary.	Weekly
	(d)	Ride in escalator/passenger conveyor, observe whether the operation is normal. Check whether there is undue vibration.	Weekly
	(e)	Check for correct operation of all safety devices; i.e. emergency stopping devices, broken step/pallet chain device, broken drive chain device, broken step/pallet device, broken handrail device, non-reverse device, missing steps safety device, step sagging safety device, comb obstruction device, skirting switches, handrail entry device, phase	Bi-weekly

Schedule No.		Description of Job	Frequency
		protection relay, overspeed governor, motor protection relay, etc.	
	(f)	Check for correct operation of emergency stop switch in machinery spaces.	Bi-weekly
2	(a)	Check and inspect the main drive system.	Monthly
	(b)	Check and lubricate the step/pallets rollers.	Monthly
	(c)	Check and inspect the handrail to ensure adequate tightness and proper functioning. Clean the inside surface to the handrail.	Monthly
	(d)	Check and inspect the control box.	Monthly
	(e)	Check and record the braking efficiency.	Monthly
	(f)	Check, inspect and test the remote monitoring system if provided.	Monthly
3	(a)	Check the landing comb for completeness.	Three monthly
	(b)	Check the lubricating pump to see if there is enough lubricating oil. Check the quality of lubricating oil.	Three monthly
	(c)	Check and clean the motor gear box.	Three monthly
	(d)	Check the lighting system.	Three monthly
4	(a)	Test overspeed governor, auxiliary brake if equipped and brake on no load.	Half yearly
5	(a)	Remove all necessary steps/pallets and clean the rail.	Bi-yearly
	(b)	Check for correct operation of the current overload and safety switches and non-reversal switches.	Bi-yearly
6	(a)	Replace all the lubricating oil.	5-yearly
	(b)	Test overspeed governor, auxiliary brake if equipped and brake on full load.	5-yearly

Note

The attention of all personnel engaged on escalators/passenger conveyors maintenance services is drawn to the need for the proper observance of all safety rules, regulations and statutory requirements. It is essential that all apparatus is rendered, and kept, safe during servicing operations. Protective clothing and other safeguards shall be worn or used. All defects in tools, steps, ladders and other items are to be reported immediately and the equipment not to be used until the fault is rectified.

The lubricants used shall be of the brands and grades recommended by the component manufacturer or their approved equivalents. Ensure adequate lubrication, but avoid excess. Spillage shall be wiped off. Oily rags or waste shall be removed.

The following items are general guidance for the proper maintenance of the escalator/passenger conveyor installation. These items are by no means exhaustive. The maintenance personnel shall follow all instructions and guidelines as recommended by their relevant manufacturer.

1. The drive chain shall be replaced immediately based on the discard/replacement criteria given by the chain manufacturer or escalator manufacturer, whichever are more stringent.

2. In long escalator with vertical rise greater than 15 m, all drive chains shall be replaced at intervals not exceeding 6 years of their services unless otherwise stated by the chain manufacturer or escalator manufacturer.

11.2.2.8 MAINTENANCE SCHEDULE FOR POWERED VERTICAL LIFTING PLATFORMS

Schedule No.		Description of Job	Frequency
1	(a)	Check the emergency alarm button in platform carriage.	Weekly
	(b)	Check the intercom system if provided.	Weekly
	(c)	Check the 'Acknowledge' indicator if provided.	Weekly
	(d)	Check the emergency stop switch in platform and lift pit.	Weekly
	(e)	Check the platform emergency lighting.	Weekly
	(f)	Check the operation of 'Landing Control Station' with constant pressure operated control buttons, landing key-operated switch and call bell button.	Weekly
	(g)	Check the landing 'In-Use' indicator if provided.	Weekly

Schedule No.		Description of Job	Frequency
	(h)	Check the landing 'Car Hire' indicator if provided.	Weekly
	(i)	Check the operation of 'Platform Control Station' with constant pressure operated control buttons, emergency stop button, key-operated switch and call bell button.	Weekly
	(j)	Check the alarm / call for help button on platform and at landings.	Weekly
	(k)	Inspect the landing door fixtures.	Weekly
	(l)	Inspect the door locking devices with mechanical, electrical interlocks and electrical contacts.	Weekly
	(m)	Test emergency stop switch under platform.	Weekly
	(o)	Check the electrical switch under platform.	Weekly
	(p)	Ensure the normal function of remote emergency alarm panel.	Weekly
	(q)	Check the emergency back-up power for emergency alarm devices.	Weekly
	(r)	Ensure the alarm bell operates without main power.	Weekly
	(s)	Ensure the normal operation of CCTV System.	Weekly
	(t)	Ensure the normal operation of Call Bell System.	Weekly
2	(a)	Check the main power switch.	Monthly
	(b)	Inspect the major relays in control panel.	Monthly
	(c)	Inspect and clean the electrical components in control panel.	Monthly
	(d)	Check the main power cable, earth bonding and wiring connections.	Monthly
	(e)	Check the control timer if provided.	Monthly
	(f)	Ensure no leakage from oil tank.	Monthly
	(g)	Ensure the oil amount in oil tank at desirable level.	Monthly

Schedule No.		Description of Job	Frequency
	(h)	Clean the hydraulic pump and motor unit running condition.	Monthly
	(i)	Ensure the hydraulic valves in operation and in good condition.	Monthly
	(j)	Inspect the pressure gauge.	Monthly
	(k)	Test the hand pump.	Monthly
	(l)	Test manual lowering valve.	Monthly
	(m)	Inspect the car frame.	Monthly
	(n)	Inspect the guide shoes. Lubricate.	Monthly
	(o)	Inspect the safety gear and electrical switch.	Monthly
	(p)	Inspect the platform side wall(s) and surface.	Monthly
	(q)	Test and inspect the door locking device.	Monthly
	(r)	Test the control key switches.	Monthly
	(s)	Test the platform control buttons.	Monthly
	(t)	Inspect the platform lighting fixtures.	Monthly
	(u)	Check the guide rail fixings and brackets.	Monthly
	(v)	Lubricate the guide rails.	Monthly
	(w)	Inspect the flexible cables and cable clips.	Monthly
	(x)	Inspect and test the limit switches.	Monthly
	(y)	Inspect and test the final limit switches.	Monthly
	(z)	Check the suspension chain / wire ropes condition.	Monthly
	(aa)	Check the diversion pulleys condition.	Monthly
	(bb)	Ensure no oil leakage from hydraulic cylinder.	Monthly
	(cc)	Check oil pipe / flexible hose.	Monthly
	(dd)	Check lift pit condition, clear debris.	Monthly

Schedule No.	Description of Job		Frequency
	(ee)	Check all labels, notice(s) and signage in proper condition.	Monthly
	(ff)	Test by simulation of overload device.	Monthly

Note

The attention of all personnel engaged on powered vertical lifting platforms maintenance services is drawn to the need for the proper observance of all safety rules, regulations and statutory requirements. It is essential that all apparatus is rendered, and kept, safe during servicing operations. Protective clothing and other safeguards shall be worn or used. All defects in tools, steps, ladders and other items are to be reported immediately and the equipment not to be used until the fault is rectified.

The lubricants used shall be of the brands and grades recommended by the component manufacturer or their approved equivalents. Ensure adequate lubrication, but avoid excess. Spillage shall be wiped off. Oily rags or waste shall be removed.

11.2.2.9 MAINTENANCE SCHEDULE FOR STAIRLIFTS

Schedule No.	Description of Job		Frequency
1	(a)	Check the emergency stop button at platform carriage.	Weekly
	(b)	Check and inspect the final limited switches at the uppermost and lowest landings.	Weekly
	(c)	Inspect the security lock for folding and unfolding of the platform.	Weekly
	(d)	Check and inspect the electrical operation of folding and unfolding of the platform.	Weekly
	(e)	Check and inspect the manual operation of folding and unfolding of the platform.	Weekly
	(f)	Check and inspect the sequential operation of ramps.	Weekly
	(g)	Check and inspect the electrical and mechanical interlock of the ramps with drive system.	Weekly
	(h)	Check the operation of bi-directional pressure sensitive sensors.	Weekly

Schedule No.		Description of Job	Frequency
	(i)	Check and inspect the mechanical lock of foldable barrier arms.	Weekly
	(j)	Inspect the electro-mechanical brake.	Weekly
	(k)	Inspect the manual release of electro-mechanical brake.	Weekly
	(l)	Check and inspect the audio-visual bystander alert device.	Weekly
	(m)	Check and inspect the guide rails.	Weekly
	(n)	Check the operation of 'Platform Carriage' with constant pressure operated control buttons and key-operated switch.	Weekly
	(o)	Check the emergency stop button at operation call stations.	Weekly
	(p)	Check the 'Power On' indicator on Operation Call Station.	Weekly
	(q)	Check the 'Activation' indicator on Operation Call Station.	Weekly
	(r)	Check the 'Fault Signal' indicator on Operation Call Station.	Weekly
	(s)	Check the 'Position' indicator of platform carriage on Operation Call Station.	Weekly
	(t)	Check the operation of 'Operation Call Stations' with constant pressure operated control switches and key-operated switch.	Weekly
	(u)	Check the emergency stop button at attendant control unit.	Weekly
	(v)	Check the operation of 'Attendant Control Unit' with constant pressure operated control buttons and emergency stop button, key-operated switch.	Weekly
	(w)	Check the emergency back-up power for emergency alarm devices.	Weekly
	(x)	Ensure the alarm bell operates without main power.	Weekly
	(y)	Check the batteries and automatic charger.	Weekly

Schedule No.	Description of Job		Frequency
2	(a)	Check the main power switch.	Monthly
	(b)	Inspect the major relays in control panel.	Monthly
	(c)	Inspect and clean the electrical components in control panel.	Monthly
	(d)	Check the main power cable, earth bonding and wiring connections.	Monthly
	(e)	Inspect the platform carriage.	Monthly
	(f)	Inspect the guide shoes.	Monthly
	(g)	Inspect the safety gear and electrical switch.	Monthly
	(h)	Test the control key switches.	Monthly
	(i)	Test the platform control buttons.	Monthly
	(j)	Check the guide rail fixings and brackets.	Monthly
	(k)	Lubricate the guide rails.	Monthly
	(l)	Inspect the flexible cables and cable clips.	Monthly
	(m)	Inspect and test the final limit switches.	Monthly
	(n)	Check the suspension chain / wire ropes condition if provided.	Monthly
	(o)	Check the rack and pinion gear condition if provided.	Monthly
	(p)	Check the screw and nut gear condition if provided.	Monthly
	(q)	Check all labels, notice(s) and signage in proper condition.	Monthly

Note

The attention of all personnel engaged on stairlift maintenance services is drawn to the need for the proper observance of all safety rules, regulations and statutory requirements. It is essential that all apparatus is rendered, and kept, safe during servicing operations. Protective clothing and other safeguards shall be worn or used. All defects in tools, steps,

ladders and other items are to be reported immediately and the equipment not to be used until the fault is rectified.

The lubricants used shall be of the brands and grades recommended by the component manufacturer or their approved equivalents. Ensure adequate lubrication, but avoid excess. Spillage shall be wiped off. Oily rags or waste shall be removed.

11.2.2.10 INSPECTIONS REQUIRED BY SUPERVISING OFFICER

The Supervising Officer or his Representative will, at his discretion, carry out inspection on any lift/escalator at any time, in particular, after major repair or periodic testing and examination of lift/escalator or upon receipt of the complaint. Adequate and sufficient technical staff on site for the smooth progress of inspection upon request shall be dispatched.

11.2.2.11 PERIODIC EXAMINATION AND TESTING DURING MAINTENANCE PERIOD

Periodic examination and periodic testing of the safety equipment as stated in the Lifts and Escalators Ordinance (Cap. 618) shall be carried out during the Maintenance Period. Copies of the test certificates duly signed by Registered Lift/Escalator Engineer shall be submitted to the Supervising Officer for record. All necessary arrangement and preparation work for the protection of the Installation shall be provided.

Notwithstanding the statutory requirements, the periodic examination and periodic testing of the safety equipment as stated in the Lifts and Escalators Ordinance (Cap. 618) shall be carried out within one month prior to the end of the Maintenance Period.

11.2.2.12 TEST AND EXAMINATION REPORT

In addition to the statutory submissions, a test/examination report following the format given in the Appendices to the Code of Practice for Lift Works and Escalator Works together with copy of EMSD/LE11 and/or Form EMSD/LE12 shall be submitted to the Supervising Officer one week before the end of the Maintenance Period.

PART 12 – CATERING EQUIPMENT INSTALLATION

SECTION 12.1

TECHNICAL REQUIREMENTS

SUB-SECTION 12.1.1

GENERAL

12.1.1.1 DESIGN OF EQUIPMENT, FIXTURES AND APPLIANCES

12.1.1.1.1 The design of catering equipment to meet the specification requirements shall be included under the works.

12.1.1.1.2 The catering equipment, fixtures and appliances shall be designed to meet the performance and functional requirements of this General Specification, especially: -

(a) Hygiene requirements in Public Health and Municipal Service Ordinance, (Cap. 132) and Provision of Municipal Service (Reorganisation) Ordinance, (Cap. 552);

(b) Safety and occupational health requirements in Occupational Safety and Health Ordinance, (Cap. 509); and

(c) Statutory environmental requirements on air, noise, water and waste disposal. All the facilities and features in the equipment shall be designed to meet with the environmental statutory requirements on its own unless otherwise stated.

12.1.1.1.3 All catering equipment installations, materials, equipment and systems shall meet the following design objectives: -

(a) Serve the purpose of cooking, boiling, steaming, frying etc. for catering use and meet the functional and performance requirements for serving the numbers and types of meal required, in particular at peak catering hours.

(b) Cater for the catering operational flow to maximise the efficiency of kitchen operation.

(c) Be safe, hygienic, convenient and effective.

(d) Be energy efficient.

(e) Allow and provide adequate maintenance facilities and accesses.

(f) Provide reliable and durable materials and equipment with a reasonably long operating life.

(g) Allow easy monitoring of system performance and equipment status.

(h) Minimise future maintenance and replacement of parts.

(i) Allow adequate standby and spare facilities to cater for the failure of any part of the installations.

(j) Achieve cost effectiveness in term of life cycle costing with low operation and maintenance cost.

(k) Select and use equipment with optimum performance and with good energy efficiency.

(l) Reduce noise, vibration and other nuisances to the occupants and neighbours.

(m) Comply with all the safety requirements in future operation and maintenance with particular attention on the occupational safety and health of the workers.

(n) Use durable materials as well as equipment having a steady and reliable supply of parts and spares.

(o) Be aesthetically acceptable for all installations in exposed positions.

(p) Minimise the environmental impact and social effect as appropriate.

(q) Be flexible to cater for future modification and expansion as appropriate.

12.1.1.1.4 Documentary evidence shall be submitted to the satisfaction and approval of the Supervising Officer that all the above design objectives as relevant are satisfied and complied with reasonably satisfactory solution. Where selection of the brand and model of equipment and material is required, it shall be required to demonstrate to the satisfaction of the Supervising Officer that the design, configuration and installation details of equipment and material so selected shall meet with all the relevant design objectives as necessary.

12.1.1.1.5 Where there are more than one catering equipment, fixtures and appliances provided in one area, the equipment, fixtures and appliances shall be designed in the most appropriate layout and arrangement in co-ordination with relevant parties and submitted to the Supervising Officer for approval. The design shall take full consideration on the operational flow and requirements, and the use of the equipment, fixtures and appliances for catering and cooking. The difference between the preparation of Chinese meals and Western meals shall be fully considered in the design. All design shall meet the currently enforcing statutory licensing requirements.

12.1.1.1.6 Equipment shall be so designed and constructed to permit it to be maintained in a hygienic condition without difficulty. Working surfaces and food compartments shall have smooth surfaces and be free of crevices. Wherever practicable, corners shall be rounded. Where applicable, means shall be provided to collect spillage and condensate, e.g. a removable tray under open top boiling rings.

12.1.1.1.7 Spaces that are not easily accessible to the user, e.g. spaces between adjacent appliances in 'en-suite' arrangements, shall be sealed to prevent ingress of spillage, dirt and vermin or the space between each appliance shall be sufficient to allow cleaning of adjacent surfaces. Tubular legs and box section material shall be completely sealed.

12.1.1.1.8 Equipment e.g. deep fat fryer, that needs to be emptied for cleaning shall be provided with a means for complete draining of the contents. Where a draw off tap is provided for this purpose it shall be protected against inadvertent operation.

12.1.1.1.9 Unless otherwise specified, steam heating equipment shall be supplied and installed with steam jacket or product having equivalent performance and function to separate steam from direct contact with items being cooked.

12.1.1.2 GREEN AND ENERGY EFFICIENCY

Water heater, cooker and domestic appliances shall comply with the latest Green Specification published by the Environment Protection Department (EPD). Unless otherwise specified, water heater, cooker and domestic appliances shall be of Grade 1 under the Voluntary Energy Efficiency Labelling Scheme where applicable, or be of recognition type under the Voluntary Energy Efficiency Labelling Scheme from Electrical and Mechanical Services Department if relevant scheme are available for the type and rating of the water heater, cooker and domestic appliances.

12.1.1.3 OPERATING CONDITIONS

All items of equipment shall be rated for continuous service at the specified duties under the prevailing atmosphere and operational conditions on-site.

12.1.1.4 GENERAL SAFETY, HYGIENIC AND OPERATIONAL REQUIREMENTS FOR ELECTRICAL APPLIANCES

The appliances including its components parts, shall be soundly constructed so that in normal use it will operate without causing danger to the user or damage to the surroundings. All mechanical moving parts and cutting surfaces shall be adequately protected with guards. Any guard, whether it is for mechanical moving parts or otherwise, accessible to the user which if opened or displaced would expose the user to danger or injury shall require a special tool to release it and be interlocked so that the machine cannot be operated unless the guard is in proper position. A warning notice shall be securely fixed to the appliance in a prominent position for the attention of the operator.

Equipment shall have adequate mechanical strength and be so constructed that it will not deform and will withstand such rough treatment as may be expected in normal use.

Equipment shall be free of sharp edges and pointed protrusions that would be liable to cause injury to personnel or damage to clothing.

Equipment with hot parts shall be properly insulated or designed to avoid direct contact and injury to personnel.

Appliances shall be designed and constructed allowing it to be maintained in a hygienic condition without difficulty. Working surfaces and food compartments shall be smooth and be free of crevices.

Handles, knobs, hinges, catches and fittings shall be so constructed and fixed that they will not become loose, deform or break in normal use or harbour grease or food debris.

The method of construction of 'en-suite' appliances shall permit individual component to be withdrawn and re-installed without difficulty.

The equipment shall be provided with a terminal for the connection of an external equipotential conductor.

The electric motors of the equipment shall have the appropriate motor protection in accordance with the Section on Electrical Installation of this General Specification.

12.1.1.5 SAFETY INTERLOCKING DEVICES FOR DOOR, COVER, GUARD, ETC.

Parts that are intended to be removable by the user, e.g. for cleaning, shall be readily accessible, shall not require the use of tools for their removal, shall be easy to assemble correctly and impossible to assemble incorrectly.

Handles, knobs, hinges, catches, and fittings shall be so constructed and fixed that they do not work loose, deform or break in normal use, or harbour grease or food debris.

Any door, cover or guard accessible to the user which, if opened or displaced could expose the user to danger or injury, shall require a tool to release it or shall be interlocked so that it cannot be opened or displaced until safe conditions have been established.

12.1.1.6 EARTH AND EQUIPOTENTIAL BONDING OF APPLIANCES

All electric appliances shall be provided with an earth terminal. This terminal shall provide an effective electrical connection with all exposed metal parts of the unit and shall be effectively connected with the consumer's earth terminal via the earth- continuity conductor of the final circuit for the appliances.

All fixed appliances shall be provided with a terminal or means for the connection of an external equipotential conductor. This terminal shall maintain an effective electrical connection with all fixed exposed metal parts of the appliances and shall allow the connection of a conductor having nominal cross sectional area up to 6 mm^2. It shall be

located in a position convenient for the connection of the earth conductor after installation of the appliances.

Snap-on type connectors shall not be used to connect conductors that are associated with bonding and earthing of an appliance. Any connector used shall allow all earthing and bonding to be made easily.

12.1.1.7 STABILITY REQUIREMENTS

Equipment, unless fixed in position, shall comply with the stability requirements given in the relevant International Standards to the acceptance of the Supervising Officer. Any appliance for which there are no specific methods of test for stability shall comply with the International Standards for a similar type of equipment.

12.1.1.8 COMPONENT CO-ORDINATION

Equipment for European cooking shall be a dimensionally co-ordinated unit. Unless otherwise specified, it shall be designed to accommodate a range of containers with sizes selected from BS EN 631-1: 1993.

The completed design with support of drawings/models of the assembled/prefabricated mechanical, electrical and plumbing systems, and the proposed integration/connections with other services shall be submitted to the Supervising Officer for approval before manufacturing.

12.1.1.9 ADJUSTABLE LEGS FOR FLOOR STANDING EQUIPMENT

Floor standing equipment shall be mounted on pedestal or on legs with adjusters for levelling, with base of the equipment not less than 150 mm clear of the floor. The adjusters shall be robust and easily adjustable by hands and without the use of any special tool.

12.1.1.10 ACCESSIBILITY

Equipment shall be constructed to allow easy access to components requiring periodic cleaning, adjusting and servicing. Access panels shall be provided as specified and indicated on the working drawings and recorded on the as-fitted drawings to show the locations especially where panels are built-in or concealed.

12.1.1.11 LOCATION OF CONTROLLING DEVICES AND SENSORS

Suitable types of controlling devices, sensors, starters, etc. shall be supplied and installed in accordance with appropriate International Standards so as to facilitate proper operation of the equipment and for maintenance purposes.

All controls mounted on external vertical surfaces of the appliances shall be set into recessed die-stamped stainless steel cups, or otherwise protected and/or guarded to prevent damage, to avoid accidental operation and to shelter from spillage in normal use.

All sensors fixed inside the appliances shall be protected by suitable compartment.

12.1.1.12 INSULATION FOR HEATED OR REFRIGERATED APPLIANCES

Heated or refrigerated appliances shall be thermally insulated to minimise heat losses or heat gains and to prevent direct contact with hot/cold parts. Thermal insulation shall be securely located and protected against mechanical damage, spillage, and sealed against infestation by insects and ingress of fluid.

All hand wheels, knobs and handles for the heated or refrigerated appliances shall be effectively insulated.

12.1.1.13 DESCALING OF WATERWAYS

It shall be possible to descale all waterways where the formation of scale may occur. The recommended method of descaling shall be given in the manufacturer's servicing instruction.

12.1.1.14 NOISE AND VIBRATION LEVEL

The level of noise and vibration from any source associated with the appliances shall be as low as practicable under all operational conditions.

In particular, no rattles, vibrations, or discreet tones shall be discernible in occupied area outside the room housing the appliance or appliance enclosures. Silencers with insertion losses, sound-sealing panels, isolation and damping devices, etc. shall be supplied and installed if required, to attenuate the noise of the appliances and to damp the vibration of machinery to a reasonable level having regard to the use and nature of the building and works.

12.1.1.15 WITHDRAWAL AND RE-INSTALLATION OF INDIVIDUAL APPLIANCE

The method of construction of 'en-suite' appliances shall permit individual appliance to be withdrawn or re-installed without difficulty.

Modular 'en-suite' back-to-back appliances shall incorporate a compartment to accommodate the services to individual appliance. Appliance connections for external services shall be so positioned that: -

(a) An appliance can be connected and disconnected with the appliance in position. Alternatively for 'en-suite' appliances approved flexible connections are acceptable to enable an appliance to be connected and disconnected in the withdrawn position; and

(b) The services can be grouped together and installed clear of the space under the appliances to facilitate cleaning.

12.1.1.16 INSTALLATION OF ELECTRIC ELEMENTS

Appliances operated with water, such as Bain Marie and steamer, shall be supplied and installed with immersion type heating elements of sufficient wattage to bear and maintain the water contained in the appliances at a temperature of 98ºC. The heating elements shall be fitted with water-tight bushings extending through the bottom or side of the appliances. Terminals shall be protected by removable caps. Each element shall be fitted with a thermostatic control with a pilot light indicator.

Appliances requiring dry heat, such as plate warmers, shall be fitted with strip or ring heaters of sufficient wattage to provide the desired heat. Unless otherwise specified, these heaters shall be installed directly below the bottom shelf. They are to be mounted in suitable channels and are to be inter-connected with insulated nickel wire. Each appliance shall be provided with one or more thermostatic controls with a pilot light indicator.

All wiring shall be properly protected in enclosures.

12.1.1.17 JOINTS AND FITTINGS IN DIRECT CONTACT WITH HEATED ELEMENTS

All joints and fittings in direct contact with materials subject to direct burner flame or heater elements shall be brazed or welded.

Copper that is subjected to direct heat shall be of a thickness not less than 1.2 mm. This requirement does not apply to heat exchanger fins that shall be of a thickness not less than 0.8 mm.

Where copper is used for water heating appliances the internal surfaces in contact with water shall be heavily tinned or nickel-plated.

12.1.1.18 KITCHEN EXHAUST

The kitchen exhaust system shall be designed with effective exhaust hoods to UL 710 or equivalent as specified under the contract such as hydrovent ventilator and electrostatic precipitator or water scrubber or other more efficient exhaust hoods including those incorporated with UV-C light tube for effective grease removal and cleansing of air ducts.

For exhaust hood equipped with UV-C grease decomposition features, it shall meet the following design requirements: -

(a) the UV-C light tube shall emit UV light at suitable band of UV-C e.g. with peak at wavelength of around 185nm and with adequate power which could demonstrate effective generation of ozone for the designed grease decomposition as specified by the manufacturer;

(b) sufficient length of air duct downstream of the UV-C hoods should be provided to ensure a sufficient time of at least 2 second for the kitchen effluent to react with ozone generated by UV-C light tube before the exhaust is discharged to open air;

(c) provision of inter-locking shall be allowed in the design to turn off the UV-C light tube while the exhaust hood is not in operation; and

(d) Ozone sensor shall also be installed for monitoring the ozone generation from the UV-C light tube, inter-locking device shall be allowed in the design to trip off the UV-C light tube when the ozone level at kitchen or discharge outlet is higher than the threshold value specified under the contract.

The Contractor shall coordinate with other contractors responsible for providing a mechanical exhaust system which shall be designed to provide sufficient air flow rate to meet the operational needs and cause environmental, safety and health impacts to tenants and the public in accordance with Part 6 of this General Specification. The type of kitchen appliances, cooking, hood style, and equipment layout plan etc., shall be reviewed to determine the required kitchen exhaust flow rate. Also, the minimum extraction velocity at grease filters shall be assessed to achieve the required grease separation performance. Energy saving features such as installing appropriate sensors to detect the activities under the exhaust hood which the signal is used to modulate down the extraction air flow rate and make up air flow rate while no cooking / heating activity is under the hood, shall be provided.

The grease filter should be stainless steel baffle filter of filter Class G2 or UL Class 2 tested to DIN 18869-5, UL 1046, ASTM 2519 or ANSI/ASHRAE Standard 52.2-2017. It shall have oil mist removal efficiency not less than 85% for grease particles of size more than 10 microns or with overall efficiency of 90% in accordance with Section 6.2.1.14 in Part 6 of this General Specification, unless otherwise specified in the Particular Specification. It should be capable to act as a fire barrier, which prevents any cooking flames travelling past the canopy.

The kitchen exhaust duct arrangement shall be designed to minimise the length of grease ductwork from the kitchen hood to the exhaust outlet and the extent of grease accumulation along with the ductwork that causes a fire risk. And the grease and odour control equipment shall be installed at the nearest location from the kitchen hood as far as practicable. The exhaust air ducts shall be fitted with access panels of sufficient number, quality, size and be accessible for regular cleaning and inspection.

The exhaust air grilles shall be strategically located close to the heat-generating equipment (e.g. ovens, cooking equipment, dishwashers, etc.) to remove the excess steam and hot air effectively.

SUB-SECTION 12.1.2

CONTROLS OF APPLIANCES

12.1.2.1 MANUALLY OPERATED CONTROL FOR FUEL ISOLATION

Fuel consuming appliance shall be provided with one or more manually operated control to enable all fuel consuming components to be isolated from the fuel supply. The number and locations of manual controls shall suit the appliance operational requirements and site conditions, and shall be to the acceptance of the Supervising Officer.

12.1.2.2 AUTOMATIC CONTROL FOR FUEL CONSERVATION

Wherever practicable, fuel consuming appliances shall incorporate automatic control devices to conserve fuel by reducing latent heat losses and eliminating unnecessary heating when the cooking process is interrupted or completed.

12.1.2.3 TIME CONTROL

Whenever the electrical heating elements or gas burners of the grills, ovens, solid top hot plates, boiling tops, etc. are specified to be under timer control, an adjustable timer shall be provided and be capable of being reset manually either forward or backwards at any time after the initial setting. The timer shall clearly indicate the time expire period of operation or the time remaining. Time setting range shall be in accordance with the maximum cooking process time of individual appliance and as specified.

12.1.2.4 AUTOMATIC PROTECTIVE DEVICES FOR SAFETY REASONS

Appliances shall incorporate adequate automatic protective devices to ensure that safe conditions are maintained under any circumstances, including but not limited to when the normal automatic temperature or pressure controls fail or the power supplied to the appliances is interrupted.

12.1.2.5 MINIMUM REQUIREMENT OF PROTECTIVE DEVICES

12.1.2.5.1 Water Heating Appliances

(a) Non pressure type

Non-pressure type water heating appliance shall be provided with at least: -

(i) A vent to atmosphere of adequate dimension so that no parts of the boiler can exceed atmospheric pressure when operated continuously at maximum heat input; and

(ii) A low water level protective device if no automatic water level control is incorporated in the appliances.

(b) Pressure type

Water heating appliances of pressure type, including water boilers, steam generators, pressure jacketed boiling pans, and etc. shall be fitted with at least: -

(i) A pressure safety valve;

(ii) A vacuum release valve;

(iii) A pressure gauge;

(iv) A low water level cut-out (except live steam heated boiling pans); and

(v) A water gauge marked with maximum and minimum water level (except boiling pans).

12.1.2.5.2 Fryers, Deep and Shallow Type

Gas or electric fryers shall incorporate at least the followings: -

(a) A high temperature limit thermostatic cut out of the manual reset type. A tool shall be required to gain access to the reset mechanism;

(b) A device to isolate the gas or electricity supply to the burners or heating elements when the tilting pan is displaced from the normal operating position; and

(c) A permanent mark to indicate the maximum oil level and adequate capacity above this level for surge boiling conditions.

12.1.2.5.3 Electrical Power Operated Appliances

Appliances such as mixer, mincer, peeler, chipper, slicer, meat saw, dishwasher, etc., and any appliances that have power driven moving parts or high pressure steam/hot water jets which could be exposed when operating or cleaning the appliances, shall incorporate devices to prevent automatic restarting after a stoppage due to drop in electrical voltage, steam pressure or failure of fuel supply. Overheat safety cut-out shall be provided for electric water heater.

12.1.2.5.4 Gas Appliances - Flame Failure Protection

Main burners in an enclosed or semi-enclosed space shall be provided with an ignition device and flame failure protection devices. It shall not be possible for gas to pass to the main burner until a pilot flame has been established, and the gas to the main burner and pilot burner if fitted, shall

automatically cut-off if the pilot flame or other means of igniting the main burner fail.

Main burners not in an enclosed or semi-enclosed space shall incorporate automatic controls to cut off the gas to the main burner shall the pilot flame or other means of igniting the main burner fail.

12.1.2.6 SPECIAL CONTROLS FOR GAS APPLIANCES

Controls, such as timers and thermostats, provided to regulate the cooking process shall not control the gas supply to pilot burners. The manual ON/OFF control and automatic safety cut-out device (if fitted) of a main burner shall also control its associated pilot burner. Automatic ignition, when specified, shall be of continuous spark fail-safe type by piezo-electrostatic or as approved by the Supervising Officer.

12.1.2.7 CONTROLS FOR STEAM OPERATED APPLIANCES

All steam-heated appliances shall be suitable for the stated working pressures. Pressure reducing valve sets shall be supplied and installed for those appliances requiring to be operated at lower pressures, each incorporating a direct acting reducing valve with screwed bronze body and bronze excess pressure relief valve. The reducing valve shall be preceded by a Y-type strainer and high and low pressure gauges with isolating valves shall be fitted at the up- and-down-stream of the pressure reducing set. Each pressure reducing set shall maintain the required pressure under no-flow conditions.

A bronze stop valve with integral seat, screwed BSP shall be supplied and installed in the steam connection to each item of equipment, and a steam trap set shall be supplied and installed in the condensate discharge connection.

Adjustable thermostatic controls shall be included.

Steam traps serving boiling pans and steam heating coils shall be of the ball-float pattern and shall discharge into the common condensate system. Each compartment of the wet steaming ovens and each of the high-speed ovens shall be drained by a trap of the balanced pressure thermostatic type discharging over the floor gully provided. Ball-float trap shall be preceded by a strainer and followed by a combined sight/check valve, pipe union and stop valve. Strainers shall not be fitted to balanced pressure traps.

SUB-SECTION 12.1.3

MATERIALS AND FINISHES

12.1.3.1 GENERAL

Materials used in appliances shall comply with the relevant approved International Standards and shall be appropriate to the duty and conditions arising in the part of the appliances in which they are used. All metal components shall be corrosion resistant or be treated to resist corrosion.

12.1.3.2 MATERIALS IN CONTACT WITH FOOD OR POTABLE WATER

Materials that make contact, or are liable to make contact with food or potable water shall not cause contamination. All food containers shall be made of Grade 316 stainless steel and shall have smooth surface and be free of crevices.

12.1.3.3 EXTERNAL SURFACES

The external surfaces of appliances shall be of vitreous enamel finishes or manufactured with Grade 316 stainless steel. The appliances shall have pleasant appearance and all surfaces shall be smooth with no sharp edges and pointed protrusions that would be liable to cause injury to the user or damage to clothing.

12.1.3.4 TRAYS, SHELVES AND BASKETS

Trays, shelves and baskets shall be of stainless steel. The compartments shall have smooth surfaces, well rounded corners for ease of cleaning and shall be free from scrap traps.

12.1.3.5 STAINLESS STEEL

Stainless steel shall be Grade 304/type No. 1.4301 or Grade 316/type No. 1.4401 complying with BS EN 10088-1: 2014.

The stainless steel shall be free from scale and all surfaces shall be polished to type 4 commercial (satin) finish.

The thickness of stainless steel sheet shall be adequate to support the designed load with a good safety margin. The thickness of the stainless steel sheet shall be 1.5 mm for top surface, shelving, trays, baskets, sinks, etc., 1.2 mm for exposed front, rear and end sections and 0.85 mm for all internal panel sections. Doors shall be double sided, 1.2 mm thick outside and 0.85 mm thick inside and shall slide easily and silently and be readily removable without the use of tools.

12.1.3.6 GALVANISED IRON

Galvanised iron shall conform to BS EN 10143: 2006 - Continuously hot-dip metal coated steel sheet and strip – tolerances on dimensions and shape. It shall be galvanised on an 8% copper bearing alloy sheet with approved hot pure zinc galvanising. Where galvanised iron has been welded, all seams shall be leaned and scale removed and finished with a prime coat of aluminium paint.

12.1.3.7 WHITE METAL AND ALUMINIUM ALLOY CASTINGS

Where white metal is specified, a white metal (commercially known as nickel silver) casting is intended. Such metal shall be of corrosion resistant quality having not less than 30% nickel content.

Aluminium alloy casting shall have chemical compositions equal to ISO 3522: 2007 Al-Si8Cu3Fe or better.

All castings shall be rough ground, polished and buffed to a bright lustre, free from pits, cold runs, checks, burrs or other surface imperfections.

12.1.3.8 VITREOUS ENAMEL FINISHES

Vitreous enamel finishes shall comply with BS 3831:1964.

12.1.3.9 ELECTRIC MOTORS FOR APPLIANCES

All motors shall be of totally enclosed type class F fan cooled, dust and moisture protected to IP54 or higher grading unless otherwise specified.

12.1.3.10 THERMAL INSULATION MATERIALS

Thermal insulating materials shall be inert, non-hydroscopic, non-flammable and shall not give off noxious or toxic fumes.

12.1.3.11 COMPONENTS, PIPES AND FITTINGS IN WATER SIDE SYSTEM

Components, pipes and fittings in water side system unless otherwise specified above in this Section shall be installed in accordance with the Section on Plumbing Installation of this General Specification.

12.1.3.12 COMPONENTS, PIPES AND FITTINGS IN REFRIGERATION SYSTEM

Components, pipes and fittings in refrigeration system unless otherwise specified above in this Section shall be installed in accordance with the Section on Air-conditioning Installation of this General Specification.

12.1.3.13 COMPONENTS, PIPES AND FITTINGS IN FUEL GAS SYSTEM

Components, pipes and fittings in Town Gas System shall comply with the Codes of Practice published by the Gas Authority, the requirements of the FSD and the Operating Procedures published by The Hong Kong and China Gas Co. Ltd.

Components, pipes and fittings in L.P. Gas system unless otherwise specified above in this Section shall be installed in accordance with the Section on Liquefied Petroleum Gas Installation of this General Specification.

12.1.3.14 COMPONENTS, PIPES AND FITTINGS IN STEAM SYSTEM

Components, pipes and fittings in steam system shall comply with respective national and International Standards such as EN and IEC standards or approved equivalent.

12.1.3.15 COMPONENTS, CABLES AND FITTINGS IN ELECTRICAL SYSTEM

Components, cables and fittings in electrical system unless otherwise specified above in this Section shall be installed in accordance with the Section on Electrical Installation of this General Specification.

12.1.3.16 EXHAUST HOODS, FANS AND DUCTWORKS

Exhaust hoods, fans, ductworks and kitchen fume purification system unless otherwise specified above in this Section shall be installed in accordance with the Section on Air-conditioning and Ventilation Installation of this General Specification.

The specified performance of grease filters shall be certified by an accredited laboratory to UL or other equivalent standards.

12.1.3.17 GREASE TRAP AND GREASE SEPARATOR

Grease trap and grease separator unless otherwise specified above in this section shall be installed in accordance with the Section on Drainage Installation of this General Specification.

SUB-SECTION 12.1.4

SERVICES AND SERVICES CONNECTIONS

12.1.4.1 FUEL GAS SUPPLY

The gas pipe including stop cocks, gas cocks, flexible hoses and all necessary accessories for a complete installation shall be supplied and installed for the connection of appliances to gas supply point.

12.1.4.2 ELECTRICITY SUPPLY

The electrical supply will be 380/220 Volt, 50 Hz. Equipment not designed for the above voltage shall be provided with a transformer of adequate capacity in compliance with the current IEC 60076 for the appliances.

The electrical load of single-phase appliances shall not exceed 10 kW and three phase appliances shall be balanced as far as practicable. A sufficient length of PVC insulated single core cable enclosed in PVC covered or metal flexible conduit shall be supplied and installed for connection of fixed appliances to power supply point. The flexible conduit shall be flame retardant and shall not evolve any corrosive or poison fume when burnt.

12.1.4.3 WATER SUPPLY

Appliances that require main water supply shall conform to the requirements of the Water Supplies Department.

12.1.4.4 STEAM SUPPLY

All steam pipes including insulation, fitting and pressure reducing devices shall be supplied and installed for the connection of steam supply point to the appliances requiring steam.

Steam trap equipment completed with accessories shall be supplied and installed for condensing steam drain to the condensate system.

SUB-SECTION 12.1.5

SINKS AND FIXTURES

12.1.5.1 TAPS, VALVES, FITTINGS, ETC.

Brass/bronze taps shall be provided for sinks. The taps shall be chromium-plated and provided with ball check to prevent cross flow of hot and cold water. Exposed piping and fittings forming part of the tap assembly shall also be chromium-plated.

Draw-off taps for hot liquids shall be of all metal bodies with insulated handles. Valves, taps and cocks shall be of smooth bore type and capable of being cleaned easily.

12.1.5.2 STAINLESS STEEL PIPES AND TUBING

Whenever stainless steel pipe or tubing is specified, it shall be seamless or welded of gauge specified and of true roundness. Seamless tubing shall be thoroughly and properly annealed, pickled, ground smooth and finished to match adjacent work. Welded tubing shall be thoroughly heated and then drawn true to size and roundness and ground as required. All tubing, where exposed to view, shall be given a final grind of polishing after installation.

12.1.5.3 STRUCTURAL STEEL SECTIONS

All angles, bends, channels or other structural sections used for framing shall be uniform and ductile in quality, free of hard spots, runs, checks, cracks or other surface defects. Where such sections are specified as galvanised or tinned, they shall be done by hot dipped process with all fluxes removed. In the case of galvanised, the finished surface shall be smooth and free from cold runs, blisters and uncoated or scaly patches.

12.1.5.4 HANDLES, BRACKETS, LOCKING DEVICES AND HARDWARE

Wherever handles, knobs, hinges, brackets or other miscellaneous hardware are provided for appliance, they shall be of either heavy satin finish chromium-plated brass or stainless steel, or other alloys as specified.

All drawers, enclosed cabinets and storage bins shall be provided with heavy-duty chromium-plated cylinder type locking devices.

12.1.5.5 FASTENERS

All welds, bolts, screws, springs, washers and nuts shall be of steel, brass or stainless steel, and each fitting shall be of the same metal type. Where dissimilar metals are fastened, screws, bolts and nuts shall be such as to ensure suitable fastening and prevent bulging of metals being fastened.

12.1.5.6 BOLTS AND SCREWS CONSTRUCTION

All exposed surfaces on appliances shall wherever possible be free of bolts, screws and rivet heads. Where bolts are used to fasten trim to panelling and body of warmers, cabinets, counters, etc. and in particular to fasten tops of counters, dish tables, etc., to top of framing, such bolts and screws shall be of concealed type. If the threads of bolts and screws wherever inside the fixtures are either visible or possible to come into contact with the hands or wiping cloth, such bolts and screw thread square are to be capped with suitable lock washer and chromium-plated brass or bronze acorn nuts. Where screw threads are not visible or readily accessible, they may be capped with standard lock washer and steel nuts to prevent rusting or corroding. When bolts or screws are welded to the underside of trim or top, the reverse side of weld shall be neatly finished and uniform with adjoining trim or top surfaces. Depression at these points will not be acceptable.

12.1.5.7 LEGS

All legs shall be constructed of not less than 38 mm outside diameter 2.0 mm thick stainless steel tubing, cold drawn annealed and pickled, and shall be spaced not more than 1800 mm from centre to centre. All legs shall be of uniform finish.

12.1.5.8 LEG CROSS BRACING

All leg cross bracing, where required, shall be constructed of not less than 25 mm outside diameter stainless steel tubing, cold drawn, annealed and pickled. All cross bracing shall run horizontal and level between all legs, 200 mm above floor or any such height to suit the installation condition, as approved by the Supervising Officer. All joints shall be completely welded around entire circumference of the tubing to form a complete seal. All welds shall be ground and polished smooth to match adjacent work.

12.1.5.9 LEG MOUNTINGS

Where units are mounted on legs, under-bracing shall be supplied and installed. Legs in all cases shall be provided with sanitary type stainless steel channel braces along full length of respective tops. Channel shall measure approximately 100 mm in width including flanges and 25 mm high. Ends of channel shall be rounded and fully enclosed by welded stamping, matching cross section of channel. Channel shall be projection welded to underside of stainless steel units at intervals of not more than 250 mm and at ends of not more than 250 mm centre to centre. Sevices between channel and underside of unit shall be fully closed and sealed off with filler. Channel braces to receive supporting legs shall be concentric with legs.

12.1.5.10 GUSSETS

Legs shall be held firmly in position by reinforced leg sockets or gussets welded to the underside of channel braces. Gussets shall have stainless steel socket and stainless steel base plate. The stainless steel base plate shall be welded to top.

12.1.5.11 UNDER-BRACING

All stainless steel counters, tables, drain boards and dish table tops shall be braced below with inverted "U" type channels of approximately 100 mm wide and 25 mm high spaced not more than 750 mm on centres and run the whole length of the fixtures.

12.1.5.12 CONSTRUCTION OF FEET

Bottom of legs shall be sealed for sanitation purpose and height of the legs shall be adjustable for levelling. The legs shall be fitted at bottom with sanitary type stainless steel bullet-shaped feet, fully enclosed and with a slightly rounded bottom to protect the floor. Top of each foot shall be fitted with a male threaded stem to fit into the end of the pipe legs and provided with a total adjustment of 40 mm. Bottom of each pipe leg shall be finished off smoothly and overlap the stem to provide sanitary fitting and prevent the accumulation of grease or other debris at this point.

All feet are to have one-piece die-stamped closed bottoms to ensure sanitation.

12.1.5.13 UNDER-SHELVING

Where flat under-shelving is specified, under-shelves shall be constructed of 1.2 mm polished stainless steel. All shelving sides shall be turned down to form a channel shape of size approximately 12 mm x 38 mm x 12 mm and with corners cut out to fit contour of leg. Shelving shall be bolted to leg with stainless steel round head bolts. Under-shelving shall be reinforced with 25 mm x 100 mm x 25 mm, 2.0 mm thick stainless steel welded channels.

Removable type shelving shall be of the same material, rolled down on all sides, with corners notched to contour of leg, with resulting notches ground and polished smooth. Under-shelving shall be constructed in sections of not more than 1000 mm and where butted against adjoining shelf section, shelving sides shall be turned down to form channel shape approximately 38 mm x 12 mm. Supporting channel shall be furnished on underside of each shelf section and shall be of size 25 x 100 x 25 mm and of stainless steel.

Where slotted under-shelving is specified, it shall consist of a series of stainless steel panels or sections, slotted and with sides of slots turned down to form cross channels. Slots shall be approximately 32 mm wide and channels approximately 75 mm wide. Panels shall have all edges rounded and polished, ground smooth to assure easy cleaning. Panel shall be removable. Panels shall be not more than 750 mm wide in any direction. Slots shall run from front to rear in all cases. Adequate reinforcement shall be provided beneath panels.

12.1.5.14 DRAWERS

Drawer fronts shall be of not less than 1.2 mm thick stainless steel, double pan type, with resulting corners welded, ground and polished smooth. Drawers shall set into an enclosed 1.2 mm stainless steel vermin-proof housing closed on all sides and bottom with stainless steel channel shaped slides, four ball bearing rollers, two rear, auto stops

and release catches. Drawer face shall be provided with recessed stainless steel pull handle welded to face.

Drawers shall be provided with suspension and stop to prevent drawers from pulling out completely and shall support heavy load without deflection. Drawers shall, however, be easily removed without the use of tools.

Refrigerated drawers shall be provided with a full-perimeter soft gasket, which shall be durable for operation in low temperature condition down to 0ºC.

12.1.5.15 WATER INLETS LOCATION

Water inlets shall be located in all cases above positive water level to prevent siphoning of liquids into the water system.

12.1.5.16 CONSTRUCTION OF PIPE CHASES

Where it is necessary for plumbing and supply piping to be passed through the base, this piping shall be enclosed in a suitable pipe chase with easily removable access panels. These access panels shall not be held in place with screws or latches, but shall be formed in a pan shape, removable without tools or hinges.

The foregoing only applies to fixtures where an access is required from the front of the fixture, as in the case of sinks. Pipe chases at the end of fixtures containing bottom and intermediate shelves need not be enclosed. Shelves in these fixtures shall be turned up a minimum of 75 mm at the edge of the pipe chase.

In detailing fixtures, the Building Contractor shall be consulted to ensure that due allowance is made for traps or other controls, particularly those under lower shelves that site on masonry bases.

Where plumbing and supply piping pass through shelves on open base tables, shelves shall be neatly punched or die-stamped for the piping. The locations of such pipe chases or stamped pipe openings shall be noted, on the plan and/or detailed drawings. They shall be of sufficient size to accommodate all necessary risers so that additional holes need not be cut on-site.

12.1.5.17 SLIDING DOORS AND HINGED DOORS

Sliding doors for cabinets, counters etc. shall be made of not less than 1.2 mm polished stainless steel exterior and not less than 0.85 mm stainless steel interior. Doors shall be equipped with die-stamped recessed stainless steel pull handles. Doors shall be of double pan construction, filled with suitable sound attenuating material of 12 mm thick, with all corners welded, ground and polished smooth to uniform finish. Doors shall be designed to permit removal for cleaning or adjustment without use of tools. Bolts and screws shall be kept to a minimum and be of corrosion resistant metal. Upper suspension stainless steel rollers shall be heavy-duty type and ground to minimise wear and noise. Precaution shall be taken in all cases to avoid friction or rubbing between doors, door suspension and upper sliding framework, including hardware. Double doors shall be provided with

double overhead tracks and carriers for maximum clear door opening. Units shall be provided with trackless bottom with concealed guide for overhead roller doors. Guides shall be equipped with limit stops to prevent telescoping of doors.

Hinged doors for cabinets, counters, etc. shall be made of polished stainless steel exterior and stainless steel pan-shaped interior, filled with suitable sound attenuating material not less than 12 mm thick, with all corners welded, ground and polished smooth. Doors shall be flush mounted and fitted with stainless steel concealed hospital type offset butt hinges with concealed fasteners. Door handles shall be of stainless steel and flush mounted. Locks and full magnetic door seal shall be provided if specified.

12.1.5.18 WELDING

All welding shall be done by electric fusion, metal-arc method. Stainless steels shall be welded by inert gas, e.g. argon. Carbon-arc or gas welding will not be permitted. All welding shall be done in a thorough manner, with welding rod of same composition as sheets or parts welded. Welds shall be complete welds, strong and ductile, with excess metal ground off and joints finished smooth to match adjoining surface. Welds shall be free of mechanical imperfections such as gas holes, pits, runs, cracks, etc. and shall have same colour as the adjoining surfaces. All joints on tops of fixtures, tables drain boards, exposed shelving, sinks, etc. shall be welded. All tops, which are constructed of more than one piece of sheet metal, shall be continuously butt-welded together with welds ground smooth and polished. Butt welds made by spot welding and filling in the voids with solder and finishing by grinding will not be acceptable.

All welded joints shall be homogeneous with the sheet metal itself. Where sheet sizes necessitate a joint, such joint shall be welded. Tops of fixtures shall be fabricated in factory with welded joints to reduce field joints to a minimum. Where fixtures join, tops of such fixtures shall be continuous with welded joints. All joints made in the field shall be closely butted, pulled together in field, field welded, ground and polished smooth. Tops of fixtures, with welded factory joints, shall be of maximum length to permit bringing of fixtures to their final positions, and to reduce field joints to an absolute minimum. Wherever welds occur on surfaces not finished by grinding and polishing as specified, such welds and the accompanying discoloration shall be suitably coated in factory by means of metallic base paint to prevent the possibility of progressive corrosion to such joints.

12.1.5.19 SOLDERING AND BRAZING

Solder shall not be used in or on containers or food handling equipment coming in contact with foods and/or potable water for drinking or processing of food. Soldering where required shall be done with solder free of lead. Soldering for plumbing works shall conform to the latest requirements of the WSD. Stainless steel requiring soldering shall be first thoroughly cleaned of surface oxides and shall then be applied with a suitable stainless steel soldering flux. After the soldering has been completed, excess or remaining flux shall be passivated clean and the entire soldered joint cleaned with liquid alkaline or neutralizing agent to prevent any attachment on stainless steel by soldering flux.

Particular and special care shall be given to neutralizing all excess soldering flux. In no case shall soldering be relied upon for stability of seams of joints. The soldering shall serve only as a filler to prevent leakage. Soldering shall not at any time be considered as replacing welding or brazing.

Brazing shall only be applied to the jointing of brass and bronze connecting fittings, particularly in the case of steam coils. All steam coils requiring dip tinning shall be fist brazed with surplus flux removed, so that metal is exposed and then dipped. Low temperature melting silver base hard solder will be considered as an equivalent of brazing.

Brazing or hard silver solder shall not in any event replace a welding operation. Stainless steel to stainless steel joints shall be made by brazing or hard silver soldering using hard solder.

12.1.5.20 GRINDING, POLISHING AND FINISHING

All welded exposed joints shall be suitably ground flush with adjoining material neatly finished to harmonise therewith. Wherever material has been sunken or depressed by welded operation, such depressions shall be suitably hammered and preened flush to adjoining surface, and if necessary, again ground to eliminate low spots. All ground surfaces shall then be polished or buffed to match adjoining surfaces, consistent with good workmanship. Care shall be exercised in all grinding operations to avoid excessive heating of metal and metal discolouration. In all cases grain of rough grinding shall be removed by successive polishing operation. Texture of final polishing operation shall be uniform and smooth, consistent with reasonable care and good workmanship. General finish of all equipment shall be of high grade.

Butt joint and contact joint shall be close fitting and shall not require solder as filler. In no case shall any soldering operation be done where dependence is placed solely on soldering for strength and stability of joint or fixture itself.

Wherever bends occur, they shall be free of undue extrusion and shall not be flaky, scaly or cracked in appearance and where marks are found on uniform surface or material, all such marks shall be removed by suitable grinding, polishing and finishing. Wherever sheared edges occur, they shall be free of burrs, fins, or irregular projections and shall be finished over such sheared edges. Where mitres or bull nose corners occur, they shall be neatly finished with under edge material neatly ground to uniform condition and in no case will overlapping materials be acceptable.

Where a welding operation occurs on stainless steel, the possibility of corrosion shall be entirely eliminated. Ways shall be used to eliminate the possibility of carbide precipitation. Each joint of welding shall be suitably finished in a bright finish to eliminate possibility of progressive corrosion. Underside of each weld shall be suitably ground or coated to prevent possibility of oxidization and progressive corrosion. Welding done by any process that eliminates or reduces carbide precipitation in connection with bolts and screws need not be so treated.

Wherever galvanised or tinned angle or channel construction is specified for welded framing, welding shall be done before hot galvanised. If galvanised structural sections are used for such a welded framework, welded joints shall be suitably treated by means

of metallic coating to cover up all surfaces marred by welding and grinding operations. All iron or galvanised pipes or other parts shall be cleaned and Duco finished in the factory with not less than two coats of Duco Grey or other approved products having equivalent general appearance, performance and functions.

Equipment shall be neatly finished without any scarf, or other manufacturing foreign matter. All external metal surfaces shall be smooth with no sharp angles, and shall be stoved enamel coated, properly painted, or finished. Where stainless steel is specified, exposed surfaces shall be given a finish equal to No. 4 (satin) or product having equivalent general appearance, performance and functions. When manufacturing process and welding disturb the original finish, it shall be carefully reground and polished and restored to match the rest of the surface.

Where specified, all cabinets, doors shelves, whether inside or outside of cabinet and wherever exposed, are to be No. 4 finish. This applies to inside finish of any cabinet having doors or otherwise. Any inside surface exposed to view when sliding or swinging door is opened shall be regarded as an exposed surface. Underside of shelf need not be No. 4 finish but such finish shall be at least equal to No. 80 ground finish. Indication of die markings not blending with final finish will not be acceptable.

12.1.5.21 CONSTRUCTION OF SINKS

All sinks, except hand basins, shall be fabricated of not less than 1.6 mm polished stainless steel and of the size and design as specified. The backs, bottom and front shall be formed of one continuous shell with the ends welded into place. Partitions for compartment sinks shall be of the same materials, electrically welded in place. The partitions shall be of double thickness with a half round top edge.

All corners both vertical and horizontal shall be rounded on a minimum 15 mm radius electrically welded, ground smooth and polished. Solder in filleted corners will not be acceptable.

Across the back of all sinks, there shall be a 150 mm minimum high splashback extended backward 25 mm across the top. Ends shall be enclosed. Two tap holes for hot and cold water taps on approximately 200 mm centres shall be provided over the centre line of partitions between compartments, 50 mm approximately from the top of the splash. Drain boards shall be pitched toward sink compartments. The front and open sides of the sink unit shall have raised rims formed from one continuous sheet with round arris having a minimum of 3 mm in radius.

The bottom of each compartment shall have four radial die-stamped grooves pitched to the drain and shall be provided with a heavy-duty standpipe drain plug with removable stainless steel strainer. Connected overflow for drain valve shall be supplied and installed. The drain point shall be suitably located so that the standpipe will not hinder any washing work.

Body shall be mounted on not less than 38 mm diameter tubular stainless steel legs fitted with stainless steel adjustable feet. Legs shall be fitted with die-formed, enclosed, sanitary closed gussets. Open type or two sided gussets will not be accepted. These gussets shall be welded to the underside of the sink.

Sink insets shall be of one-piece deep drawn construction of at least 1.6 mm thick stainless steel with all corners rounded on not less than 15 mm radius. Sinks shall be welded integral with counter tops with no gap in between.

All sinks shall be provided with drains and connected overflows. Connected overflow shall be furnished with stainless steel perforated plates constructed so that constant water level is at least 25 mm below dividing partitions. All sinks shall be 360 mm deep as a minimum.

12.1.5.22 CONSTRUCTION OF HAND BASINS

Hand basins, separated from the sinks, shall be constructed with at least 1.2 mm thick stainless steel, sanitary, ground and smooth, with backsplash. Basin shall be furnished with swivel spout mixing tap and cast brass grid drain plug with tailpiece and completed with anti-siphon trap. Detergent dispensers and paper dispensers for hand basins shall be provided. Dispensers shall be mounted on wall at a convenient level suitable for use.

12.1.5.23 CONSTRUCTION OF METAL TABLE TOPS

Metal tabletops shall be constructed of single piece of stainless steel sheet not less than 1.6 mm thick, ground smooth, and polished. Large metal tabletops shall be constructed of not less than 2.0 mm thick stainless steel where specified. All working tops on closed base fixtures shall be reinforced on the underside with a framework of at least 40 mm iron channel sections of galvanised steel of same thickness as top. All open base tables shall be reinforced with 40 mm x 40 mm x 3 mm stainless steel angles or alternatively inverted 'U' channels 100 mm wide with 25 mm turn downs of the same thickness as top. Reinforcing sections shall be spaced not more than 750 mm apart.

Cross-angle members or inverted 'U' channels shall be placed at each pair of legs. One angle runner or 'U' channel, running lengthwise, shall be provided on tops up to 750 mm; two provided on all tops over 750 mm. All tops shall be reinforced so that there shall not be any noticeable deflection and all reinforcements shall be stud welded to the underside of the top. No rivets or bolts shall be used through the top.

Field joints shall be provided in the top where necessary and they shall be located for practical construction and consistent with sizes convenient for shipping and accessibility into the building.

All metal tops shall be turned down approximately 50 mm in a box section except where adjacent to walls or other places of equipment. The wall side shall be turned up 150 mm and back 25 mm. Ends of this splash shall be closed.

Where tables meet with dish-washing machine or pot washing machine, their sides shall be turned down and a flange shall be provided, arranged so as to permit the bolting of 5 mm neoprene gasket between the flanges and turn down of table forming water tight joint across top edges of tables.

Underside of tables shall be provided with suitable sound attenuating materials. Sound attenuating materials shall be waterproof. Dish table and sink table shall be provided with sound attenuating materials.

12.1.5.24 CONSTRUCTION OF ENCLOSED BASES

All enclosed bases or cabinet bodies shall be of a least 1.6 mm stainless steel thick. They shall be enclosed on the ends and sides. The bases shall be reinforced at the top with a framework of 40 mm x 40 mm x 3 mm stainless steel angle or inverted 'U' channel sections with all corners of said framework mitred and welded. Bottom shall be reinforced with channels and gussets. Additional angles and channel cross members shall be provided to reinforce shelves and support tops. All free corners of enclosed bases or cabinet bodies shall be rounded on 15 mm radius and all corners against walls and other fixtures shall be square.

In the case of fixtures fitted against or between walls, the boxes shall be set in at least 25 mm from the wall line, but the tops shall extend back to the wall line. This shall permit adjustment to wall irregularities. A vertical trim strip of the same material as the body shall be provided at each end of the fixture to close the gap between the back edge of the body and the wall, or the end of the body shall extend 25 mm to the wall line.

These fixtures shall be constructed with 150 mm long legs as specified in this Section.

12.1.5.25 CONSTRUCTION OF SHELVES

Interior shelves in cabinet bodies and enclosed bases shall be constructed of not less than 1.6 mm thick stainless steel. The front shall be flanged down 50 mm and under 12 mm. The rear and ends shall be turned up approximately 50 mm against the interior of the body. Shelves shall be solid in un-heated bases and shall be perforated in heated bases. Perforations shall be 20 mm in diameter and spaced 100 mm on centres. All shelves shall be rigidly reinforced with angle and/or channel framework to prevent sagging.

Eelevated shelves above free standing work tops shall be constructed of minimum 1.2 mm thick stainless steel. Long shelves shall be constructed with thicker stainless steel as approved by the Supervising Officer. Wall mounted elevated shelves shall be constructed of minimum 2.0 mm thick stainless steel. All edges shall be turned adjacent to walls or other fixtures where they shall be turned up 50 mm. All corners shall be welded and ground smooth. Shelves on wall line shall be mounted on not less than 2.0 mm thick stainless steel brackets. Brackets shall be spaced not more than 900 mm. Shelves over the top of free standing fixture shall be mounted on not less than 25 mm diameter stainless steel uprights or not less than 38mm diameter stainless steel tubular stands at the back edge of the fixture with cantilevered stainless steel brackets on the top.

12.1.5.26 SPLASHBACK

Stainless steel tables and counters adjacent to building walls, shall be furnished with not less than 150 mm high splashback returned 25 mm to wall with welded closed ends and be formed from one continuous sheet with tabletop or countertop with round arris having a minimum of 3 mm in radius.

SECTION 12.2

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 12.2.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

12.2.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

12.2.1.2 TESTS AND CERTIFICATES

12.2.1.2.1 Functional and Performance Tests

Complete functional tests and performance tests shall be carried out for all appliances provided under the Contract, either by the manufacturers during production or on-site. The results of all functional tests and performance tests shall be provided for all non-standard production appliances.

Performance tests shall include but not be limited to: -

(a) Heating up/cooling down time test;

(b) Thermal efficiency test;

(c) Temperature maintenance test;

(d) Test on the proper operation of all functional control devices;

(e) Test on the proper operation of all protective and safety devices;

(f) Test on the accuracy and proper operation of meters, gauges and other indication devices;

(g) Pressure test on pressure type components incorporated in an appliance, which operate above atmospheric pressure;

(h) Leakage test on water circuits, steam circuits, refrigeration circuits, fuel gas circuits, fuel oil circuits, etc.; and

(i) Insulation and earth continuity tests for electrical circuits.

Functional tests shall include demonstration and tests to prove the functionality of the equipment and installations in fulfilling the design intent and operational requirements. This shall include the tests on all switches and control.

12.2.1.2.2 Certificate of Test for Pressure Type Appliances

A certificate of test issued by a competent person shall be provided for each pressure type boiler, steam generator and vessels incorporated in an appliance which operates above atmospheric pressure, in accordance with the Boilers and Pressure Vessels Ordinance, (Cap. 56), Laws of the Hong Kong Special Administrative Region.

12.2.1.2.3 Certificate of Test of Gas Appliances

When it is so required by the Gas Authority, the certificate for gas appliances shall be provided.

SUB-SECTION 12.2.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

12.2.2.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during Maintenance Period shall also comply with the specific requirements in this Sub-section.

Operation, servicing and maintenance of the Installations, if specified, shall also refer to the equipment manufacturer's recommendations and specifications.

12.2.2.2 INSPECTION DURING MAINTENANCE PERIOD

In addition to the routine servicing and maintenance including all periodic inspections, tests, preventive maintenance, and stand-by operations testing in accordance with the manufacturers' recommendations/instructions, further inspections to check and, if necessary, to re-adjust the equipment/systems to meet the actual operational conditions and to test the installations shall be made to meet statutory requirements including the submission of test reports and certificates. The routine services shall include: -

12.2.2.2.1 Gas/Oil Heated Appliances

(a) To check and where necessary correct for adequate provision of combustion and ventilation air for each item of appliance;

(b) To clean all combustion spaces up to the appliance outlet and all internal boiler flue passages;

(c) To clean and adjust all burner equipment including checking and adjusting burner gas pressure;

(d) To check and where necessary correct for satisfactory operation of the gas pilot and ignition device;

(e) To check and where necessary correct the conditions of all exposed flue systems and terminals including the functioning of draught diverters to ensure safe and proper combustion. Where flue pipes have minor defects, these shall be repaired by welding and finished with heat resisting aluminium paint;

(f) To check and where necessary correct all gas valves, cocks and taps to ensure that they are gas tight and easy to operate, in proper condition;

(g) To check and where necessary correct all pressure and temperature operated valves, flame failure and all other control devices to ensure that they are in proper working condition;

(h) To check and where necessary correct any water cock that forms an integral part of a gas appliance;

(i) To check and where necessary correct the general performance of the appliance; and

(j) To ensure that the appliance, on completion of its inspection and maintenance, is not leaking water or gas and is in proper working condition and to the satisfaction of the user.

12.2.2.2.2 Refrigerated Appliance

(a) To check condition of compressor and condenser fan and replace defective and worn-out parts;

(b) To clean condenser and remove dirt and dust between fins;

(c) To check and refill refrigerant where necessary;

(d) To check controls for proper operation;

(e) To check and correct the general performance of the appliances where necessary; and

(f) To ensure the appliance is in proper working condition and to the satisfaction of the users.

12.2.2.2.3 Electric Appliances

(a) To carry out insulation and earth test to ensure the safe operation;

(b) To check all functional controls are in proper operation;

(c) To ensure all protective and safety devices are working and set properly;

(d) To check moving parts and replace defective and worn out parts;

(e) To check and correct the general performance of the appliances where necessary; and

(f) To ensure the appliance is in proper working condition on completion of its servicing, and to the satisfaction of the users.

PART 13 – PLUMBING INSTALLATION

SECTION 13.1

INSTALLATION METHODOLOGY

SUB-SECTION 13.1.1

PLUMBING SYSTEMS

13.1.1.1 GENERAL

The Scope of Installations under this Sub-section shall include the complete plumbing installation for fresh, flush, fire service pipework systems as shown on the Drawings and as specified, including but not limited to: -

(a) Fresh and flushing water supply systems, pumps and pipework installations commencing from the government mains at the entry of site boundary to individual sanitary fixtures, gas water heaters and taps (including connection to sanitary fixtures and associated taps and water heaters installed by others) where shown on the Drawings or as specified;

(b) Water supply for fire service installation commencing from the government mains at the entry of the site boundary including the up-feed pipework and connection to the fire service roof/transfer tanks where shown on the Drawings or as specified;

(c) Hot water pipework installations (including connection to sanitary fixtures and associated taps and water heaters/boilers/calorifiers installed by others) where shown on the Drawings or as specified;

(d) Rainwater Harvesting system including associated pumps and pipework installations and water treatment equipment, where shown on the Drawings or as specified;

(e) Water supply for feeding/make-up to air-conditioning installation, fountain installation, swimming pool installation and irrigation system; and

(f) Extend and connect the fresh, flush and fire service water pipes to the government mains outside the site boundary, if applicable. Where shown in the Drawings or as specified, connection shall be made to existing in-service supply mains of adjacent building blocks instead of government mains.

The complete plumbing installation shall mean, not only the major items of equipment and apparatus conveyed in the General Specification and Drawings, but all the incidental sundry components necessary for the complete execution of the works and for the proper operation of the installation with their labour charges, whether or not these components are mentioned in detail in the Contract.

All necessary applications to WSD shall be made for the Installations. Any tests and inspections as required by the representative of WSD shall be attended.

13.1.1.2 HANDLING AND STORAGE

Materials shall be stored properly in accordance with the manufacturer's instructions to afford maximum protection against weather, corrosion, mechanical damage and other causes prior to installation.

Pipes shall be stored with closed ends. The exposed end of pipework shall be covered throughout the erection.

Pipes and fittings shall be stored under cover and clear of a levelled, well-drained and maintained hard-standing ground. Do not rest pipes on their sockets.

Rubber jointing rings shall be stored in protective bags. Plastic pipes and fittings under storage shall not be exposed to sunlight to avoid any deformation.

Pipes and fittings shall be cleaned before erection to remove all scale, burrs, furs, sand, slag etc. Damaged pipes or fittings shall be removed from the Site immediately.

13.1.1.3 FIXING PIPES AND FITTINGS

13.1.1.3.1 General

Pipes and fittings shall be inspected before fixing.

Avoid crimping and restricting the diameter of tubes when forming bends in pipes.

Provide air vents of automatic type at high points as shown on the Drawings.

13.1.1.3.2 Protection to Movement and Expansion

Make adequate provision to control and/or allow for thermal movement in the length of pipes and gutters.

Provide expansion joints in plastic pipes by means of loops or other methods in accordance with the manufacturer's recommendation.

Provide solar protection or insulation for pipes running at roof top by shelter or by painting them white.

13.1.1.3.3 Pipework Arrangement

Water pipes shall not run over electrical switchgear; inside transformer room, switch room, generator room, meter room, telephone equipment room, PABX room, server room, riser duct for electrical services, or any

other rooms containing electrical hazard or susceptible to water damage hazard.

Dead legs and stagnant corners in the pipework shall be avoided. The number and length of spurs shall be minimised.

Unless otherwise approved, do not embed pipes in concrete or grout in or install in such a way as to make alterations difficult at a later date.

Pipes requiring protection against corrosion shall be fixed with 40 mm (minimum) clearance between the pipe, structure or adjacent surfaces.

Pipework shall not be casting in or build into chases in walls and floor unless otherwise approved by the Supervising Officer. Where this is unavoidable and approved, pipes shall be wrapped in an approved protective tape.

Pipework installation shall avoid contact between certain dissimilar metals in particular avoid the direct contact of copper with galvanised iron or steel pipes. If unavoidable use gunmetal joints between dissimilar metals.

Automatic air vents shall be provided at all the highest points of system and ensure completed venting.

13.1.1.3.4 Bends and Offsets of Copper Pipework

Offsets shall be achieved using 45° in preference to 90° bends.

Bends and offsets of up to 90° shall only be formed for pipe sizes from 15mm to 35mm provided they: -

(a) Have a minimum centre line radius of more than or equal to 3.5 times the pipe diameter;

(b) Are only formed using tools specifically manufactured for that purpose, i.e. spring benders and formers; and

(c) Are free of deformation that may restrict water flow.

Bends and offsets of up to 30° and have a minimum centre line radius of more than or equal to 3.5 times the pipe diameter shall only be formed in pipe sizes less than or equal to 54 mm by heat bending/ annealing techniques without the need for bending tools.

Do not remove or damage the polyethylene sheath where bends are formed in copper pipes with factory applied polyethylene sheath.

Terminate factory applied polyethylene sheath at a consistent/uniform distance not more than 20 mm from the connecting compression type fitting body.

13.1.1.3.5 Pipe Sleeves

Where pipes pass through walls, beams and floor/ceiling slabs, pipe sleeve shall be provided and fixed with uniform annular clearance to allow for expansion and movement of pipe.

For pipes passing through walls and beams, pipe sleeves shall be fixed that flush with the finished surfaces.

For pipe passing through floor slabs, pipe sleeves shall be fixed in position with 100 mm projection above finished floor level and flush with the underside of the floor.

For metal sleeves used in walls and slabs between fire compartments, the sleeves shall be filled for its full length of annular space between the sleeve and the pipe with non-flammable mineral wool or approved equivalent materials. Caulk both ends with fire-rated mastic sealant which is durable and effective in sound insulation to maintain the required FRR of the walls/floor slabs.

Puddle flange cast in basement shall be used for pipes passing through external basement walls where there is ground water pressure.

13.1.1.4 JOINTING PIPES AND FITTINGS

13.1.1.4.1 General

All pipe joints shall be carried out in accordance with the manufacturer's instructions. Pipe joint shall not be made in the thickness of any wall, floor and ceiling unless otherwise approved by the Supervising Officer.

Particular care shall be taken to ensure that joints are not built in and if bends are necessary they shall be made bends and not jointed bends.

Expansion joint shall be provided for all pipework passing through any building expansion joint and where necessary to absorb the effect of expansion on pipes.

Jointing rings, couplings and adaptors shall be of types recommended by the manufacturer of the pipes being jointed.

Cut ends of pipes and gutters clean and square, and chamfer internally or externally if required using equipment appropriate to the material.

Jointing material shall not project into the bore of pipes or fittings.

13.1.1.4.2 Jointing of Galvanised Steel Pipes

Galvanised steel pipes of sizes up to and including 100 mm shall be jointed with screwed fittings. Screwed flanges shall be employed only for connection to flanged valves or equipment.

Galvanised steel pipes of sizes of 150 mm and above shall be jointed with screwed flanges.

Do not joint steel pipes by welding unless approved.

Screwed fittings shall have pipe threads complying with BS 21:1985 or BS EN 10226-1:2004. Screwed joints shall have tapered threads and shall be made with approved jointing material.

13.1.1.4.3 Jointing of Copper Pipes

(a) Unless otherwise specified in Particular Specification or Drawings, mechanical joint fittings (compression or push-fit or press-fit), solder (end feed or integral) capillary fittings or brazed capillary fittings shall be used for copper pipe sizes less than or equal to 54 mm diameter. For pipe size larger than 54 mm diameter, solder (end feed or integral) capillary fittings or brazed capillary fittings shall be used for jointing. For pipe size larger than 108 mm, brazed capillary fittings shall be used for jointing.

(b) For copper pipe joint by mechanical joint fittings, written confirmation from the manufacturer or supplier on suitability of the compression type fittings for use with hot water piping system in 80°C under the required working and maximum pressure shall be submitted to the Supervising Officer for examination and approval for use.

(c) For mechanical joint fittings used for hot water pipework, submission of type test report issued by organizations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by Hong Kong Accreditation Service (HKAS), or organizations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS for proving their suitability for use at a pressure (working and / or maximum static pressure that may arise upon failure of the associated pressure reducing devices) above that allowed at 80°C in BS EN 1254-2 or equivalent standard by the following tests: -

(i) Temperature cycling test of a pipe / fitting assembly of the mechanical joint fittings to be carried out by alternately circulating water of 80°C and 15°C through it and pressurise the assembly to the working or maximum static pressure, whichever is higher, for 2 minutes after it reaches 80°C and 15°C respectively in each cycle. A total of 400 cycles of test shall be performed;

(ii) Pressure test of the pipe / fitting assembly to be carried out after the temperature cycling test at 1.5 times the working or maximum static pressure, whichever is higher, for 24 hours with its temperature maintained at 80°C throughout the 24-hour period; and

(iii) The mechanical joint fittings are to be regarded as capable of withstanding the working and maximum static pressure that may arise upon failure of the associated pressure reducing devices at 80°C if no sign of deformation of the fittings and water leakage from the pipe / fitting assembly are observed / detected throughout the tests.

(d) Soldering alloys for copper and copper alloy capillary fittings shall comply with Table 6 Section II and III of BS EN 1254-1:1998. Chemical compositions of soldering alloy shall comply with Table 3 of BS EN ISO 9453:2014 and shall be of lead-free. Non-corrosive type of flux recommended by the solder alloy manufacturer shall be used.

(e) Lead-free soldering alloys and cadmium-free brazing alloy shall be used in installations for water for human consumption and shall fully comply with the requirements of WSD and this section. Supporting document of lead-free grade and /or cadmium-free grade soldering materials and filler metal used in soldering/brazing shall be provided.

(f) All plumbing works using soldering for connecting copper pipes shall have the permission of the Water Authority.

(g) Brazing alloys for copper and copper alloy capillary fittings shall comply with Table 6 in Section VI of BS EN 1254-1:1998. Chemical compositions of brazing alloy shall comply with Table 7 of BS EN ISO 17672:2010 with 2% nominal silver content and shall be of cadmium-free. These brazing alloys shall never be used on copper alloys containing nickel. Flux shall not be used for brazing copper-to-copper joints. For joints other than copper-to-copper, type of flux recommended by the brazing alloy manufacturer shall be used.

(h) Use dielectric fittings or epoxy coated flange with gasket for connecting copper pipe to galvanised steel or ductile iron pipe or cast iron valve.

(i) The capillary type joints and fittings after jointing of the pipework shall be covered with fit “clip-on” type preformed polyethylene sheaths to BS3412 or of equivalent quality, or other materials in accordance with manufacturer’s recommendation, that is suitable for use up to 80°C.

(j) The following procedures shall be followed for jointing copper pipes with soldering: -

(i) Remove copper oxide and dirt from pipe spigot and fitting socket prior to the application of soldering flux.

(ii) Apply flux sparsely, insert the pipe end into fitting cup and remove excess flux prior to heating.

(iii) Apply heat to the body of the fitting and pipe.

(iv) Apply a small amount of lead-free solder wire to the pipe where it enters the fitting. The solder will be drawn inside the joint by capillary action.

(v) Clean pipe joints with a damp cloth on completion to remove flux residues and excess solder.

(k) The following procedures shall be followed for jointing copper pipes with copper alloy capillary fittings by brazing: -

(i) Apply flux to the tube spigot and fitting socket and assemble the joint.

(ii) Apply heat to the body of the fitting and pipe.

(iii) Apply the brazing filler metal to the pipe where it enters the fitting. The filler metal will be drawn inside the joint by capillary action.

(iv) Remove residual flux after brazing.

13.1.1.4.4 Jointing of Stainless Steel Pipes

Jointing of stainless steel pipe shall be made by mechanical joint or other jointing approved by the Supervising Officer.

All pipe installation to be carried out in strict accordance with the manufacturer's instructions.

Joint stainless steel pipes to ductile iron pipes with purpose made stainless steel flange adaptor in accordance with the manufacturer's recommendations.

Pipes shall be cut to square ends, free from harmful burrs and be prepared in accordance with the manufacturer's recommendations. Equipment recommended by the manufacturer shall be used for cutting the pipes.

All grooves on the pipes shall be roll-formed in accordance with the manufacturer's standards and recommendations. Purpose made equipment recommended by the manufacturer shall be used for forming the grooves.

13.1.1.4.5 Jointing of Ductile Iron Pipes

All ductile iron pipes shall be jointed with screwed flanges or flanged fittings. Flanges shall comply with BS EN 1092-2:1997 PN16 as minimum. Gasket to BS EN 681-1 and shall be suitable for the operation condition in which they are installed.

13.1.1.4.6 Jointing of UPVC Pipes

UPVC pipe shall be solvent joint using spigot and socket end and fittings. Solvent shall be recommended by the manufacturer.

Unless otherwise approved by the Supervising Officer, interchangeability shall not be allowed between different plastic pipe manufacturer's products.

Pipes shall be cut to square ends, free from harmful burrs and be prepared in accordance with the manufacturer's recommendations. Equipment recommended by the manufacturer shall be used for cutting the pipes.

All UPVC pipes shall be jointed with sockets and fittings and as recommended by the manufacturer.

Solvent cementing shall be used for all pipeworks. All the surfaces shall be cleaned with abrasive paper and spirit cleaner. In the application of solvent cementing, heat shall be avoided as the cement may dry before chemical bonding between the two surfaces is completed. Mating surfaces shall be turned for even spread of the solvent. Excessive cement shall be wiped off quickly.

Flanged joints shall be used where solvent cementing is not practicable and at locations to facilitate dismantling. Neoprene ring gaskets provided or approved by the flange manufacturer shall be used between flanges. The jointing compound for the pipe and flange must be applied in accordance with the jointing compound manufacturer's recommendation.

13.1.1.5 PIPEWORK SUPPORT

13.1.1.5.1 General

Pipework shall be supported in such a manner as to allow adequate movement for expansion and contraction.

Pipes on flat roofs shall be supported at least 150 mm above roof finish on concrete blocks and pipe brackets or PVC sleeves.

Pipe brackets shall be of stainless steel to BS EN 10088-3:2014 number 1.4301 or SAE Grade 304 or other approved material. The pattern shall suit the type of pipe and the surface to which they are to be fixed, including where appropriate: -

(a) Flanged ends for building in;

(b) Plain round ends fixing in drilled holes with an approved adhesive;

(c) Approved expanding bolts or stud anchors for fixing to concrete, brickwork etc.;

(d) Threaded ends for fixing to steelwork, or wood, as required;

(e) Holed face plates for screwing to wood or plugs.

Bolts, nuts and washers for pipe brackets shall be of stainless steel to BS EN 10088-3:2014 number 1.4301 or SAE Grade 304 or other approved materials.

Pipe bracket inside pump room shall not be anchored on wall or ceiling as far as practicable. If unavoidable, neoprene or rubber vibration isolation pad of 8 mm thick between the pipe and bracket for those pipe brackets mounted on wall, and vibration isolator for those pipe bracket mounted to ceiling or steel support frames, shall be added.

Do not connect pipe brackets to copper pipes by means of brazing or soldering.

Pipe bracket shall be lined with plastic which fitted between the pipe and the bracket for UPVC pipes and copper pipes.

13.1.1.5.2 Pipe Bracket Intervals

Pipe bracket shall be installed at intervals not exceeding those shown in Table 13.1.1.5.2 for straight runs, and with not less than one bracket per length of pipe. Short length of pipe can be without pipe bracket if approved by the Supervising Officer. All brackets shall be equally spaced.

Table 13.1.1.5.2 Spacing of Pipe Fixing

Pipes	Nominal Size (mm)	Maximum Spacing (mm)	
		Vertical pipes	Horizontal pipes
Cast iron and ductile iron	All	3000	1750
Steel	Up to 15	2400	1800
	20 and 25	3000	2400
	32	3000	2700
	40 and 50	3600	3000
	65 to 80	4500	3600
	100 to 125	4500	4000
	150	5400	4500
Copper	15	1800	1200
	22 and 28	2400	1800
	35 and 42	3000	2400
	54	3000	2700
	76 and 108	3600	3000
UPVC	Up to 25	1500	750
	32	1800	900
	40 and 50	2000	1000
	65 to 150	2500	1200

Additional pipe brackets shall be provided next to cast iron valve installed in UPVC pipe. Also, additional pipe brackets shall be provided at turning point of UPVC flush water pipe riser and down pipe.

13.1.1.6 THERMAL INSULATION

Thermal insulation to the requirements as specified in this General Specification or other parts of the Contract shall be applied to hot water supply pipework and fittings.

Pipework insulation shall include all pipework, valves, flanges, fittings, pumps and other plant items whether specifically mentioned or not.

13.1.1.7 VALVES

Unless otherwise specified, install the valve in accordance with manufacturer's recommendations.

Non-return valve shall be installed horizontally or in such a manner that the water flow direction is in an upward direction for vertical installation.

Non-return valve shall be installed at relevant upstream tee-off branches to non-drinking water points to avoid cross contamination between drinking and non-drinking water points.

Non-return valve shall be installed immediately before water filters to avoid contamination of upstream pipework.

The portion of pipework connecting to flushing valve shall be flushed to clear debris before the installation of flushing valve. .

No pipe sealant or plumbing grease shall be allowed on any flushing valve components or couplings unless otherwise specified in the manufacturer’s literature.

Valves and taps installed in public areas, not intended for public use, shall be housed in vandal resistant and corrosion resistant enclosures.

13.1.1.8 CISTERNS AND TANKS

13.1.1.8.1 Connection of Pipes

Generally, when connecting pipes to cisterns and tanks, ensure that cisterns and tanks are properly supported to avoid undue stress on the pipe connections. Correctly position holes for the connection of pipes to cisterns and tanks. Remove all debris and fillings. Holes in cisterns and tanks shall not be formed by flame cutters.

Connect steel pipes to steel or glass fibre reinforced plastics cisterns and tanks by either: -

(a) backnuts and washers both inside and outside;

(b) by using bolted or welded flanged connections; or

(c) as recommended by the manufacturer.

Connect plastic pipes to steel or glass fibre reinforced plastics cisterns by a backnut to the inside. Use corrosion resistant support washers on both the inside and outside of the cistern or tank.

Connect copper pipes to GRP cisterns or tanks in a similar manner.

Do not connect copper pipes to steel cisterns or tanks.

Connect pipes to concrete tanks with short thread flanged connections having a puddle flange either cast or welded on. Ensure that the connections are properly aligned both in the horizontal and vertical planes when being cast into the concrete. Compact around the puddle flange to ensure a water tight joint.

All outlet pipes from cisterns and tanks shall, whenever possible, be positioned at the opposite side to the inlet supply pipe to prevent stagnation of water.

13.1.1.8.2 Connection of Overflow Pipes and/or Warning Pipes

Overflow pipes shall be at least one commercial size larger than the inlet pipe and shall be in no case less than 25 mm diameter. Warning pipes shall be 25 mm diameter unless otherwise specified. Overflow pipes and/or warning pipes shall be extended to terminate in conspicuous positions which are not susceptible to water damage.

The top of the overflow pipe and/or warning pipe shall be not less than 25 mm below the invert of the inlet pipe or the face of the outlet nose of the ball float valve.

13.1.1.8.3 Tank Covers

Fit FRP or stainless steel access covers and frames to water tanks.

Fit double sealed access covers to potable water tanks.

Bed and haunch access cover frames in cement mortar.

13.1.1.9 WORKS OUTSIDE SITE BOUNDARY

All necessary provisions shall be made for the connection of water supply mains from town mains to the Installations.

WSD shall be notified accordingly to inspect completed pipework and valve pit prior to back filling.

13.1.1.10 PROTECTION OF WORKS

13.1.1.10.1 Sealing the System

Ends of pipes and openings shall be sealed off to prevent entry of foreign matter into the system during construction. Access covers and cleaning eyes shall be fitted when the works proceed.

13.1.1.10.2 Valves and Taps

House valves and taps installed in public areas or those not intended for public use in vandal-resistant and corrosion-resistant enclosures.

13.1.1.10.3 Underground Pipework

Underground pipework shall be protected against corrosion and mechanical damage.

Anti-corrosion petrolatum tape shall be applied for steel pipe without external protective coating, flange joint, slip-on coupling and flange adaptor. Bituminous tape shall be applied in buried or non-exposed condition for welded joints of steel pipe. The pipework shall be cleaned before applying the anticorrosion tape.

Underground pipework shall be pressure tested before the application of anti-corrosion tape.

Anti-corrosion tape shall be of proprietary type and have a high resistance to cathodic disbondment, acids and alkalis. Primer and mastic filler for use with anti-corrosion tape shall be compatible with the tape and shall be a type recommended by the manufacturer of the tape. No dirt or grits shall be allowed to stick on the edge of the tape before applying the tape for pipe protection.

13.1.1.10.4 Pipework Passing under Road

Pipes crossing under roads shall be passed through in ducts of similar construction to cable ducts as Clause 24.31 of General Specification for Building.

Where top of the underground pipework is less than 900 mm from finish level of roads for vehicles, the pipework shall be surrounded by concrete.

13.1.1.11 CLEANSING AND DISINFECTION OF INSTALLATIONS

13.1.1.11.1 General

The plumbing installation pipework and water storage tanks shall be thoroughly flushed clean to remove rust, sludge and sediment upon commissioning. Fresh water distribution pipework and associated water storage tanks shall be further disinfected and flushed thoroughly with

potable water upon completion of cleansing and before water supply is resumed. The water sample tests to the satisfaction of the Water Authority shall be arranged.

Disinfection of plumbing installation for potable use shall be carried out not more than 7 days before hand over the installation to users for operation. Where the plumbing installation for potable use is not brought into use immediately after commissioning, it shall be disinfected before use unless it has been flushed weekly to maintain a flow of water.

13.1.1.11.2 Methodology of Cleansing and Disinfection

The cleansing and disinfection shall be carried out in accordance with the requirements as required by WSD and as stipulated in the Testing and Commissioning Procedure for Plumbing Installation in Government Buildings Hong Kong issued by the Building Services Branch, Architectural Services Department, and to the satisfaction of the Water Authority.

For pipework downstream of the water tank or downstream of the water meter for the case of direct feed system, the disinfection process shall be in accordance with the requirements of WSD.

A cleansing and disinfection plan shall be submitted to indicate the scope of work, detail of the compartmentation if any, work schedule, method statement, procedures and equipment for checking and testing, location of sampling, method statement for the de-chlorination, etc. for the Supervising Officer's approval prior to carrying out the work.

Any discharge of disinfectant solution or used water for disinfection shall comply with the Water Pollution Control Ordinance (Cap. 358). A method statement shall be submitted for the de-contamination of used water to the Supervising Officer for approval.

13.1.1.11.3 Systematic Flushing

For newly installed inside service for potable water purpose in new buildings, the systematic flushing shall be carried out and the records of carrying out the systematic flushing according to WSD's requirements before carrying out water sampling tests shall be submitted to WSD. The procedures of systematic flushing shall be approved by the Supervising Officer.

13.1.1.11.4 Water Quality Test

The water sampling tests shall be arranged upon completion of the cleansing and disinfection, and systematic flushing of the plumbing installations. The water sampling tests shall also comply with the requirements of WSD and to the satisfaction of the Water Authority. The procedures of the water sampling tests shall be approved by the Supervising Officer.

Sampling and analysis of the water samples shall be carried out by the Water Authority or by organizations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organizations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS. For water samples to be tested by accredited organizations, the water samples shall be taken on site by the accredited organizations in accordance with the sampling procedures developed with reference to BS EN ISO 5667-5: 2006.

If any of the water samples fails to comply with WSD's requirement, the cause shall be investigated and the necessary rectification action shall be taken and water quality testing for the concerned part of installations shall be re-arranged.

13.1.1.12 QUALITY CONTROL OF SOLDERING/BRAZING JOINTS FOR COPPER PIPES

13.1.1.12.1 General

All soft solder materials, soldering flux and filler metal used in soldering, brazing and/or welding for jointing copper pipes for the fresh water supply system shall be of lead-free and cadmium-free grade. All precautions shall be taken to ensure good quality control during installation.

13.1.1.12.2 Site Record

The record of soldering/brazing joints done by each individual plumber/worker during installation shall be kept and submitted to the Supervising Officer for checking.

13.1.1.12.3 Sampling and Testing of Soldering/Brazing Joints

To ensure the soldering/brazing joints of copper pipes are in compliance with the lead-free grade to Table 3 of BS EN ISO 9453:2014 and cadmium-free grade to Table 7 of BS EN ISO 17672:2010, the sampling and testing of soldering/brazing joints shall be arranged and the sampling and analysis methodology, including but not limited to the proposed organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS, and the procedures for collection and analysis of test samples and submission of test results, shall be submitted to the Supervising Officer for approval.

The Supervising Officer shall at random select a number of completed soldering/brazing joints for carry out testing of the lead and cadmium content of the jointing materials. Quick lead test on the surface of the soldering joints may be used to aid the random selection.

The cutting out and repair of all such joints for inspection as required by the Supervising Officer shall be borne.

The testing of the lead and cadmium content of the soldering/brazing joints shall be carried out by organisations accredited by HOKLAS or by HKAS , or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS. The declaration shall be written that the organisations accredited by HOKLAS or by HKAS , or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS appointed has no affiliation as a legal entity.

The Supervising Officer shall agree either to appoint representative(s) from organisations accredited by HOKLAS or by HKAS, or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS to collect test samples on site or to arrange representative(s) to collect test samples on site. All the procedures stated in the approved methodology are strictly followed shall be guaranteed. Test samples collected shall be kept in sealed container inaccessible to unauthorised persons at all times.

If any of the soldering/brazing joint is found with lead or cadmium content that exceeds the required limit, Supervising Officer shall order same number of the soldering/brazing joints at random selection for further testing. If any of the samples from further testing is found with lead or cadmium content, it is sufficient to conclude that the soldering/brazing materials are not lead-free or cadmium-free and the remedial plan shall be submitted to rectify the defects for the approval by the Supervising Officer. Further contractual and legal actions shall be taken as appropriate.

SUB-SECTION 13.1.2

WATER HANDLING EQUIPMENT

13.1.2.1 GENERAL

The installation details shall be in accordance with the instruction prepared by the manufacturer.

Pumps shall be "Type-tested" in accordance with the requirement of BS EN ISO 9906:2012. Test certificates with performance curves shall be submitted to the Supervising Officer.

Pumps and their drives shall be segregated such that failure of pump seals shall not result in damage to the drive motors.

13.1.2.2 STORAGE

The equipment shall be stored in a dry space when they are delivered to Site. Special rust preventive measures to protect the internal parts of pumps shall be applied if the equipment must be stored for an extended period of time. Such provisions shall be removed completely before final installation and the bearings shall then be re-lubricated.

13.1.2.3 PUMPS

13.1.2.3.1 Centrifugal Water Pumps

Common Installations for Fresh Water Pumps and Flushing Water Pumps

(a) Driving Arrangements

The pump and motor shall be direct coupled and mounted on a substantial machined bedplate; accurately aligned, and fitted with guards. The whole assembly including the bedplate shall be provided by the pump manufacturer. Coupling with spacer shall be used for end suction pumps so that the impeller may be dismantled from the motor side for servicing without neither disrupting the pipework nor dismounting the motor.

The pump and motor for vertical multi-stage pump for potable application shall be of close-coupled type.

The pump driving arrangement fulfilled the above requirements shall be checked and assured.

(b) Stand-By Pumps Arrangement

Where stand-by pumps are specified with automatic changeover provision, the changeover shall be initiated by means of flow

sensing devices of an approved pattern. The necessary non-return valves shall be incorporated in the pipework to interconnect such pumps.

13.1.2.4 PLANT ROOM LOCATION

Adequate working space must be provided to access for maintenance and sufficient headroom to lift the parts for repairing is provided. For large pumps, a hoist with travelling crane or other facility shall be provided over the pump location.

For an open loop system, the location of pump shall be sited so that it will use the shortest and most direct suction and smallest vertical lift. Where possible, the pump centre line shall be placed below the level of the liquid in the suction tank.

All precautions shall be taken against flooding when pumps are located in pits or other places liable to flooding. The pumps shall be of the vertical spindle type with the motor mounted above the potential flooding level. Motor and pump shall form one unit being joined by a common stool. Where shaft extension is required, the pump shall be driven through a flexible shaft that consists of a universal joint at each of the drive and driven end and the slip joined at centre of travel.

13.1.2.5 PUMP FOUNDATION

The foundation for a pump shall be of sufficient size and rigidity to properly support the full area of the base-plate, to absorb any normal strains and to maintain correct alignment. The minimum mass of inertia block of concrete shall be not less than 2.5 times the mass of the pump assembly with at least 100 mm thick and 150 mm wider than the pump base-plate.

The space between the pump unit and the foundation bolts shall be allowed in accordance with the manufacturer's recommendation. Each foundation bolt shall be installed in a pipe sleeve type holder and shall be cast before the concrete foundation is being poured.

Unless otherwise specified, pump base shall be mounted on the raised housekeeping plinth using appropriate anti-vibration spring mountings. Each spring shall be individually selected according to load distribution and shall have an additional free travel equal to one half of the rated deflection. Spring mounts shall have a leveling bolt and shall be mounted to the concrete inertia block via height saving brackets that allows a base clearance of 50 mm.

A curb ring or soleplate shall be used as a bearing surface for mounting of a vertical wet-pit pump. The mounting face of the curb ring or soleplate shall be machined for pump alignment. Tie rods shall be installed to secure the pump for discharge below ground.

13.1.2.6 PUMP ALIGNMENT

The pump unit shall be accurately aligned in accordance with the manufacturer's instructions prior to operation. The unit shall be supported over the foundation by strips of steel plate close to the foundation bolts, allowing a space of 20 to 50 mm between the

bottom of the base-plate and the top of the foundation for grouting. The alignment shall be rechecked after the suction and discharge piping have been bolted to the pump to test the effect of piping strains.

The pump and driver alignment shall be rechecked and adjusted correct at the expiry of the Maintenance Period.

13.1.2.7 GROUTING OF PUMP BASE

The base-plate shall be grouted before piping connections are made and pump alignment is finally rechecked. Grouting shall be properly done with concrete that shall compose of one part of pure cement and two parts building sands or be a proprietary non-shrink grout to the acceptance of the Supervising Officer to prevent lateral shifting of the base-plate. Grout holes shall be allowed in the base-plate to serve as vents for air escape. The expose surface of the grout shall be covered with wet burlap to prevent cracking from drying too rapidly. The pump alignment shall be rechecked thoroughly after the grouting has hardened for a period that shall not be less than 72 hours.

13.1.2.8 SUPPORT FOR PIPING

Suction and delivery pipes shall be supported independently of the pump. The connecting pipes to a pump shall not strain the pump. Pipes installation shall match up to the respective flanges without being strained into position. The faces of the coupling shall be checked with a straight edge to make sure that they are parallel and concentric.

13.1.2.9 CONNECTION PIPING TO PUMP

13.1.2.9.1 Suction Piping

The suction piping shall be properly installed for a satisfactory pump operation. This shall be achieved by keeping as direct and as short as practicably possible with a minimum number of bends. The installations shall be laid out such that a continuous fall can be maintained from the pump to water source to prevent air pockets forming. Concentric reducers shall not be used on suction branch.

The size of the suction pipe shall be larger than the pump inlet and eccentric reducers shall be used. If the source of supply is located below the pump centreline, the reducer shall be installed straight side up. If the source of supply is above the pump, the straight side of the reducer shall be at the bottom.

A straight section piping at least 4 to 6 diameters long at the pump inlet and long radius bend shall be used for suction pipeline installations to create less friction and provide more uniform flow distribution.

13.1.2.9.2 Delivery Piping

Unless otherwise specified, the size of the delivery pipe shall be at least one size larger than the pump delivery and the velocity shall be kept around 2 metre per second for pumping water over long distance. The check valve shall be installed between the pump and the gate valve. The gate valve shall be installed close to the pump discharge for pump priming and repairing. Provision such as a sprocket rim wheel and chain shall be provided for manually operated valves that are difficult to access.

Air release valves shall be installed at the highest points on each rise to allow accumulated air or vapour or other gases to escape from the pipe.

A 'Y' type branch connection shall be used for distribution of more than one-discharge points.

A taper piece with the included angle between 10-13 degrees shall be used for reduction of pipe diameter.

Adequate support and anchorage shall be provided if the pipes are laid above or below ground. For this purpose, it is acceptable to have thrust blocks in either corner type or puddle flange type to absorb reactions or turning forces to ensure no mechanical and hydraulic forces imposed on the pump.

13.1.2.9.3 Pipe Flanges

Pipe flanges shall match with the sizes of pump flanges with full-face gaskets.

13.1.2.9.4 Expansion Joints

Expansion joints/flexible connectors shall be installed in suction and delivery pipelines to take up vibration but shall not be used to take care of the misalignment during installation. A suitable pipe anchor shall be installed between the expansion joint and the pump.

If expansion joints are not specified, expansion loops that are formed by looping the pipe shall be provided to prevent the transmission of strains to the pump.

13.1.2.9.5 Intake

The installation work shall be carried out properly to prevent air being entrained as bubble within the water. The intake pipe shall run well below the sump tank level to prevent from forming air gulps.

High level entry into the sump shall be avoided as air may be entrained by the falling jet.

Vortex inhibitor shall be installed to prevent air being drawn from bottom of vortex into the intake.

13.1.2.10 SUCTION STRAINERS

The suction strainer shall be installed as close as practicably possible to the pump. This suction pipe strainer shall not be used for flushing the pipe. A temporary strainer fitted with a finer mesh than the permanent strainer shall be used for flushing all piping and cleaning thoroughly all possible mill scale and other foreign matter. The temporary strainer shall be removed afterwards.

13.1.2.11 VENTING VALVES FOR PUMP SET

Venting valves shall be installed at one or more points of the pump-casing waterway to provide a means to escape for air or vapor trapped in the casing. These valves shall be connected so as not to endanger the operation staff in handling toxic, inflammable or corrosive liquid.

13.1.2.12 DRAIN FOR PUMP SET

All drain and drip connections shall be piped to a point where the leakage can be disposed of or collected for reuse if specified.

13.1.2.13 INSTRUMENTATION

Each pump installation shall include pressure gauges and a gas cock to measure the system pressures and pressure drop.

All measuring and isolation instruments, such as the pressure gauges, check valves, globe valves, gate valves and strainers, etc., or as specified in the Particular Specification shall be installed properly to maintain a close check on control on the performance and condition of the pumps.

Instruments shall be mounted in a suitable location so that they can be easily observed.

13.1.2.14 SMART WATER CONSUMPTION ANALYTIC SYSTEM

The smart water consumption analytic system shall be supplied and installed, where specified in the Particular Specification and if required to retrieve data from the entire, or part of the water supply network within the building, i.e. flow rates from water meters, water tanks levels, pressure, etc., monitor and forecast water consumption, detect leakage, provide real-time analysis of the sensor data and recommend appropriate corrective measures by harnessing the power of artificial intelligence algorithms and big data analytics.

Full smart water consumption analytic system, when specified, shall interface with the building Central Control and Monitoring System (CCMS) or other centralised monitoring system.

SUB-SECTION 13.1.3

RAINWATER HARVESTING INSTALLATION

13.1.3.1 GENERAL

The works include the supply, install, testing and commissioning, and maintenance of rainwater harvesting installation as shown on the Drawings, other parts of tender documents, and as specified, including but not limited to: -

(a) Rainwater collection tank and accessories including level sensors, vent pipe, insect screen, drain valve, inlet valve and overflow pipe, etc. and interface pipeworks for rainwater inlets;

(b) Rainwater pump set and associated control and/or monitoring facilities;

(c) Rainwater treatment plant including sand filters, activated carbon filters, chlorine disinfection system and associated control and/or monitoring and alarm facilities;

(d) Mixing tank and accessories including level sensors and/or switches, vent pipe, insect screen, drain valve, inlet valve, overflow pipe and interface pipeworks, etc.;

(e) Make-up break tank and accessories including level sensors, vent pipe, insect screen, drain valve, inlet valve and overflow pipe, etc. and interface pipeworks for main water supply;

(f) Pipeworks, valves and fittings;

(g) Warning and pipework identification labels;

(h) Control system and monitoring devices;

(i) Electrical works; and

(j) Water sampling draw-off points.

The complete rainwater harvesting installation shall mean, not only the major items of equipment and apparatus conveyed in the Specification and Drawings, but all the incidental sundry components necessary for the complete execution of the works and for the proper operation of the installation with their labour charges, whether or not these components are mentioned in detail in the Contract.

The works include the use of the proper, correct and consistent components to match the system proposed with all requirements specified. In the event that these requirements cannot be met due to the use of improper, incorrect or inconsistent components, all such components shall be replaced to the satisfaction of the Supervising Officer.

The rainwater harvesting installation shall be suitable for landscape irrigation, toilet flushing, street cleansing purpose and/or other non-potable application(s) as required.

The system shall be an integrated system such that make-up from the mains supply could be used for the application under dry season and shall be installed with a backflow prevention device to prevent the treated rainwater from entering the potable mains water supply. Electromagnetic flow meter connected to CCMS shall be provided for monitoring of consumption of the collected rainwater, the make-up water and treated rainwater.

13.1.3.2 RAINWATER COLLECTION TANK, MIXING TANK AND MAKE UP BREAK TANK

First flush device shall be provided for first stage filtering of rainwater before entering into the rainwater collection tank.

Rainwater collection tank, mixing tank and make-up break tank shall be selected to minimise the risk of contamination from pollutants such as dust, leaves, pollens, pesticide sprays, fertilisers, bird drops or insects etc. Proper screening devices in form of wire mesh shall be provided.

13.1.3.3 RAINWATER TREATMENT PLANT AND WATER PUMP

Rainwater treatment plant with filtration and disinfection functions shall be provided to the satisfaction of the Supervising Officer. The filtration shall be in the form of sand filter. The disinfection process shall be by chlorine disinfection system. The rainwater treatment plant shall suit the flow rate of the intended application.

Rainwater pump(s) shall be selected and provided as specified in Clause 13.1.2.3 if the rainwater pressure by gravity fall from the rainwater collection tank is not sufficient to provide the minimum required inlet pressure of the rainwater treatment plant.

Alarm system shall be provided for rainwater treatment plant for monitoring. The minimum instrumentation shall consist of alarms for critical treatment units including the sand filter and chlorine dosing to alert operator of malfunction.

Flow meter shall be provided at the downstream of the rainwater treatment plant. The flow meter shall be of electromagnetic type and able to provide reading for accumulated water flow.

13.1.3.4 PIPES, CONTROL, DRAW-OFF POINTS AND MISCELLANEOUS

All sections of rainwater collection pipes shall be coordinated to direct downward but the size of collection pipes shall not be more than 150mm in diameter unless otherwise specified. Collected rainwater shall enter at the high level of the rainwater collection tank. Rainwater collection pipes network shall have no rising section to avoid potential traps of sediments or stagnant water.

A complete control system and its associated sensor and wiring accessories shall be provided to enable the proper operation of the rainwater harvesting system as specified in this General Specification and other drawings / specifications as required.

Suitable draw-off points with secured plugs shall be provided at locations for water sampling purposes. The water sampling points shall be well allocated throughout the rainwater harvesting installations and shall include the far end point of the distribution pipeworks.

The health risk assessment of the rainwater harvesting installation shall consider the intended applications, site conditions, site surrounding and various constraints to identify the potential risks. Risk mitigation measures to the identified risks shall be proposed and incorporated in the system installation. The details of the risk assessment shall be submitted to the Supervising Officer for approval.

SUB-SECTION 13.1.4

AUTOMATIC METER READING

13.1.4.1 GENERAL

13.1.4.1.1 To facilitate the implementation of the Automatic Meter Reading (AMR) System for water supply, AMR Outstations, cable containment and the associated cabling shall be provided as applicable. The supply, installation, testing and commissioning of the AMR Outstation, electrical and instrumentation panels /cubicles, programmable logic controller, instrumentation equipment and power supply equipment for telemetry system shall be in accordance with WSD's standard specifications and requirements.

13.1.4.1.2 The following items shall be submitted to Supervising Officer and WSD for approval: -

(a) AMR Outstation proposal detailed the arrangement, layout and equipment for building up the AMR Outstation prior to commencement of installation work;

(b) Testing and commissioning (T&C) procedure prior to commencement of installation work; and

(c) Operation and Maintenance (O&M) manual complete with all necessary documentation catalogues, drawings, reports, test certificates and T&C records prior to handing over of the system.

13.1.4.1.3 The scope of work for AMR Outstation installation shall comprise of the following: -

(a) Supply, installation, testing and commissioning and warranty of the AMR Outstation;

(b) Supply and installation of all infrastructures for AMR equipment and network including concealed conduits and junction boxes;

(c) Site works for laying, connection and termination of associated cables for all equipment and smart water meters including power cables, signal cables, control cables and communication network cables;

(d) Site works for the programming and configuration of AMR Outstation including programmable logic controller (PLC), data concentration unit (DCU), meter interfacing unit (MIU) and communication equipment;

(e) Provision of electricity power supply at all necessary locations for operation of AMR Outstation before and after handing over of the system to the WSD;

(f) Supply, installation, connection and termination of a complete system of power cables, control cables, M-bus cables and communication network cables to all equipment, instrument and ancillaries supplied, modified and installed;

(g) Supply and installation of all necessary earthing system to form a complete, neat and safe installation as required to comply with the relevant wiring regulations; and

(h) Provision of the broadband/3G network services to enable the AMR Outstation securely data communicating with the AMR Master Station prior to handing over of the system to the WSD.

13.1.4.1.4 Upon successful commissioning of the AMR Outstation to the satisfaction of the Supervising Officer and WSD, the whole system including communication network shall be handed over to the WSD for operation and maintenance. All approved drawings, documents, test records/certificates shall form parts of the operation and maintenance manuals to be submitted to the WSD prior to handing over of the system.

13.1.4.1.5 The detail inspections of the power supply for AMR meter and panels, cable containment for AMR signal wirings and electrical conduits for cabling of AMR system shall be carried out and all necessary checking shall be made to the satisfaction of the Supervising Officer before handover of the installation.

13.1.4.1.6 All the equipment supplied and installed shall be subject to a warranty against defects and workmanship for 24 months from the handing over date of the AMR Outstation to the WSD.

13.1.4.1.7 If Electromagnetic (EM) water meter is provided with pulses output for AMR application, a pulse-to-M-Bus converter for interfacing of metering data in pulses with DCU in M-Bus protocol shall be provided under the scope of works.

13.1.4.1.8 All water meter shall be housed in a meter room or meter boxes as per the requirement set out in the Hong Kong Waterworks Standard Requirements for Plumbing Installation in Building.

13.1.4.1.9 At least two cable conduits shall be provided to run through the meter room of each floor and terminate with adaptable box in each of the meter rooms for installing M-Bus cables and network communication cables.

13.1.4.1.10 AMR panel (for housing of PLC, DCU and communication equipment) shall be installed in the meter room (hereinafter called AMR equipment room). If one AMR panel is provided, the panel shall be housed in the meter room on the ground floor, or near the ground floor, so as to facilitate ease communication network connection and maintenance works. If more than one AMR panel is provided, the panel shall be housed in the meter room at the middle floor level, or at an appropriate floor, to minimise the length of M-Bus cable from smart water meters to the AMR panel.

13.1.4.1.11 A 220V 50Hz a.c. power supply with a 13A fuse spur unit and sufficient wall space for mounting an AMR panel shall be provided. Alternatively, a covered and lockable area on the same floor level of the respective meter room shall be provided. In this arrangement, two cable conduits running through the above-mentioned meter room to the AMR equipment room shall be provided.

13.1.4.1.12 If more than one AMR equipment room within a development, a cable conduit running through the AMR equipment rooms for network communication cables shall be provided.

13.1.4.1.13 If master meter and check meter positions are provided, two cable conduits running through the master meter room and check meter room to the AMR equipment room shall be provided, or individual AMR panel with associated electricity power supply point and telecommunication cable conduits hall be provided at each of the meter rooms.

13.1.4.1.14 The installation location of the AMR panel, battery charger panel, battery panel and any other auxiliary equipment shall be easily accessible to facilitate the operation and maintenance works. The AMR panel and auxiliary equipment shall not be installed under any pipework. The maximum distance between the terminal box to either of the smart water meter shall be 1.5 metres. If the cables run across the access or without proper supports, suitable fixed cable conduits and flexible conduit shall be provided for cable protection.

SECTION 13.2

MATERIAL AND EQUIPMENT SPECIFICATION

SUB-SECTION 13.2.1

PLUMBING SYSTEMS

13.2.1.1 GENERAL

13.2.1.1.1 All materials and equipment shall be constructed of materials suitable for the required working and test pressures and temperatures of the fluid carried. They shall be capable of withstanding concerned working pressure and maximum static pressure that may arise upon failure of the associated pressure reducing devices.

13.2.1.1.2 All materials and equipment shall be of standard products. On-site fabricated products shall not be used unless otherwise approved by the Supervising Officer.

13.2.1.1.3 All materials and equipment shall be approved by the Water Authority for the intended application. Type test reports and certificates to the required standards issued by organisations accredited by HOKLAS or by HKAS, or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS shall be submitted to prove compliance with this General Specification.

13.2.1.1.4 The internal lining of pipes, pipe fittings, joints and gaskets for potable water applications shall be certified safe for potable water use. Test reports or certificates demonstrate compliance to BS 6920-1:2014 for non-metallic components shall be provided.

13.2.1.1.5 Pipes and fittings shall have marking in accordance with manufacturing standard and the make.

13.2.1.1.6 The testing requirement of material and equipment for the compliance of relevant standards shall be accepted by WSD.

13.2.1.1.7 All materials and equipment (excluding products for non-potable fresh water system, flushing water system and fire service installation) to be low metal leaching rate metallic plumbing products under the GA Scheme of WSD shall be adopted for potable fresh water systems unless otherwise specified.

13.2.1.1.8 Water efficient products of the WELS Types shall be adopted unless otherwise specified.

13.2.1.2 PIPES, JOINTS AND FITTINGS

13.2.1.2.1 General

The application of pipework types to the various plumbing systems shall be as follow unless otherwise specified in the Contract.

(a) Cold water potable and non-potable water supply systems (mains supply and up feed riser)

Ductile iron pipe and fitting to BS EN 545:2010 with minimum thickness in full compliance with the following Table 13.2.1.2.4 with internal cement lining; or

Copper pipe to BS EN 1057: 2006 +A1:2010, copper pipe fitting to BS EN 1254-1 to 5:1998 and BS EN 1254-6, 8:2021 or BS 8537:2010; or

Stainless steel pipe to BS EN 10312:2002 +A1:2005 or BS EN 10217-7:2014 (for pipe size over 50 mm dia.), stainless steel pipe fitting to AS 3688:2016

(b) Cold water potable and non-potable water supply systems (down feed and branch pipes, including drinking water circuits such as drinking fountain, water dispenser, pantry, kitchen and the like)

Copper pipe to BS EN 1057: 2006 +A1:2010, copper pipe fitting to BS EN 1254-1 to 5: 1998 and BS EN 1254-6, 8:2021 or BS8537:2010; or

Stainless steel pipe to BS EN 10312: 2002 +A1:2005 or BS EN 10217-7:2014 (for pipe size over 50 mm dia.), stainless steel pipe fitting to AS 3688:2016

(c) Fire service mains supply

Comply Fire Service Installation Part of this General Specification

(d) Hot water potable and non-potable water supply systems

Copper pipe to BS EN 1057:2006 +A1:2010, copper pipe fitting to BS EN 1254-1 to 5:1998 and BS EN 1254-6, 8:2021; or

stainless steel pipe to BS EN 10312: 2002 +A1:2005 or BS EN 10217-7:2014 (for pipe size over 50 mm dia.), stainless steel pipe fitting to AS 3688:2016

(e) Flushing water supply system

Ductile iron pipe and fitting to BS EN 545:2010 with minimum thickness in full compliance with the following Table 13.2.1.2.4 with internal cement lining; or

UPVC Pipe to BS EN ISO 1452-2:2009 series S10 or above, or UPVC to BS 3505:1986 Class E. UPVC Fitting to BS 4346-1:1969 or BS EN 1452-3:2010

13.2.1.2.2 Copper Pipes, Joints and Fittings

Copper pipe shall be of hard drawn temper copper tubes to BS EN 1057: 2006 +A1:2010. For pipe sizes with nominal diameter equal to or below 28 mm, half hard temper copper tubes to BS EN 1057:2006 +A1: 2010 is acceptable.

Copper and copper alloy fittings such as end feed capillary, integral solder capillary and mechanical joint type (compression, push-fit and press-fit) bushes, reducers, bends and tees shall comply with BS EN 1254-1:1998, BS EN 1254-2:1998, BS EN 1254-3:1998, BS EN 1254-4:1998, BS EN 1254-5:1998 and BS EN 1254-6, 8:2021 or BS 8537:2010.

Copper pipes for cold water application shall be encapsulated with factory applied moisture resistant polyethylene sheath to BS 3412:1992.

Joints and fittings, such as end feed capillary, integral solder capillary and compression type bushes, reducers, bends and tees for cold water application shall be encapsulated with moisture resistant polyethylene sheath or other approved type sheath for protection.

Copper pipes for hot water application above 30°C but below 80°C shall be pre-insulated with factory applied thermal insulation polyethylene sheath comply with BS 3412:1992 with internal profile to entrap air and provide thermal barrier. Thermal insulation for pipework install inside plant room and pipe duct shall refer to other section of this General Specification.

Lead-free soldering alloys and cadmium-free brazing alloy shall be used in installations for water for human consumption and shall fully comply with the requirements of WSD and Clause 13.1.1.4.3.

13.2.1.2.3 Stainless Steel Pipes, Joints and Fittings

Stainless steel pipe shall be to BS EN 10312: 2002+A1:2005 light gauge stainless steel tubes or

Stainless steel pipe shall be to BS EN 10217-7:2014 for pipe size greater than 50 mm diameter.

Stainless Steel pipe fitting shall be tested to AS 3688:2016.

Stainless steel pipe fittings, including fasteners, shall be of stainless steel to BS EN 10088-1:2014 Grade 1.4301.

Stainless steel fasteners, including bolts, screws, studs and nuts, shall be Grade 4 to BS EN ISO 3506-1 & 2:2020 unless otherwise specified and shall be assembled to manufacturer's recommendations.

Use dielectric fittings or epoxy coated flange with gasket for connecting stainless steel pipe to pipes and fittings made of other metals except copper or copper alloy in order to prevent potential corrosion.

13.2.1.2.4 Ductile Iron Pipes, Joints and Fittings

Ductile iron pipe, fitting and accessories shall be to BS EN 545:2010, with minimum thickness in full compliance with the following Table 13.2.1.2.4 with internal cement lining and external bitumen coating.

Table 13.2.1.2.4 Minimum Thickness of Ductile Iron Pipe & Fitting

Nominal Size DN (mm)	Class	Minimum Pipe & Fitting Thickness (mm)
80	100	5.6
100	100	5.8
150	100	6.4
200	64	6.9
250	64	7.5
300	64	8.0
350	64	8.6
400	50	9.1
450	50	9.7
500	50	10.2
600	50	11.3

Ductile iron pipe shall be coated with metallic zinc and bitumen finishing externally and lined with cement mortar internally. Ductile iron pipe fittings and accessories shall be coated with metallic zinc and bitumen or epoxy finishing externally and lined with cement mortar or epoxy internally. Epoxy coating shall be complied with BS EN 14901-1:2014+A1:2019.

13.2.1.2.5 UPVC Pipes, Joints and Fittings

UPVC Pipe shall be to BS 3505:1986 Class E, or to BS EN ISO 1452-2:2009 series S10 (SDR 21) PN10 or higher to suit system pressure.

UPVC pipe fittings shall comply with BS EN ISO 1452-3:2010 or BS 4346-1:1969.

Jointing compound shall be of type recommended by the manufacturer.

All UPVC pipes must be properly supported and shielded from direct sunrays and must be painted with protective paint when exposed.

Joints and fittings for use with UPVC pressure pipes:

(a) Injection moulded UPVC fittings for solvent welding for use with pressure pipes, including potable water supply: BS 4346-1:1969.

(b) Mechanical joints and fittings principally of UPVC: BS EN 1452-1 to 5:2009.

(c) Solvent cement: BS EN 1452-1 to 5:2009.

13.2.1.3 EXPANSION JOINTS AND FLEXIBLE CONNECTORS

13.2.1.3.1 Stainless Steel Type Expansion Joint

Stainless steel type expansion joint shall be used for potable water application. It shall be of axial pattern bellow type and able to withstand horizontal and vertical movement.

The expansion joint shall be screwed or flanged ends as appropriate to suit application. Be screwed ends to BS EN 10226-1:2004, BS EN 10226-2:2005, BS EN 10226-3:2005 or flanged ends to BS EN 1092-1:2018 as appropriate to facilitate replacement.

The expansion joint shall be manufactured from stainless steel to relevant parts of BS EN 10088:2014 number 1.4301 or SAE Grade 304. It shall be manufactured to withstand the test pressure of the system and maximum static pressure that may arise upon failure of the associated pressure reducing devices. In any case, the working pressure shall not be less than 16 bar with a minimum test pressure of 150% of the working pressure and a minimum burst pressure of 40 bar.

The expansion joint shall be equipped with guide rod assembly which consists of guide rod plates, guide rods, steel washers at both sides, and shall be fitted with resilient neoprene sleeves, resilient neoprene washers on at least one side of the assembly for isolating vibration transmission.

Test report and certificate shall be provided to prove suitability for potable application if installing for potable water supply system.

13.2.1.3.2 Rubber Type Expansion /Flexible Joint

Rubber type expansion /flexible joint shall be used for flush water application. It shall be of double or multiple arch/sphere type, non-toxic, corrosion and abrasion resistant and of sufficient length for effective isolation of vibration.

The expansion /flexible joint shall be fitted with galvanised steel or ductile iron floating flanges to BS EN 1092-1:2007+A1:2013 or BS EN 1092-2:1997 wherever applicable. It shall include a flexible tube made of multiple layers of high tensile fabric reinforcement with EPDM, neoprene or synthetic rubber cover and liner. Tube end shall be of locked

bead construction with steel wire bead ring and raised face. The system working pressure shall not be less than 16 bar, with a minimum test pressure of 1.5 times of the system working pressure and a minimum burst pressure of 55 bar.

The expansion /flexible joint shall be equipped with control rod/cable assembly to prevent damage from excessive movement. The assembly shall consist of control rod/cable plates, control rods/cables, resilient neoprene sleeves, resilient neoprene washers and steel washers to prevent metal to metal contact between the rod/cable and the connector flange.

13.2.1.4 PIPE SLEEVES

13.2.1.4.1 Diameter of pipe sleeves shall be as shown on Drawings, otherwise at least one size larger than the pipe that passes through.

13.2.1.4.2 For pipes passing through walls, slabs etc. which separate different fire compartments, use sleeves of galvanised steel to BS EN 10255:2004 medium grade and carbon steel to BS EN 10217-1:2002 for pipe diameter up to and above 150 mm respectively. Pre-fabricated sleeves of hot dipped galvanised steel to BS EN 10346:2015 can be used for pipe diameter up to and above 150mm subject to approval from Supervising Officer.

13.2.1.4.3 For pipes passing through walls, slabs etc. within the same fire compartment, use sleeves of UPVC pipe to BS 3505:1986 or BS EN ISO 1452-2:2009.

13.2.1.4.4 Where UPVC pipe passes through fire barriers such as fire rated walls and floor slabs, provide an approved type fire collar to BS EN 1366-3:2009 or BS 476-20:1987 with equal or higher fire resistant rating than that of the walls and slabs.

13.2.1.4.5 Puddle sleeves shall be used for pipe passing through external basement walls where there is ground water pressure.

13.2.1.4.6 Puddle flanges for fresh water systems shall be of stainless steel to BS EN 10088-1:2014 Grade 1.4301 with flange end connection to BS EN 1092-1 or gunmetal to BS EN 1982:2008. Puddle flanges for salt water systems shall be of cast iron to BS EN 1561:2011 or ductile iron to BS EN 545:2010.

13.2.1.5 STRAINERS

13.2.1.5.1 Strainer shall be of Y-type or U-type (bucket / basket type) with minimum free flow area ratio of 2 and the maximum aperture size to be of diameter 1.5mm for strainers or nominal size 100mm or below and of diameter 3mm for strainers of nominal size 150mm or above.

13.2.1.5.2 Strainer shall have the same nominal sizes as the pipes in which they are connected and shall be suitable for both working and test pressures of the piping system in which they are installed.

13.2.1.5.3 The construction of fresh water application strainer with nominal sizes up to and including 50 mm shall be as following: -

(a) Body & cover: copper alloy to BS EN 1982:2008 CuSn5Zn5Pb5; and

(b) Screen: austenitic chromium nickel stainless steel or austenitic chromium nickel molybdenum stainless steel to BS EN 10088-1: 2014 number 1.4301 or 1.4401.

13.2.1.5.4 The construction of flush water application strainer with nominal sizes up to and including 50 mm shall be of UPVC or gunmetal or epoxy coated ductile iron body type.

13.2.1.5.5 The construction of fresh water and flush water application strainer with nominal sizes above 50 mm shall be as following: -

(a) Body & cover: grey cast iron to BS EN 1561:2011 EN-GJL-250, or spheroidal graphite cast iron to BS EN 1563:2011 EN-GJS-400-15 or BS EN 1563 EN-GJS-450-15:2011 or BS EN 1563 EN-GJS-500-15:2011;

(b) Screen: austenitic chromium nickel stainless steel or austenitic chromium nickel molybdenum stainless steel to BS EN 10088-1: 2014 number 1.4301 or 1.4401;

(c) Drain plug: malleable iron or copper alloy; and

(d) Cast iron components shall be coated with an epoxy based material.

13.2.1.5.6 All metallic type strainers with nominal sizes up to and including 50 mm shall be of screwed female end connection to BS 21:1985 in conjunction with BS EN 10226-1:2004, and all cast iron type strainers with nominal sizes above 50 mm shall be of flanged end connection to BS EN 1092-2:1997 PN16.

13.2.1.6 VALVES

13.2.1.6.1 General

Valves shall be constructed of materials suitable for both the working and test pressure of the piping system in which they are installed and the temperature of the fluid carried. Unless otherwise specified, all valves shall have a working pressure of not less than 16 bar.

Valves shall be pressure tested in accordance with the relevant standards by the valve manufacturer before leaving the factory. Unless otherwise approved by the Supervising Officer, valves of the same type and same size shall be from the same manufacturer.

Valves shall be of the same nominal size as the pipe in which they are installed except those for flow or pressure control such as modulating float valves or pressure reducing valves as shown on the Drawings.

Manually operated valves shall be closed by turning the handwheel in a clockwise direction when facing the handwheel.

Isolation valves shall be of the full-way solid or split-wedge disc-type and handwheel operated.

All valves shall be provided with or fitted with an indicator to show the open and shut position unless otherwise approved by the Supervising Officer.

Valves and cocks for installation in screwed joined pipework shall have taper screwed ends. Flanges of flanged valves shall be BS EN 1092-2:1997 for PN16 rating or otherwise specified.

Valves shall generally comply with the following standards: -

- Cast iron globe valve shall be to BS EN 13789:2010.

- Copper alloy gate, globe and non-return valve shall be to BS 5154:1991 or BS EN 12288:2010 as appropriate.

- Cast iron non-return valve shall be to BS EN 12334:2001.

- Cast iron gate valve for fresh potable water application, street fire hydrant system and underground pipework system for fresh/flush water application shall be to BS 5163-1:2004 and BS 5163-2:2004 in conjunction with BS EN 1074-1:2000 and BS EN 1074-2:2000.

Valves shall be of the type approved by the WSD. The type test certificates/reports issued by organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS, confirming that the valves have been tested in conformity with this General Specification shall be submitted. Wherever appropriate, the following type test certificates/reports shall be provided upon the request by the Supervising Officer: -

- Test certificates for valves in compliance with the standards quoted in this General Specification.

- Test certificates on composition analysis, chemical, physical and mechanical properties of the metallic materials for valves.

- Test certificates for resilient seating material and epoxy coating showing compliance with the physical property and thickness requirements of this General Specification.

- In case of valves in potable water application, test certificates issued by WRAS or an equivalent organisation for non-metallic materials including resilient seating material and epoxy coating, showing compliance with the full tests of effect on water quality to BS 6920-1:2014 and suitable for potable water usage.

All bronze valves shall be of the screwed female-end connections and all cast iron valves to be of the flanged-end connections.

Threads in screwed-end connections shall comply with BS 21:1985 and flanges of flanged-end connections to comply with BS EN 1092-2:1997 PN 16.

Cast iron parts of all valves shall be coated with an epoxy based material both on internal and external surfaces. The minimum thickness of epoxy coating shall comply with Table 13.2.1.6.1. The coating for use in fresh potable water shall comply with the requirement laid down in BS 6920-1:2014 and shall be approved by WSD.

Table 13.2.1.6.1 Minimum Thickness of Epoxy Coating for Cast Iron Parts of Valve

	Electrostatically Fusion Powder Coated (μm)	Airless Sprayed Application (μm)
Flat and pressurised parts	250	400
Convex outer edges	150	300

13.2.1.6.2 Valves for Fresh Water and Fire Service Application

(a) For nominal sizes up to and including 50 mm: -

(i) Body, bonnet and disc: copper alloy to BS EN 1982:2008 CuSn5Zn5Pb5;

(ii) Stem: brass to high tensile brass to BS EN 12163:2016 or BS EN 12164:2016 or BS EN 12167:2016.

(b) For nominal sizes above 50 mm:

(i) Body and bonnet:

Grey cast iron to BS EN 1561:2011 EN-GJL-250, or spheroidal graphite cast iron to BS EN 1563: 2011 EN-GJS-400-15 or BS EN 1563-GJS-450:2011 or BS EN 1563-GJS-500:2011;

(ii) Disc and seat:

Solid or trimmed with bronze to BS EN 1982:2008 CuSn5Zn5Pb5 or trimmed with austenitic chromium nickel stainless steel to BS EN 10088-3:2014 number 1.4301 or 1.4401;

Resilient material to BS EN 681-1:1996, Type WA, Hardness Category "70" with nominal thickness of minimum 1.5 mm on the non-seating areas and 4.0 mm on the seating areas, and in case for potable water application, showing compliance with full tests of effect on water quality to BS 6920-1:2014.

(iii) Stem

For underground application as well as cast iron gate valve installed in fresh potable water or street fire hydrant system, stainless steel to BS EN 10088-3:2014 number 1.4057.

For applications other than that mentioned in above clause, brass to high tensile brass to BS EN 12163:2016 or BS EN 12164:2016 or BS EN 12167:2016 or stainless steel to BS EN 10088-3:2014 number 1.4301, 1.4401, 1.4006, 1.4005, 1.4021 or 1.4057.

13.2.1.6.3 Valves for Flush Water Application

(a) For nominal sizes up to and including 50 mm: -

(i) Plastic Type Valve

Body, bonnet and disc: PVC or UPVC;

Stem: one-piece with O-ring for positive sealing of the body;

Valve shall be operated by wrench turned in a clockwise direction to close when facing the wrench;

Suitable stops for both fully open and fully closed positions of valve shall be provided;

Socket or union shall be suitable for direct connecting to pipe to which it is installed;

It shall be suitable for both the working pressure and test pressure of the piping system in which it is installed with working pressure of at least 10 bar at 35°C unless otherwise specified.

(ii) Metallic Type Valve

Body, bonnet and disc: copper alloy to BS EN 1982:2008 CuSn5Zn5Pb5;

Stem: brass to high tensile brass to BS EN 12163:2016.

(b) For nominal sizes 65 mm and above: -

(i) Body and bonnet:

Grey cast iron to or BS EN 1561:2011 EN-GJL-250, or spheroidal graphite cast iron to BS EN 1563:2011 EN-GJS-400-15 or BS EN 1563-GJS-450:2011 or BS EN 1563-GJS-500:2011;

(ii) Disc and seat:

Solid or trimmed with zinc free bronze to BS EN 1982:2008 CuSn10 or trimmed with austenitic chromium nickel stainless steel or austenitic chromium nickel molybdenum stainless steel to BS EN 10283:2019 Grade 1.4308 or 1.4408.

Resilient material to BS EN 681-1:1996, Type WA, Hardness Category "70" with nominal thickness of minimum 1.5 mm on the non-seating areas and 4mm on the seating areas.

Stem: stainless steel to BS EN 10088-3:2014 number 1.4401 or 1.4057.

13.2.1.6.4 Non-return Valves

Non-return valves shall be of hinged swing type or wafer spring type or recoil type suitable for vertical or horizontal installations unless otherwise specified.

Non-return valves shall be closed before reversal of flow starts.

Spring type non-return valves shall have a flow area not less than the cross-sectional area of the connected pipework and shall be non-slam in operation. Springs shall be of stainless steel.

Cast iron swing non-return valves shall have the cap and body bolted together to ensure a strong, tight closure.

Bronze swing non-return valves shall have screwed type cap. Hinge pins shall be of brass / bronze for nominal size of 50mm or below and stainless steel for nominal size above 50mm.

Flange end connections shall be to BS EN 1092-1:2007+A1:2013, BS EN 1092-2:1997 and BS EN 1092-3:2003 whenever applicable.

Wafer type spring non-return valves will be acceptable, provided the body ends are capable of matching connecting flanges complying with the requirements of BS EN 1092-1:2018, BS EN 1092-2:1997 and BS EN 1092-3:2003.

13.2.1.6.5 Gate and Globe Valves

Gate valve shall be full way solid or split wedge disc type with rising or non-rising stem.

Globe valve shall be of straight globe type with rising stem.

The valves shall be provided with an indicator to show the open and shut position at critical locations for cast iron valves as shown on Drawings.

For bronze type valves, the bonnet shall be of the screwed type with ample threads to ensure positive sealing to the body.

All bronze valves shall be of the screwed female end connection to BS 21:1985 in conjunction with BS EN 10226-1:2004 and all cast iron valves shall be of the flanged end connections to BS EN 1092-2:1997 PN16.

For cast iron type valve, the body and bonnet shall be bolted together and the disc shall be guided. The gland shall be fitted with non-asbestos packing and shall be bolted for cast iron valves.

13.2.1.6.6 Control Valves of Flushing Cisterns

Plastic type ball valve shall be used. It shall be ball centre-pivoted, smooth and spherical with a circular orifice, and seated on resilient seating suitable for tight shut off.

At fully open position of valve, wrench shall be mounted parallel to the flow of passage through the valve. The valve shall be fully closed with the wrench operates at a quarter turn.

The valve shall be suitable for both the working and test pressure of the piping system in which it is installed with working pressure of at least 10 bar at 35°C unless otherwise specified.

13.2.1.6.7 Ball Float Valves for Water Tanks

Ball float valves shall be of the slow closing type unless otherwise specified. The valve body shall be robust and shaped to give a good flow pattern.

The valve piston shall close in the direction of flow such that the pressure in the water supply mains shall tend to keep the valve closed and that the piston seal is afforded protection from the flow by the piston.

All internal parts shall be easily removable for maintenance with the face and piston seals easily replaceable.

Ball floats shall be of tinned copper to BS 1968:1953 and BS 2456:1990 or of stainless steel to relevant parts of BS EN 10088:2014 for fresh water application and of neoprene coated copper or 316 stainless steel for flush water application. All ball floats shall be spherical.

Lever arms shall be of stainless steel for flush water application.

Ball float valves of sizes 50 mm and under shall be copper alloy to BS 1212-1:1990 suitable for high pressure application.

Ball float valves for tanks for sizes over 50 mm shall be cast iron or ductile iron body with gunmetal piston, seat and guide, suitable for high pressure. For salt water systems ball float valves shall be of cast iron, zinc free bronze or stainless steel body with zinc free bronze piston, seat and guide or with all 316 stainless steel internal construction.

13.2.1.6.8 Ball Float Valve for Flushing Cisterns

Ball float valve for flushing cisterns shall be of diaphragm type float operated valve to BS 1212-3:1990 with rubber or plastic diaphragm, unless otherwise approved by the Supervising Officer and be suitable for high, medium or low pressure as required. It shall be suitably coated to prevent corrosion on metal parts. Valve sample shall be submitted for approval prior to installation.

13.2.1.6.9 Flushing Valves

Flushing valve shall be corrosion resistant, made of brass, stainless steel or high grade thermoplastics and activated by sensor and/or manually pressing on a push-button or lever.

The flow rate of the flush water shall be adjustable. Flush valve with cistern and direct flush valve shall maintain minimum flow rate of 1.5 litre/second and 0.7 litre/second respectively.

The valve shall have such feature to allow it to go through the complete flush cycle and then shut off automatically, regardless of whether the handle is held down or released. Such automatic closure to take place slowly and progressively without hammering effect.

The volume of water per flushing cycle shall match with the sanitary fitments.

The minimum water volume per flushing cycle shall be 4.5 litres for water closet (full flush) and 1.0 litre for urinal.

13.2.1.7 PRESSURE REDUCING VALVES

13.2.1.7.1 Fixed Ratio Type Pressure Reducing Valves

Fixed ratio type pressure reducing valve shall be able to maintain the outlet pressure as a fixed ratio of the inlet pressure, independent of the magnitude of the inlet pressure and the water flow across the valve.

It shall be of a size and pressure ratio as specified on the Drawings.

The operating pressure range of the valve shall be suitable for the particular application and it shall have a rated working pressure of not less than 16 bar.

Each valve shall be hydraulic tested at 1.5 times the nominal pressure of the valve for a period of not less than 1 minute at the factory.

Details of the pressure reduction against flow rate and inlet pressure performance curve and test certificates /reports issued by organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS, confirming that the valve has been tested in accordance with the requirements of this Specification shall be submitted to the Supervising Officer for examination and approval of use.

The valve body shall be of gunmetal to BS EN 1982:2008 CuSn5Zn5Pb5 or stainless steel to BS EN 10088-1:2014 number 1.4401.

The non-metallic components / parts including lubricant / grease for PRV shall show compliance with the relevant requirements in BS 6920-1:2004 as required by the WSD for non-metallic components in contact with water intended for human consumption.

The valve shall have a piston of straight through configuration, constructed of stainless steel at least to BS EN 10088-3:2014 number 1.4301 for fresh water and BS EN 10088-3:2014 number 1.4462 for flush water application unless otherwise approved by the Supervising Officer.

The valve shall with seats and O-ring seals of high grade synthetic rubber.

The valve shall be provided with an arrow on the exterior to indicate the direction of flow.

The valve shall with end connections of thread-in screw type to BS EN 10226-1:2004, BS EN 10226-2:2005, BS EN 10226-3:2005 or flanged type to BS EN 1092-1: 2018 whenever applicable. Testing of valves shall comply with BS EN 1567:1999.

13.2.1.7.2 Pilot Type Pressure Reducing Valves

Pilot type pressure reducing valve shall be hydraulically operated, pilot-controlled and of diaphragm or piston-actuated type. The whole valve shall be assembled and tested by the manufacturer.

The valve shall be provided with a strainer in the pilot control system. It shall be of flanged-end connection with flange to BS EN 1092-2:1997 PN16. The main valve and its pilot control system shall contain no packing glands or stuffing boxes.

The valve shall be capable to reduce a higher inlet pressure to a steady downstream pressure regardless of fluctuations in flow rate and/or varying inlet pressure. The downstream pressure shall be adjustable and could be reduced down to a pressure suitable for the application. The valve shall be selected in such way that no cavitation shall occur within the anticipated flow and pressure ranges.

Means shall be provided for adjusting the response of the valve to changes in inlet pressure without the use of special tools.

The valve, when in operation, shall not cause any noise nuisance. Otherwise, a suitable acoustic enclosure to cover the valve shall be provided.

The operating pressure range of the valve shall be suitable for the particular application. Unless otherwise specified, the minimum rated working pressure of the valve shall not less than 16 bar.

Each valve shall be hydraulic tested at 1.5 times the nominal pressure of the valve for a period of not less than 1 minute at the factory.

The valve shall be of the type approved by the Water Authority as in accordance with its application. Details of the pressure reduction against flow rate and inlet pressure performance curve within the specified pressure range and test certificates /reports issued by organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS, confirming that the valve has been tested in accordance with the requirements of this General Specification shall be submitted to the Supervising Officer for examination and approval of use.

The valve shall have the minimum standard as specified below for its intended purposes: -

(a) Body and bonnet:

Cast iron to BS EN 1561:2011 EN-GJL-250 or ductile iron to BS EN 1563:2011. The body shall be epoxy or polyester coated both inside and outside.

(b) Disc:

Solid or trimmed with bronze to BS EN 1982:2008 CuSn5Zn5Pb5, or with stainless steel to BS EN 10088-2:2014 number 1.4301, or with ductile iron to BS EN 1563:2011; or trimmed with rubber compound for use in fresh water.

Solid or trimmed with zinc free bronze to BS EN 1982:2008 CuSn10 or stainless steel to BS EN 10088-2:2014 number 1.4301 or ductile iron to BS EN 1563:2011 with epoxy /polyester coated; or trimmed with rubber compound for use in flush water.

(c) Seat:

Bronze trimmed as disc for use in fresh water.

Zinc free bronze or stainless steel trimmed as disc for use in flush water.

(d) Stem:

High tensile brass to BS EN 12163:2016 or stainless steel to BS EN 10088-3:2014 number 1.4006, 1.4005 or 1.4021 for use in fresh water.

Stainless steel to BS EN 10088-3:2014 number 1.4301 or 1.4401 for use in flush water.

13.2.1.8 CISTERNS AND TANKS

Cisterns and tanks for intended applications shall comply with the requirements by the Water Authority.

Galvanised low carbon steel cisterns and lids, tanks and cylinders shall be manufactured to comply with BS 417-2: 1987 of Grade A thickness. Joints between sections of cistern lids to have weatherproof standing welt type laps.

Glass fibre reinforced plastic cistern shall be to BS EN 13280:2001.

SUB-SECTION 13.2.2

WATER HANDLING EQUIPMENT

13.2.2.1 FRESH WATER PUMPS FOR POTABLE APPLICATION

13.2.2.1.1 Pumps for potable application unless otherwise specified, shall be of one of the following types: -

(a) Vertical multi-stage centrifugal type, the pump set shall be packaged type with close-coupled pump motor integrated as a single unit. The pump unit shall be a proprietary product. The pump motor shall be able to dismantle from the pump unit without disruption of the pipework nor dismounting the pump unit from the plinth; or

(b) End suction centrifugal type, the pump set shall be installed with spacer type coupling so that the pump impeller can be dismantled from the motor side for servicing without disruption of the pipework nor dismounting the motor. Where large static heads have to be pumped against, multi-stage configurations shall be used.

13.2.2.1.2 Materials of Construction

Unless otherwise specified, the materials of construction of the pumps shall be as follows whenever applicable: -

Casing	:	Stainless steel
Impeller	:	Stainless steel
Shaft	:	Stainless steel
Sleeves	:	Stainless steel
Casing rings	:	Stainless steel
Shaft nuts	:	Stainless steel
Stuffing box housing	:	Gunmetal
Glands	:	Bronze
Lantern ring	:	Bronze

Alternative materials shall subject to the approval of the Supervising Officer.

13.2.2.1.3 Standards

(a) Casing Material

Unless otherwise specified for the above types of pumps, casing shall be of stainless steel to AISI 316.

(b) Impellers & Guide Rings

The impeller shall be of the enclosed type and be of stainless steel to AISI 316. Renewable guide rings shall be bronze and shall be provided in the casing, keyed to prevent rotation.

(c) Shaft, Sleeves and Glands

Stainless steel shall be to BS EN ISO 683-3:2018 and BS EN ISO 683-4:2018, ground and polished. The sleeves shall be keyed to prevent rotation and secured against axial movement.

(d) Stuffing Boxes and Drain Piping

Gunmetal stuffing boxes housing shall comply with BS EN 1982:2017 or ISO 197-4:1983 and shall be of ample length with bronze lined gland and neck bush, fitted with approved packing and lantern ring water seal. Drain piping to the nearest builder's drain to remove gland leakage shall be provided. Alternatively, a mechanical seal may be offered. Mechanical seals shall be of leak free operation. The mechanical seal shall be the product of specialist proprietor and the materials used shall be suitable for the pumped liquid.

13.2.2.2 FRESH WATER PUMPS FOR NON-POTABLE APPLICATION

13.2.2.2.1 Pumps for non-potable application unless otherwise specified, shall be of one of the following types: -

(a) Centrifugal type with volute casing split on the centreline of the shaft with suction and delivery connections flanged and fitted to the non-removable half of the casing;

(b) End suction type, the pump set shall be installed with spacer type coupling so that the pump impeller can be dismantled from the motor side for servicing without disruption of the pipework nor dismounting the motor; or

(c) Vertical spindle type centrifugal pump installed on pump plinth or supported by pipework.

Where large static heads have to be pumped against, end suction type or vertical spindle type centrifugal pump shall be used in multi-stage configurations. In general, the type of pump required shall be as specified in the Particular Specification and/or in the Drawings. However, if this is not so specified, the type end suction type pump set shall be installed.

13.2.2.2.2 Materials of Construction

Unless otherwise specified, the materials of construction of the pumps shall be as follows: -

Casing	:	Cast iron / Stainless Steel
Impeller	:	Zinc free bronze / Cast iron / Stainless steel
Shaft	:	Carbon Steel / Stainless Steel
Sleeves	:	Bronze / Stainless Steel
Casing rings	:	Bronze / Stainless Steel / Cast Iron
Shaft nuts	:	Bronze / Stainless Steel
Stuffing box housing	:	Cast Iron / Gunmental
Glands	:	Carbon Steel / Bronze
Lantern ring	:	Bronze

13.2.2.2.3 Standards

(a) Casing Material

Unless otherwise specified for the above types of pumps, casing shall be cast iron comply with BS EN 1561:2011 or ISO 185:2005 or stainless steel to AISI 316.

(b) Impellers & Guide Rings

The impeller shall be of the enclosed type and be of stainless steel to AISI 316, or stainless steel to AISI 316.

Renewable guide rings shall be bronze and shall be provided in the casing, keyed to prevent rotation.

(c) Shaft, Sleeves and Glands

Stainless steel shall be to BS EN ISO 683-3:2018 and BS EN ISO 683-4:2018 ground and polished.

Bronze sleeves shall comply with BS EN 1982:2017 or ISO 197-4:1983 and shall be provided through the sealing glands to protect the shaft from wear. The sleeves shall be keyed to prevent rotation and secured against axial movement.

(d) Stuffing Boxes and Drain Piping

Cast iron stuffing boxes housing shall comply with BS EN 1561:2011 or ISO 185:2005 and shall be of ample length with bronze lined gland and neck bush, fitted with approved packing and lantern ring water seal. Drain piping to the nearest builder's drain to remove gland leakage shall be provided. Alternatively, a mechanical seal may be offered. Mechanical seals shall be of leak free operation. The mechanical seal shall be the product of specialist proprietor and the materials used shall be suitable for the pumped liquid.

13.2.2.3 FLUSHING WATER PUMPS

13.2.2.3.1 These pumps shall be utilised for pumping seawater, harvested rainwater wherever these applications apply. Unless otherwise specified, the configuration of flushing water pumps inside a building plant rooms shall be of the centrifugal type with volute split casing type.

13.2.2.3.2 Materials of Construction

Unless otherwise specified, the materials of construction for saline water pump shall be as follows: -

Casing	:	Cast iron / Stainless Steel
Impeller	:	Zinc free bronze / Stainless steel
Shaft	:	Stainless Steel
Sleeves	:	Bronze / Stainless Steel
Casing rings	:	Stainless Steel
Shaft nuts	:	Bronze
Stuffing box housing	:	Cast Iron
Glands	:	Carbon Steel
Lantern ring	:	Bronze

13.2.2.3.3 Standards

(a) Casing

Unless otherwise indicated, the casing shall be of cast iron to BS EN 1561:2011 or ISO 185:2005 or stainless steel to BS EN 10283:2019 Grade 1.4408 or better and approved.

(b) Impeller and Shaft Sleeve

Impeller and shaft sleeve of saline water pumps shall be of one of the materials as below: -

- Zinc-free bronze to BS EN 1982:2017 CC480K or CC481K; or ISO 197-4:1983;

- Austenitic cast iron to BS EN 13835:2012 Number 5.1500; or ISO 2892: 2007 Ed2 (R10); or

- Stainless steel to BS EN 10283:2019 Grade 1.4408.

For pumping seawater in harbour area, stainless steel shall be used.

(c) Shaft

The shaft shall be of stainless steel to BS EN ISO 683-3:2018 and BS EN ISO 683-4:2018, AISI 316, ground and polished.

(d) Stuffing Boxes and Drain Piping

Stuffing boxes shall be of cast iron housing and ample length completed with bronze lined gland and necks bushes, fitted with approved packing and bronze lantern ring water seal. Drain piping to the nearest builder's drain for gland leakage shall be provided. Alternatively, a mechanical seal may be offered. Mechanical seals shall be of leak free operation. The mechanical seal shall be the product of specialist proprietor and the materials used shall be suitable for the pumped liquid.

13.2.2.4 PUMP BASE PLATE

The based plate shall be made of cast iron or fabricated mild steel. Couplings shall be flexible of the steel pin and synthetic rubber bushing type, and fitted with steel guards.

13.2.2.5 VIBRATION ISOLATORS

The bases shall be mounted on the raised housekeeping plinth using appropriate anti-vibration spring mountings that shall be individually selected according to load distribution and shall have an additional free travel equal to one half of the rated deflection.

Vibration isolator shall contain a steel spring with minimum 8mm pad of neoprene in series and enclosed in hanger box. The neoprene element shall be moulded with a rod isolation bushing that passes through the isolator hanger box.

Spring diameter and isolator hanger box hole sizes shall be large enough to permit the hanger rod to swing through a 30 degrees arc before contacting the edge of the hole and short-circuiting the spring. The minimum static deflection of the spring shall be 20 mm.

13.2.2.6 GAUGES

Pressure gauges shall comply with BS EN 837-1:1998 calibrated in kPa from zero to not less than 1.3 times and not more than twice the operating pressure of the respective equipment/system and shall be accurate to 1.5% of full scale reading, unless otherwise specified.

The dials of gauges shall not be less than 100 mm diameter and the cases shall be of polished brass or chromium-plated or anti-corrosive painted mild steel with optical sight glass.

Pressure gauges used solely to indicate the head and pressure of water shall be provided with an adjustable red pointer set to indicate the normal working pressure or head of the system.

13.2.2.7 DRAIN AND VENT

The drain vent shall be built-in completed with a drain plug except where the pump is inherently self-venting.

13.2.2.8 FLANGED CONNECTIONS

Pumps shall have flanged connections conforming to the Table of BS EN 1515-1:2000, BS EN 1092-1:2018, BS EN 1092-2:1997, BS ISO 7005-1:2011 or ISO 7005-2:1988 as appropriate to the maximum working pressure. Taper pieces shall be provided where necessary for connection to pipework.

SUB-SECTION 13.2.3

DRINKING FOUNTAIN AND WATER DISPENSER

13.2.3.1 GENERAL

13.2.3.1.1 All the plumbing works of the integral set of drinking fountain and water dispenser including ultraviolet (UV) steriliser and water filters (and water chiller if required) shall be in full compliance with the Waterworks Ordinance (Cap.102); Waterworks Regulations (Cap. 102A); other subsidiary legislation made under the Ordinance; requirements of Water Authority (WA), and be carried out by Licensed Plumber (LP).

13.2.3.1.2 For drinking water safety, the non-metallic parts in contact with water shall comply with BS 6920:2014.

13.2.3.1.3 The Drinking Fountain and Water Dispenser shall be certified to meet the requirement of NSF/ANSI Standard 61: Drinking Water System Components–Health Effects and NSF/ANSI Standard 372: Drinking Water System Components–Lead Content or any equivalent standard(s) approved by WSD.

13.2.3.1.4 The Drinking Fountain and Water Dispenser shall be suitable for local installation and fitted with a 3-core PVC insulated and sheathed flexible cable conforming to BS EN50525-2-11:2011 or equivalent standards, and complete with a suitably fused 13 A plug conforming to the Electrical Products (Safety) Regulation, (Cap. 406G). The Drinking Fountain and Water Dispenser shall also comply with Telecommunication (Control of Interference) Regulations, (Cap.106B).

13.2.3.1.5 All the water pipes interconnecting with the drinking fountain/water dispenser and its associated accessories shall be of one of the below types to suit on site condition: -

(a) Half hard temper copper tubes for aboveground installation and hard temper copper tubes for underground installation to BS EN 1057:2006+A1:2010.

(b) Rubber hose for aboveground installation to BS 6920:2014 for application in potable water system.

(c) Stainless steel pipe Grade 316 for aboveground installation to BS EN 10312:2002 +A1:2005 or BS EN 10217-7:2014 (for pipe size over 50 mm dia.), stainless steel pipe fitting to AS 3688:2016.

13.2.3.1.6 Unless otherwise specified on Drawings, push fit or press fit type fittings shall be adopted for connection of copper pipework unless or otherwise approved by the Supervising Officer.

13.2.3.1.7 The water distribution pipework of drinking fountain/water dispenser and associated accessories shall be installed in good practice to prevent

growth of legionella bacteria and other water-borne organisms. The length of the water distribution pipework shall be minimised and the configuration shall prevent proliferation of legionella or other bacteria in stagnated water. Dead legs and stagnant corners shall be avoided and the length of piping shall be minimised.

13.2.3.1.8 The thermal insulating material shall be of non-combustible and non-CFC type. Polystyrene foam insulation will not be accepted.

13.2.3.1.9 When the water filter set for water dispenser is clogged and the visual indicating alarm signal is activated, the clogged filter set shall be replaced.

13.2.3.1.10 Routine inspection of water filter and UV steriliser quartz sleeve (with cleaning of UV steriliser quartz sleeve) in every three months shall be conducted. The water filter and UV lamp shall be replaced according to manufacturer's recommendation but not less than an interval of every three months for filter and six months for UV lamp during the Maintenance Period.

13.2.3.2 DRINKING FOUNTAIN

13.2.3.2.1 Drinking fountain in general shall be connected directly to fresh water supply with a drain point to the drainage discharge. It shall comprise of a cold water tank (with water chiller if required); a set of UV steriliser, in-line water filter(s) and control accessories. Drinking fountain, either of bubbler and/or bottle filling types shall comprise of a drinking fountain equipment, an UV steriliser as described in Clause 13.2.3.4, an in-line water filter as described in Clause 13.2.3.5, and a chiller (if required) as described in Clause 13.2.3.6. These components form an integral set of the system and the technical performance of each component is specified below. It shall be required to supply and install an integral set of the system with the components as described above to be the minimum provision, to the satisfaction of the Supervising Officer.

13.2.3.2.2 The works include supply, install, test and commission the drinking fountain where shown on the Drawings or as specified.

13.2.3.2.3 For pedestal bottle-filling station, there shall be a platform under the spout for steady placing a cylindrical bottle with diameter not less than 100mm. The height between the spout and the top of the fountain basin shall be at least 250 mm.

13.2.3.2.4 The bubbler type shall deliver drinking water at flow rate of minimum 0.5 litre per minute. The bottle filling type drinking fountain shall deliver drinking water at flow rate of minimum 4 litres per minute.

13.2.3.2.5 The working water pressure of the drinking fountain shall be between 2 to 5 bar.

13.2.3.2.6 The drinking fountain shall be vandal resistant and manufactured from corrosive-resistant stainless steel to ensure complete rigidity. Unless

otherwise specified, the basin of the drinking fountain shall be in Grade 316 stainless steel with a finish to the satisfaction of the Supervising Officer.

13.2.3.2.7 The drinking fountain shall be completed with an integral drain strainer

13.2.3.2.8 Wall-mounted bottle-filling type drinking fountain shall include but not limited to the following requirements: -

(a) The drinking fountain assembly shall be safely and firmly mounted according to the recommendation of the manufacturer;

(b) Coated with antimicrobial coating;

(c) Control supply of water by touchless electronic bottle sensor under the spout and pressure sensor button(s) at the front and/or sides of the basin; and

(d) Completed with a LED indicator light showing the filter status to be switched on when filter change is necessary, controlled either by cumulative operation timer or flow sensor.

13.2.3.2.9 A warning label advising the users to flush before consumption shall be permanently attached at conspicuous location near the spout(s). Information label(s) indicating the last replacement and scheduled next replacement date and time of in-line water filter, UV lamp and UV steriliser quartz sleeve shall also be attached at conspicuous location near the spout(s).

13.2.3.2.10 The drinking fountain shall fully comply with the barrier free access requirements in Chapter 5.6 and relevant parts/figures in Design Manual: Barrier Free Access 2008 published by Buildings Department.

13.2.3.3 WATER DISPENSER FOR PANTRY

13.2.3.3.1 The works include supply, install, test and commission the indoor used water dispenser where shown on the Drawings or as specified. The specifications as described below are the minimum provisions, appropriate supplementary or alternative provisions shall be required to the satisfaction of the Supervising Officer.

13.2.3.3.2 The water dispenser shall comprise of a water dispenser equipment, an UV steriliser, an in-line water filter and control accessories.

13.2.3.3.3 The test certificates issued by WaterMark Technical Specification WMTS-105, NSF/ANSI, WRAS or an equivalent organisation for the water dispenser in compliance with international standards shall be submitted. Alternatively, type test reports and certificates to the following required standards issued by organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an

accreditation scheme mutually recognised by HOKLAS or HKAS, shall be submitted: -

(a) Boiled water sample in compliance with the guideline values published by World Health Organization (WHO);

(b) Manufactured from lead-free soldering material; and

(c) Low lead content components, i.e. less than 1% by mass.

13.2.3.3.4 The water dispenser shall be of floor standing, wall-mounted, or countertop type where shown on the Drawings or as specified in this General Specification. The water dispenser shall be able to connect to potable water supply point and have discharge drain.

13.2.3.3.5 The water dispenser shall be able to supply water of drinking quality as follows: -

(a) Hot water with adjustable temperature from 90 ºC to 100 ºC at spout. It shall be boiled up to temperature of 100 ºC before dispensing and shall provide adequate heating capacity of minimum 60 litres per hour of hot drinking water which is stored at the hot water tank with minimum capacity of 20 litres. Tank size shall follow the manufacturer's recommendation and to suit the user's operational need;

(b) Water at room temperature; and

(c) Chilled water at 15ºC or below at spout.

13.2.3.3.6 The water tanks of water dispenser shall be of stainless steel to BS EN 10088-3:2014 or equivalent.

13.2.3.3.7 The water dispenser shall comply with the latest edition of IEC 60335-1; IEC 60335-2-15 and IEC 60335-2-24 on electrical safety.

13.2.3.3.8 The basin underneath the spout(s) shall have flat surface grating and drain. The space between the spout(s) and the grating shall be not less than 200mm height and 100mm width.

13.2.3.3.9 The minimum heating capacity of the electric water heater shall be of 1kW. The water heater shall be fitted with automatic thermal safety and low hot water tank level cut-off.

13.2.3.3.10 The minimum cooling capacity of the chiller shall be of 0.5 litre per minute at 15°C water temperature at the spout. Refrigerants used in chillers shall comply with Clause 6.1.6.1.

13.2.3.3.11 For water dispenser with direct water supply from water mains, backflow prevention device with certificate issued by WRAS and accepted by the Water Authority shall be provided at upstream of the water incoming inlet of the water dispenser.

13.2.3.3.12 The incoming water of the water dispenser shall be first filtered by water filter(s) and then sterilised by UV steriliser at upstream of the hot water tank. The water filter(s) and UV steriliser shall be built-in inside the water dispenser of floor mounted type, unless or otherwise to the satisfaction of the Supervising Officer for consideration of other types as appropriate.

13.2.3.3.13 The thermal insulating materials shall be of non-combustible and non-CFC type.

13.2.3.3.14 The water dispenser shall be manufactured for heavy duty application to ensure complete rigidity.

13.2.3.3.15 The water dispenser shall be fitted with the following devices: -

(a) A "power ON" indicator light; and

(b) An indicator light for the refrigeration unit to indicate its operation.

13.2.3.4 UV STERILISER

13.2.3.4.1 The UV steriliser shall be installed at downstream of the water pipework connecting to the drinking fountain or water dispenser unless or otherwise to the satisfaction of the Supervising Officer.

13.2.3.4.2 The UV steriliser shall be sterilise potable water by means of high energy UV irradiation at wavelength of 253.7 nm with a minimum exposure dosage of 16 mJ/cm^2 at designed flow and with normal service life not less than 6,000 hours. The UV irradiation shall comply with the latest NSF/ANSI Class B Standard.

13.2.3.4.3 The working water pressure of the UV steriliser shall be between 1 to 5 bar. It shall be suitable to operate with a 220V±10% 50Hz power supply.

13.2.3.4.4 The lamp in the UV steriliser shall not come into contact with water and shall be housed in special fused quartz sleeve.

13.2.3.4.5 Pipe length from UV steriliser to the spout shall be kept as short as possible to minimise the volume of water remain in the pipework.

13.2.3.4.6 The UV steriliser shall be fitted with "power on" and "lamp failure" indicator lights to indicate the lamp condition.

13.2.3.4.7 The water dispensing function shall be suspended in case the UV steriliser was in failure to ensure water safety. Safety shut-off valve and fail-safe deactivation system shall be fitted to stop flow of water in case of failure of the UV steriliser. The safety shut-off valve shall be installed at upstream of the UV steriliser. In case solenoid valve is employed for the safety shut-off valve, the heat generated by the solenoid shall not heat up water to temperature above 30°C under prolonged operation.

13.2.3.5 IN-LINE WATER FILTER

13.2.3.5.1 For drinking fountain and water dispenser with direct water supply from mains, backflow prevention device as approved by WSD shall be provided at upstream of the in-line water filter and there shall be no branch pipe in between the backflow prevention device and the filter.

13.2.3.5.2 The in-line water filter shall be installed at the upstream of the water pipework connecting to and close to the drinking fountain or water dispenser.

13.2.3.5.3 The in-line water filter shall be either ceramic type or carbon type and comply with NSF/ANSI 42 or equivalent standard. Indication of filter clog shall be provided for alarming the necessity of replacing water filter set.

13.2.3.5.4 The working water pressure of the in-line water filter shall be between 1 to 5 bar and suitable for operating temperature between 5°C and 38°C.

13.2.3.6 CHILLER

13.2.3.6.1 Any parts of equipment including the cooling coils which are in contact with drinking water shall be of lead free material. Written confirmation shall be provided by the manufacturer of the product to prove compliance.

13.2.3.6.2 The chiller shall have adequate cooling capacity to provide minimum of 4 litres chilled drinking water per hour at a temperature between 10°C and 13°C from a water inlet temperature of 27°C under ambient temperature of 35°C.

13.2.3.6.3 The working water pressure of the chiller shall be between 2 to 5 bar. It shall be suitable to operate with a 220V±10% 50Hz power supply. The refrigeration process shall stop automatically if the water temperature inside the water pipe leaving the chiller is equal to or less than 10°C.

SUB-SECTION 13.2.4

RAINWATER HARVESTING INSTALLATION

13.2.4.1 FIRST FLUSH DEVICE

13.2.4.1.1 The first flush device shall be capable of preventing the first 20 to 25 litres of rainwater per 100m^2 catchment area entering the rainwater collection tank.

13.2.4.1.2 A slow release drain valve for automatic emptying the chamber of the first flush device after rain shall be provided. First flush diverter shall be provided for diverting the first few minutes away from the rainwater collection tank. The diverted water shall be drained via an appropriate drainage system.

13.2.4.1.3 An automatic oil trap, where the oil is skimmed off automatically upon activation by a timer or sensors, shall be included into the rainwater harvesting installations for driveways, car parks, etc.

13.2.4.2 RAINWATER COLLECTION TANK

13.2.4.2.1 The rainwater collection tank shall be provided and installed with an effective capacity to suit the contract requirements. The tank shall also comply with the requirements set out in the Waterworks Regulations.

13.2.4.2.2 By-pass pipeworks shall be provided to divert the rainwater to drain when the rainwater collection tank is full. The size of overflow pipe shall not be less than the diameter of the inlet pipe. A three-way valve with a set of by-pass valve for maintenance purposes shall also be provided to divert water from entering the collection tank during roof surface cleaning.

13.2.4.2.3 Fibreglass water tanks shall comply with relevant requirements in Part 15 of this General Specification.

13.2.4.2.4 Proper insect screening devices in the form of wire mesh shall be provided for all openings and vent pipes.

13.2.4.2.5 A warning label displaying “Caution – Non-drinking water, do not drink” in English and “小心 - 非飲用水，請勿飲用” in Chinese shall be provided and secured in a proper and conspicuous side of all water tanks.

13.2.4.3 MIXING TANK

13.2.4.3.1 The mixing tank shall be supplied and installed in accordance with WSD’s drawing No. Figure 15 of the Technical Requirements for Plumbing Works in Buildings.

13.2.4.3.2 Fibreglass water tanks shall comply with relevant requirements in Part 15 of this General Specification.

13.2.4.3.3 Size of the overflow pipe shall be twice of the diameter of the respective largest inlet pipe or 40mm, whichever is greater.

13.2.4.3.4 Proper insect screening devices in the form of wire mesh shall be provided for all openings and vent pipes.

13.2.4.3.5 A warning label displaying "Caution – Non-drinking water, do not drink" in English and "小心 - 非飲用水，請勿飲用" in Chinese shall be provided and secured in a proper and conspicuous side of all water tanks.

13.2.4.3.6 A water level control system shall be provided to prioritise the use of collected rainwater instead of fresh water supply from the make-up break tank. The level difference for control shall be 200mm minimum.

13.2.4.4 MAKE-UP BREAK TANK

13.2.4.4.1 The make-up break tank shall provide a means of isolation between the make-up water supply and rainwater harvesting installation. The water consumption from make-up water tank and from treatment system shall be measured by flow meters. The tank shall comply with the requirement set out in the Waterworks Regulations.

13.2.4.4.2 Fibreglass water tanks shall comply with relevant requirements in Part 15 of this General Specification.

13.2.4.4.3 Proper insect screening devices in the form of wire mesh shall be provided for all openings and vent pipes.

13.2.4.4.4 A warning label displaying "Caution – Non-drinking water, do not drink" in English and "小心 - 非飲用水，請勿飲用" in Chinese shall be provided and secured in a proper and conspicuous side of all water tanks.

13.2.4.5 RAINWATER PUMP SET

13.2.4.5.1 The rainwater pump shall be sized and selected with sufficient pressure head and flow rate to deliver collected rainwater from the rainwater collection tank to the mixing tank through the filtration and treatment system.

13.2.4.5.2 Unless other specified, there shall be at least one standby pump in addition to the duty pump for each pump set.

13.2.4.5.3 The pump impeller, shaft, sleeves and casing ring shall be of stainless steel materials.

13.2.4.5.4 Unless otherwise specified, the rainwater pump and the local motor control panel shall comply with relevant requirements in this General Specification.

13.2.4.5.5 A basket type strainer with removable stainless steel basket shall be provided upstream the rainwater pump.

13.2.4.6 RAINWATER TREATMENT PLANT

13.2.4.6.1 The rainwater treatment plant shall comprise of filtration system, chlorine disinfection system and associated pipework, electrical accessories, automatic control and monitoring equipment, structural support and all other necessary accessories.

13.2.4.6.2 The sand filter and activated carbon filter in filtration system shall comply with relevant requirements in this General Specification.

13.2.4.6.3 To allow efficient distribution of water in the filter, the inlet and outlet distribution pipe shall be installed to cross the whole length of the filter for horizontal tank or cross the whole diameter of the filter for vertical tank. Internal inflow diffuser for even distribution of water flow across the filter bed shall be provided inside the filter vessel.

13.2.4.6.4 Each filter vessel shall be equipped with inlet and outlet pressure gauges and differential pressure sensor (for auto-control backwash) for filtering and automatic backwashing operations. The automatic backwashing operations shall also be controlled by timer or differential pressure sensor in the control system. The backwash frequency shall not be less than once per week.

13.2.4.6.5 The filter vessel shall have suitably sized inlet and outlet connections, drain connection, access ports and vent fittings if required. The vessel shall be equipped with automatic air vent, manual air vent and manual drain valve.

13.2.4.6.6 Filter bed shall consist of at least two but preferably more layers of filter media, each having a different particle size properly supported by a suitable under drain.

13.2.4.6.7 The filtering media shall consist of quartz sand /a composite filter media containing quartz sand and granular activated carbon. Quartz shall have mean particle diameter of 0.4 to 0.6mm and granular activated carbon shall have mean particle diameter of 0.6 to 1.1mm. The depth of filter media shall be sized according to the plant capacity and the manufacturer's recommendation for low to medium filtering rate. The sand filter shall have minimum 90% particulate removal efficiency for particle size of 10 micro meters.

13.2.4.6.8 The activated carbon filter shall be capable of filtering sediment, colour and odour for raw rainwater filtration application. The activated carbon filter shall have minimum 90% particulate removal efficiency for particle

size of 20 micro meters. The filter shall not release carbon fines during operation.

13.2.4.6.9 The body of the filter vessel shall be of fibreglass reinforced plastic (FRP) or injection moulded high impact plastic for durability. It shall be UV and corrosion resistant.

13.2.4.6.10 Thermoplastic rubber gaskets shall be provided at all maintenance openings for effective sealing.

13.2.4.6.11 The chlorine disinfection system shall be equipped with probe type residual chlorine sensor at appropriate locations to continuously monitor the concentration of chlorine of the collected rainwater. The chlorination shall be adjusted by injecting dosage at the mixing tank.

13.2.4.7 PIPEWORKS, VALVES AND FITTINGS

13.2.4.7.1 All pipes and fittings shall comply with the Waterworks Regulations and guidelines issued by WSD.

13.2.4.7.2 Unless otherwise specified, pipe materials used in rainwater harvesting system shall be of UPVC type complying with relevant clauses in Part 15 of this General Specification.

13.2.4.7.3 All valves and fittings shall be able to resist the corrosion of chemicals likely to be present in the rainwater. Valves and accessories shall comply with relevant clauses in Part 15 of this General Specification.

13.2.4.7.4 All plant room valves and circuit control valves shall be provided with approved plastic labels. A circuit control diagram of appropriate size showing the location of each isolating, regulating and control valve shall be provided and fixed in a glazed hardwood frame in a position indicated by the Supervising Officer.

13.2.4.7.5 A warning label displaying “Caution – Non-drinking water, do not drink” in English and “小心 - 非飲用水，請勿飲用” in Chinese shall be provided and secured at all draw-off points.

13.2.4.7.6 The distribution pipework and outlet fittings for use of recycled rainwater shall be configured to prevent improper use as potable water. All components of the rainwater harvesting installation shall be clearly and consistently identified. Identification shall be as the three-band colour code identification band system as specified in BS 1710. The identification scheme shall be submitted for approval.

13.2.4.8 CONTROL SYSTEM AND MONITORING DEVICES

13.2.4.8.1 The functions of the control system shall include, but not limited to, start/stop/changeover of rainwater pump set, activation of rainwater treatment plant, backwash operation, water level monitoring and control, motorised valve control, fault indications and system interface.

13.2.4.8.2 The control system shall interface with the water level sensors in the rainwater collection tank and ball valve and level switches in mixing tanks.

13.2.4.8.3 A smart weather station shall be configured, supplied and installed, where specified in the Particular Specification, to control the automatic irrigation if rainwater harvesting system is provided to supply water for landscape irrigation. The smart weather station shall consist of rain sensing component and wind sensing component and be able to interrupt scheduled irrigation whenever it detects preset value of rainfall or wind speed.

13.2.4.8.4 The detailed control strategy and control flow diagram shall be submitted to the Supervising Officer for approval.

13.2.4.8.5 The control panel for rainwater harvesting system control shall be of wall-mounted type, unless otherwise specified, to house all the control and monitoring equipment. The panel material shall be stainless steel to Grade 316. Protection class of the cabinet shall be not less than IP44 for indoor and IP55 for outdoor application. The entire surface shall be applied with chemical rust inhibitor, rust resisting primer coat and topcoat to give maximum corrosion protection. Anti-condensation heater shall be provided. All indicating lamp shall be of light emitted diode (LED) type.

13.2.4.9 CONTROL INTERFACE WITH CCMS

13.2.4.9.1 The works include supply and install an interface marshalling box for interfacing with the Central Control and Monitoring System (CCMS) or other centralised monitoring system as specified in the Contract. All the required control and monitoring points, either digital or analogue, shall be terminated in the marshalling box.

13.2.4.9.2 A dedicated monitoring panel shall be installed inside the rainwater treatment system plant room. The interfacing points shall include, but not limited to, the following: -

- Water levels from all level sensors
- On/off/status of rainwater pump
- Running time of the rainwater pump
- Local/remote switch status
- On/off/status of chlorine disinfection system
- Normal /backwashing status of sand filter
- Differential pressure of the sand filter
- On/off/status of motorised control valve

- Water consumption from flow meters
- Energy data from energy meter
- Accumulative volume flow from flow meters

13.2.4.10 ELECTROMAGNETIC FLOW METER

13.2.4.10.1 The electromagnetic flow meter shall comply with relevant clauses in Part 15 of this General Specification and provision of the flow meters shall be referred to the Drawings provided.

13.2.4.10.2 The electromagnetic flow meter shall be able to interface with the CCMS by RS485.

13.2.4.10.3 The electromagnetic flow meter shall be of digital type and capable of measuring the accumulated water flow with self storage function of minimum 90 days.

13.2.4.11 DIGITAL MULIFUNCTION POWER METER

13.2.4.11.1 Digital multifunction power meter shall be provided to measure and record the electrical parameters of rainwater pump motor. The meter shall comply with relevant clauses in Part 7 of this General Specification.

13.2.4.11.2 The energy meter shall be capable of interfacing with other systems via RS485.

13.2.4.12 ELECTRICAL WORKS

13.2.4.12.1 The power from the isolator switch installed shall be connected to the rainwater harvesting system installation. All the power supply distribution and circuit protection downstream the isolator switch shall be carried out.

13.2.4.12.2 A separate motor control panel shall be provided for the rainwater pump. The control panel shall be of wall-mounted type, unless otherwise specified, to house the motor starter and switchgear. The panel material shall be stainless steel to Grade 316.

13.2.4.12.3 Anti-condensation heater shall be provided for motor control panel. The anti-condensation heater shall be controlled such that the heater shall be de-energised when the starter is switched on and vice versa. Heaters shall be wired from the motor control panel.

13.2.4.12.4 All indicating lamps shall be of light emitted diode (LED) type.

SECTION 13.3

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 13.3.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

13.3.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

13.3.1.2 INSPECTION AND TEST REQUIRED BY THE AUTHORITES

The works shall include the coordination with WSD for the final inspections, including but not limited to, carrying out spot-check of the pipes and fittings at the premises and taking water samples at random locations of the Approved Plumbing Works, attention of the licensed plumber is drawn to the licensed plumber's duty to construct of the Approved Plumbing Works covered by the submitted Form WWO 46 or WWO 1149 in compliance with the approved plumbing proposals and the Waterworks Ordinance and Regulations.

All mandatory testing, to meet the statutory requirements and to the satisfaction of the relevant Authorities, including Water Authority, Building Authority, DSD, EPD, FSD and WSD, etc. shall be carried out. All necessary applications to the Authorities well in advance shall be made and tests conducted by their representatives shall be attended.

Non-destructive tests of lead content for solder joints selected by the WA shall also be carried out according to the WSD's requirement.

The mandatory lead check on randomly taken samples of pipe-fittings with integral solder materials shall be carried out upon delivery according to WSD's requirement. Relevant test records shall be submitted to the WA together with Form WWO 46 in compliance with the approved plumbing proposals and the Waterworks Ordinance and Regulations. The non-destructive lead checks by the WA do not apply to the joints of pipe-fittings with integral solder rings that have passed the lead checks prior to installation.

SUB-SECTION 13.3.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

13.3.2.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during the Maintenance Period shall also comply with the specific requirements in this Sub-section.

Operation, servicing and maintenance of the Installations, if specified, shall also refer to the equipment manufacturer's recommendations and specifications.

All information required for Water Safety Plan as per WSD's requirement shall be provided and submitted.

13.3.2.2 REQUIREMENTS OF ROUTINE MAINTENANCE DURING MAINTENANCE PERIOD

Routine maintenance for the Installations as specified in this Sub-section shall be carried out during the Maintenance Period. A maintenance programme shall be prepared and submitted before the commencement of the Maintenance Period for the approval of the Supervising Officer. The dates for routine and periodic inspection, servicing and maintenance of the installations shall be indicated.

The routine services shall in include, but not limited to, the following: -

13.3.2.2.1 Monthly Routine Maintenance Services

(a) Check the general condition of the whole installation to ensure the system are satisfactorily performed as required by the Contract;

(b) Clean internally all water tanks according to A Guide to Cleansing of Fresh Water Storage Tanks issued by WSD;

(c) To check any water leakage from the pipework and to repair if required; and

(d) To examine the condition of joints, stop valves, covers and seals for leaks, repair as required.

13.3.2.2.2 Quarterly Maintenance Services

(a) Works as required in monthly routine maintenance services; and

(b) Clean all strainers.

13.3.2.2.3 Half-yearly Maintenance Services

(a) Works as required in monthly and quarterly routine maintenance services; and

(b) To inspect the condition of pipe fittings, supports etc. for sign of corrosion. Remove the rust and repaint with primer and finish coating as necessary.

13.3.2.2.4 Annual Maintenance Services

Works as required in monthly, quarterly and half-yearly routine maintenance services.

13.3.2.2.5 Others

Carry out all necessary site works and provide necessary documents to facilitate users for applying the Quality Water Supply Scheme for Buildings – Fresh Water (Plus) and Quality Water Supply Scheme for Buildings – Flushing Water of WSD.

PART 14 – DRAINAGE INSTALLATION

SECTION 14.1

INSTALLATION METHODOLOGY

SUB-SECTION 14.1.1

ABOVE GROUND DRAINAGE SYSTEM

14.1.1.1 GENERAL

Foul water drainage above ground shall be installed generally to BS EN 12056-2:2000.

Surface water drainage above ground shall be provided and installed generally to BS EN 752:2017 and as per requirement stipulated in the Stormwater Drainage Manual published by DSD when applicable.

14.1.1.2 HANDLING AND STORAGE

Do not expose plastic pipes and fittings to sunlight and avoid any deformation.

Store rubber jointing rings in protective bags and do not expose them to sunlight. Avoid any deformation.

Store pipes, gutters and fittings under cover and clear of a levelled, well-drained and maintained hard-standing ground.

Stack pipes without resting them on their sockets.

Prevent entry of foreign matter into any system by sealing off ends of pipes and openings during construction.

14.1.1.3 FIXING PIPES AND FITTINGS

14.1.1.3.1 General Details

Inspect pipes and fittings inside and out before fixing. Reject any which are defective.

Fix pipes and fittings securely with fixings and fastenings appropriate to the location and the material.

Do not cast in or build pipes into chases in walls and floors unless approved by the Supervising Officer, in which case: -

(a) Coat all pipes which come into direct contact with concrete with an approved protective tape;

(b) Ensure that there are no joints in straight pipes built in other than elbows and tees.

Avoid crimping and restricting the diameter of tubes when forming bends in pipes.

Do not fix roof outlet gratings until after all other work at roof level is completed. Outlets that are contaminated in any way shall be replaced.

Surface channel and floor drain shall be flush with the walkway surface.

Bolted access doors or inspection units shall be provided at all branches and bends other than ventilating and anti-syphon pipes, and at the foot of main soil stacks. The access doors or inspection units shall be fitted to cast iron soil stacks with stainless steel or gunmetal bolts and rubber gaskets.

Unless expressly authorised by the Supervising Officer, interchangeability shall not be allowed between different plastic pipe manufacturer's products.

Pipes requiring protection against corrosion shall be fixed with 40mm (minimum) clearance between the pipe, structure or adjacent surfaces. Avoid fixing such pipes at internal angles.

Vertical pipes in situations which are accessible to rodents shall be placed at least 100 mm away from any adjacent wall or pipe to a minimum height from ground level of 1500 mm.

14.1.1.3.2 Protection to Movement and Expansion

Make adequate provision to control and/or allow for thermal movement in the length of pipes and gutters depending on material specified and in accordance with details shown on the Drawings.

Provide expansion joints in plastic pipes by means of loops or other methods in accordance with the manufacturer's recommendations.

Provide solar protection for pipes running at roof top by shelter or by painting them white.

14.1.1.3.3 Pipework Arrangement

Unless otherwise approved by the Supervising Officer, pipes shall not run over electrical switchgear, inside transformer room, switch room, generator room, meter room, telephone equipment room, PABX room, server room, riser duct for electrical services, or any other rooms containing electrical hazard or susceptible to water damage hazard.

The routing and arrangement of pipework shall allow the replenishment of sealing trap of floor drains by diverting waste water from waste fitments.

The arrangement of pipework shall prevent cross flow of foul water at the tee inlets of branch pipe or stack pipe. Tee fittings shall not be double junction type.

The arrangement of pipework shall prevent backflow of foul water to the trap. The level of the trap outlet shall be at least 200mm higher than the foul water branch pipe or stack pipe tee inlet being connected with.

Size of ventilating stack pipe at the highest floor shall be the same size as soil stack at the lowest floor.

Cross vent between ventilating stack pipe and foul water stack pipe shall be provided at least in an interval of every 5 floors.

Metallic pipework shall be used at the bottom of UPVC pipe stack to prevent hydraulic jump.

14.1.1.3.4 Fixing Plastic Gutters

Fix gutters with screwed gutter brackets as follows: -

(a) At 1000 mm (maximum) centres; and

(b) Generally to falls of 1 in 300 (minimum).

14.1.1.3.5 Fixing UPVC Two-way Floor Drain Outlet

Fix UPVC two-way floor drain outlet as follows: -

(a) Cast in UPVC horizontal drain pipe at the correct level fall and alignment as shown on the Drawings and to suit the thickness of wall and floor finishes;

(b) Fix UPVC adaptor unit to the horizontal drain pipe. Cut the length of spigot if necessary where it connects onto the hopper of the drain pipe to suit the thickness of wall finishes, and ensure to maintain a minimum 8 mm of overlap between the spigot and the connecting hopper of the drain pipe;

(c) Fix UPVC adjustable horizontal grating unit to the adaptor. Cut down the height of the unit if necessary to suit the finished floor level;

(d) Ensure the fixing as mentioned above are to manufacturer's recommendations and all joints are watertight;

(e) Seal the joints between the adaptor unit and wall tiles, and the joints between adjustable horizontal grating unit and floor tiles;

(f) Install gratings to adaptor unit and adjustable horizontal grating unit with stainless steel screws.

14.1.1.4 JOINTING PIPES AND FITTINGS

14.1.1.4.1 General

Carry out all pipe joints in accordance with the manufacturer's instructions and do not allow jointing material to project into bore of pipes or fittings.

Cut ends of pipes and gutters clean and square, chamfering internally or externally if required using equipment appropriate to the material.

Joint pipes with gaskin and cold caulking compound.

Joint gutters with jointing compound and bolt together.

Jointing rings, couplings and adaptors shall be of types recommended by the manufacturer of the pipes being jointed.

Joint plastic pipe and gutters in accordance with the manufacturer's recommendations.

14.1.1.4.2 Jointing of Cast Iron Spigot and Socket Pipes

Joint pipes with cold caulking compound in accordance with manufacturer's instruction.

14.1.1.4.3 Jointing of Cast Iron Spun Spigot Pipes

Joint pipes with flexible joints in accordance with the manufacturer's recommendations. Pipes shall not be jointed with molten lead.

14.1.1.4.4 Jointing of Steel Pipes

Joint steel pipes with screwed sockets with jointing compound or pipe thread tape. Cutting threads with a tapered die. Threads found to be cut too deep will be rejected.

Paint all threaded surfaces with one coat of non-toxic anti-corrosion epoxy base polymide primer or red oxide primer and one coat compatible finish.

14.1.1.4.5 Jointing Steel Pipes to Cast Iron Pipes

Joint steel pipes to sockets of cast iron pipes with cold caulking compound in accordance with manufacturer's instruction.

14.1.1.4.6 Jointing Pipes to Clay Pipe Sockets

Joint cast iron pipes to clay spigot and socket pipes with gaskin and cement and sand 1:2.

Joint steel pipes to clay spigot and socket pipes with gaskin and cement and sand 1:2.

14.1.1.4.7 Jointing of UPVC Pipes

Fix and joint UPVC pipes in accordance with the manufacturer's recommendations. Joint UPVC pipes to pipes of other materials with proprietary adapters.

Screw threads to UPVC pipes shall not be allowed unless otherwise ordered by the Supervising Officer. Where screw connections are required, screwed adapter bushes shall be used.

Proprietary adaptors shall be used for jointing plastic pipes to pipes of other materials.

14.1.1.4.8 Joints Between Dissimilar Metals

Proper adaptors shall be used for making joints between different metals.

The contact between following dissimilar materials shall be avoided: -

(a) Aluminium alloys with copper alloys, nickel, lead or stainless steel;

(b) Iron and steel with copper alloys;

(c) Zinc with copper alloys. In particular avoid the direct contact of copper with galvanised iron or steel pipes.

If unavoidable, use gunmetal joints between the dissimilar metals.

14.1.1.5 PIPEWORK SUPPORT

14.1.1.5.1 General

Support pipes on flat roofs and canopies at least 150 mm above roof and canopy finish on concrete blocks with pipe clamps.

Do not use branch pipes that connect to vertical pipes as pipe supports.

Corrosion-resistant fixings such as stainless steel brackets and connections or similar corrosion-resistant fixing supports shall be used. The fixings shall be properly anchored into solid wall.

Pipe brackets shall be of stainless steel to BS EN 10088-3:2014 number 1.4301 or SAE Grade 304 or other approved material. The pattern shall suit the type of pipe and the surface to which they are to be fixed, including where appropriate: -

(a) Flanged ends for building in;

(b) Plain round ends for fixing in drilled holes with an approved grout;

(c) Approved expanding bolts or stud anchors for fixing to concrete, brickwork etc.;

(d) Threaded ends for fixing to steelwork, or wood, or panel wall with plug as required;

(e) Countersunk-holed face plates for screwing to wood or plugs, or panel wall with plug; and

(f) Brackets lined with resilient plastic at pipe clamps for plastic pipes, plastic coated pipes and cast iron pipes.

Bolts for cast iron and steel pipework shall be of brass, cadmium plated steel or other non-corrodible metal.

Bolts for soil stack access doors for cast iron and steel pipework shall be of stainless steel or gunmetal.

Wood screw shall be brass with countersunk heads and of a length sufficient to ensure a secure fixing.

Plugs for fixing to hard materials shall be of proprietary plastic, fibre, soft metal or similar material. Plugs for fixing to friable materials, plasterboard and the like shall be of proprietary fixings for the purpose. Plugs containing asbestos shall not be used.

14.1.1.5.2 Pipe Bracket Intervals

Pipe bracket shall be installed at intervals not exceeding those shown in Table 14.1.1.5.2 for straight runs, and with not less than one bracket per standard length of pipe. All brackets shall be equally spaced.

Table 14.1.1.5.2 Spacing of Pipe Fixing

Pipes	Nominal Size (mm)	Maximum Spacing (mm)	
		Vertical pipes	Horizontal pipes
Cast iron and ductile iron	All	3000	1750
Steel	Up to 15	2400	1800
	20 and 25	3000	2400
	32	3000	2700
	40 and 50	3600	3000
	65 to 100	4500	3600
	125 and 150	5400	4500
UPVC	Up to 25	1500	750
	32	1800	900
	40 and 50	2000	1000
	65 to 150	2500	1200

14.1.1.6 PIPEWORK PENETRATING BUILDING STRUCTURE

14.1.1.6.1 Pipes Through Walls and Floors

Where pipes pass through walls or floors:

(a) Cast or build in UPVC sleeves to BS 3505:1986 or BS EN ISO 1452-1:2009 with 2 to 12 mm clearance to allow for expansion and movement of pipe.

(b) Finish sleeves flush with finished face of walls and ceilings and projecting 100 mm above finished floor level.

(c) Provide loose plastic or chromium plated cover plates, when specified, to ends of sleeves visible in completed work. Plates shall be 50 mm larger than the external diameter of pipe and either clipped to the pipe or screwed or plugged and screwed to the adjacent surfaces.

(d) If required to be water tight, point with approved mastic sealant.

(e) No split PVC sleeves shall be permitted.

14.1.1.6.2 Metal Pipes Through Fire Barriers

The works shall follow the requirements of pipes pass through walls or floors, and

(a) Cast or built in Medium duty galvanised mild steel pipe sleeve to BS 1387:1985 with 2 to 25mm clearance.

(b) Firmly fix sealing system around the pipes to properly seal up the gaps between the pipes and the fire barriers to maintain the required FRR of the fire barriers and in compliance with the Code of Practice for Fire Safety in Buildings. The sealing system shall be tested to BS EN 1366-3:2009 or BS 476-20:1987 and the installation of which shall be in accordance with the manufacturer's recommendations.

14.1.1.6.3 Non-Metal Pipes Through Fire Barriers

Suitable fire collars shall be used. The fire collars shall be tested to BS EN 1366-3:2009 or BS 476-20:1987 with integrity not less than of the fire barriers as prescribed under the relevant Building Regulation and the Code of Practice for Fire Safety in Buildings. The fire collars shall be fixed at underneath of fire barriers or other locations around the pipes in accordance with the manufacturer's recommendations.

14.1.1.6.4 Pipes Through Basement Wall

Cast or build in cast iron or 2.5 mm galvanised mild steel sleeve to BS EN 10255:2004 after fabrication with 2 to 12 mm clearance.

Caulk space and point both ends with approved mastic sealant.

14.1.1.6.5 Pipes Through Basement Wall with Ground Water Pressure

Cast or build in short length of cast iron pipe as sleeve with split bolt on puddle flange and with socket on outside.

Well caulk socket around pipe with yarn and lead including a cast iron plug drilled to take long screw and backnuts if necessary.

Point inside with an approved mastic sealant.

14.1.1.6.6 Pipes Through Flat Roofs

Where pipes pass through flat roofs incorporating either asphalt or proprietary roofing waterproofing material:

(a) Cast or build in fire rated pipe sleeves with 2 to 12 mm clearance projecting 150 mm above roof finish.

(b) Fill the annular space between pipe and sleeve and caulk all spaces and voids at both ends for the full length with approved fire rated materials and sealant, e.g. mastic sealant, add waterproof protection and sealant where necessary;

(c) Cover tops of sleeves with stainless steel collars or cover as per roofing specification or as specified by pipe manufacturer.

SUB-SECTION 14.1.2

UNDERGROUND DRAINAGE SYSTEM

14.1.2.1 GENERAL

This Sub-section covers surface and foul water drainage below ground level.

Carefully examine each pipe before laying for evidence of damage with special emphasis on inspection of the jointing section. Remove all damaged pipes from Site as soon as possible.

During construction, plug open ends of pipes and maintain until completion, to prevent entry of debris.

Concrete shall be as specified in Section 6 of the General Specification for Building and listed as follows shall be of appropriate concrete grade strength and approved by the Supervising Officer: -

(a) Channels, manholes, inspection chambers, gullies, catchpits and all reinforced concrete work.

(b) Pipe bedding, pipe haunching, pipe surrounds and all other work.

(c) Filling.

14.1.2.2 HANDLING AND STORAGE

14.1.2.2.1 General

Pipes, joints and fittings shall be transported, handled and stored in accordance with the manufacturer's recommendations and: -

(a) In a manner which will not result in their damage, deformation or contamination;

(b) Protect pipes, joints and fittings from damage;

(c) Handle pipes and fittings manually or by using lifting appliances or chains, wire rope or canvas slings of a type with valid LALG certificate and recommended by the manufacturer and agreed by the Supervising Officer and do not use hooks;

(d) Place slings around the pipes and fittings and provide padding at the points of contact between pipes and fittings and metal lifting appliances and slings; and

(e) Do not subject pipes and fittings to rough handling, shock loading, or dropping and do not roll down ramps unless otherwise approved, in which case the ramps must be padded.

14.1.2.2.2 Storing and Handling Pipes

Pipes shall be stored horizontally on a level surface and bottom supported by barrel or wedged timber bearers with their sockets overhanging. They shall be stored at least 75 mm above the ground on the bottom support. The bottom layers and the outer pipes in each layer shall be securely wedged to prevent sideways movement and stack collapse. Pipes shall not be stacked higher than 2m.

Spigot and socket pipes shall be stored with the sockets alternating and in such a manner that loads are not applied to the sockets.

Pipes shall not be string out along the route of the pipeline unless otherwise approved.

Pipes shall not be rolled over rough ground.

Pipes off loaded on skids shall be suitably wrapped to avoid risk of damage to pipes.

Do not lift pipes by slings or chains passing through bore of pipe.

Pipes shall be stored under cover.

14.1.2.2.3 Storage of UPVC Pipes, Joints and Fittings

Rubber jointing rings shall be stored in protective bags. Plastic pipes and fittings shall not be exposed to sunlight or to conditions which may affect the material.

14.1.2.2.4 Storage of Bolts and Nuts

Bolts and nuts shall be packed in sealed containers.

14.1.2.2.5 Storage of Elastomeric Joint Rings

Elastomeric joint rings shall be packed in bags. Lubricant for joints shall be stored in sealed containers and marked to identify the contents. The joint rings and lubricant shall not be exposed to conditions which may affect the materials.

14.1.2.2.6 Storage of Anti-corrosion Tape and Joint Filler

Anti-corrosion tape and joint filler shall be stored in accordance with the manufacturer's recommendations and in a dry, weatherproof store with a raised floor.

14.1.2.2.7 Storage of Granular Bedding Materials

Aggregates for granular bedding shall not be handled in a manner which will result in mixing of different types and sizes, or in contamination of

the aggregates. Different types and sizes of aggregates shall be stored in separate stockpiles.

14.1.2.2.8 Storage of Manholes, Chambers and Gullies

Units for manholes, chambers and gullies shall only be lifted at the lifting points recommended by the manufacturers. The units shall not subject to rough handling, shock loading or dropping.

The units shall be stored off the ground on level supports which will not result in their damage, deformation or contamination. Protection shall be provided to avoid damage of the units.

14.1.2.2.9 Storage of Covers, Gratings and Kerb Overflow Weirs

Manhole covers, gully gratings, kerb overflow weirs and valves, including fittings shall be stored off the ground on level supports which will not result in their damage, deformation or contamination. Protection shall be provided to avoid damage of the units.

14.1.2.3 SETTING OUT

14.1.2.3.1 The centreline of trench shall be set out accurately. Top width of trench shall be marked by means of suitable pegs and offset side check pegs.

14.1.2.3.2 Temporary benchmarks in stable positions shall be established. Erect strong site rail, planed true, painted in contrasting colours fixed to rigid posts across centre of each manhole. Indicate the centreline of pipeline on sight rail and its height related to an even dimension to invert level of pipe. At least three rails shall be provided on each gradient at maximum spacing of 30 m. Length of travellers used between sight rails at frequent intervals shall be checked.

14.1.2.3.3 Before commencing excavation, invert levels of existing drains, sewers and manholes shall be checked against levels shown on drawings.

14.1.2.4 EXCAVATION OF TRENCH

14.1.2.4.1 General

Unless otherwise specified, all excavation and earthworks shall be in accordance with the General Specification for Building.

Excavation shall only be commenced when the nature, location and size of existing utilities which may be affected by the excavation have been ascertained and the setting out details had been approved.

Excavation shall only be commenced after reasonable steps are conducted and all reasonable measures shall be taken according to Code of Practice on Working near Electricity Supply Lines.

Excavation for drainage works shall be carried out after adjacent bulk excavation or filling is completed. Excavated trench shall be kept free of water at all times. Material made unsuitable by inadequate construction drainage shall be replaced.

Trenchless excavation (pipe-jacking), if proposed, shall be approved by the Supervising Officer.

14.1.2.4.2 Trench Width

Trench widths measured at the crown level shall not exceed those specified in Table 14.1.2.4.2. In addition, minimum side clearance from pipe to trench face on each side of pipeline shall be as follows: -

(a) 150 mm for pipes up to and including 675 mm internal diameter.

(b) 225 mm for pipes exceeding 675 mm internal diameter.

Table 14.1.2.4.2 Trench Widths

Pipe Size (mm)	Trench Width (mm)
100	600
150	600
200	700
225	700
250	750
300	750
375	1050
450	1150
525	1200
600	1350
675	1450
750	1500
900	1900
1050	2050
1200	2300
1350	2450
1500	2600
1650	2800
1800	2950

Trenches to be excavated for subsoil and cut off drains having pipes up to 150 mm diameter shall be to a width of at least four times the nominal diameter of the pipe. Trench width shall be the external diameter of the pipe plus 450 mm or as specified for pipes above 150 mm diameter.

Localised hard and soft spots or other obstructions in trench bottoms and under drainage structures shall be removed and replaced with compacted special filling material to Section 3 of the General Specification for Building.

14.1.2.5 BEDDING AND LAYING OF PIPES

14.1.2.5.1 General

Pipes shall be bedded within any individual drain length between any two drainage chambers.

The laying of pipes shall be proceeded without delay on completion of excavation. Brick or other hard material shall not be used under pipe for temporary support.

Pipes shall be laid in single, straight to line and true to gradient with sockets facing upstream starting at the downstream end of the trench.

Minimum 150 mm clearance shall be maintained around the pipelines passing through building foundations. Space around shall be filled with flexible material or fine sand. At least two flexible joints shall be provided to the pipelines for passing through the foundations.

Mortar for bedding covers or for rendering shall consist of one part cement and three parts clean well graded sand with just enough water to give plastic consistency.

Pipes, joints, fittings and valves, including internal and external coatings, shall be inspected immediately before and after pipelaying. Valves shall be inspected to ensure that they are in working order and are capable of being fully opened and closed. Deleterious material shall be removed and damage shall be repaired immediately before and after pipelaying.

14.1.2.5.2 Granular Bedding

Recycled or non-recycled granular bedding material shall be clean, hard, durable, crushed rock or crushed concrete, broken stone, hard brick, concrete, or other comparable hard inert, approved material to pass a 25mm BS sieve, but shall be retained on a 5mm BS sieve.

Granular bedding material shall be tested as follows: -

(a) Apparatus to be used:

(i) Open ended cylinder 250 mm long and 150 mm diameter.

(ii) Metal rammer with a striking face 40 mm diameter and of total weight of 1.25 kg.

(b) Stand the cylinder on a firm surface. Using a sample of material having a moisture content equal to that of the material at the time of use, pour the sample of material into the cylinder without supplementary compaction and strike off the material level with the top of the cylinder. Lift the cylinder clear of its contents and place on a fresh area of flat surface. Replace about one quarter of the material in the cylinder and tamp vigorously until no further

compaction is evident. Repeat this process quarter by quarter until the whole of the material measured loose in the cylinder is compacted.

(c) The final measurement from the top of the cylinder to the compaction surface divided by the height of the cylinder is the Compaction Fraction value.

(d) The suitability for use shall be determined from Table 14.1.2.5.2.

Table 14.1.2.5.2 Compaction Fraction

Compaction Fraction	Suitability
0.10 or less	Material suitable
0.10 to 0.30	Material suitable but requires extra care in compaction. May not always be suitable if the pipe is subject to water logged conditions after laying.
Over 0.30	Material unsuitable

Granular bedding shall be compact and trim to correct gradient and shape under barrel and pipe sockets to ensure uniform support along whole barrel length. The granular bedding material shall be compact concurrently on each side of the pipe to specified level after laying, jointing and testing of pipeline.

14.1.2.5.3 Natural Bedding

Natural bedding shall be accurately trimmed to provide uniform and solid bearing for pipes throughout the length of the barrels. Short recesses shall be formed in bed to clear sockets by minimum 50 mm.

14.1.2.5.4 Concrete Bedding, Haunch and Backfilling

Concrete bedding, haunch and backfilling to pipelines for drainage works shall be constructed as follows: -

(a) Pipes shall be supported at the required level by precast concrete wedges, blocks or cradles or by other methods of appropriate concrete grade strength and approved by the Supervising Officer. One support shall be placed adjacent to each end of each pipe and the spacing between supports not to exceed 3 m. Compressible sheeting shall be placed between the pipes and supports.

(b) Flexible joints shall be formed in concrete bedding, haunch and surround at flexible joints in pipelines. Joint filler shall be placed next to the flexible joint in the pipeline and to extend for the complete thickness of the bed, haunch and surround. Precut the filler to the finished profile of concrete and pipe. Joint filler shall be 25 mm thick for pipes not greater than 1200 mm diameter and 50 mm thick for pipes greater than 1200 mm diameter.

(c) Polythene sheeting or a blinding layer shall be placed on the trench bottom before concreting.

(d) Concrete shall be placed evenly over the complete width of the end and over the complete length of the pipe being concreted up to a level of 25 mm below the underside of the pipe. Concrete shall be placed on one side of the pipe only and work under the pipe until the concrete spread under the pipe. Concrete shall be placed equally on both sides of the pipe to the specified level.

(e) Pipes for drainage works which are within 1 m below the surface of a carriageway shall be protected with concrete surround in appropriate grade strength as approved by Supervising Officer.

(f) Keep concrete and pipes damp until backfilling placed.

(g) Do not commence backfilling for at least 24 hours from time of placing concrete.

If specified, place and secure reinforcement in position. Reinforcement shall not pass through flexible joints in the concrete bedding.

Unless otherwise specified, pipes for subsoil and cut-off drains shall be bedded on a 75 mm thick concrete in appropriate strength, which is to be brought up until at least one third of the depth of the pipe is supported and in the case of perforated pipes, no line of perforations is blocked. Pipes for subsoil and cut off drains shall be laid generally in accordance with the requirements for other drains.

14.1.2.5.5 Subsoil Drain Bedding

Subsoil drain bedding shall be of granular or natural bedding where appropriate for bedding type specified. Flexible membrane waterproof underlay where specified shall be 500 grade plastics sheet or equivalent approved standard.

14.1.2.6 BACKFILLING OF TRENCH

14.1.2.6.1 General

Backfilling generally shall be in accordance with Section 3 of the General Specification for Building.

Where pipes are not surrounded with concrete, backfill evenly up both sides of pipe and up to 300 mm above top of pipe with special filling material as per Section 3 of General Specification for Building. Laid and hand compacted in 100 mm layers.

Backfill the remainder of the trench with general filling material as Section 3 of General Specification for Building unless otherwise specified.

Keep uniform the depth of fill over the full length of the pipeline being backfilled. Do not tip or push backfill material into the trench by mechanical plant.

14.1.2.6.2 Backfilling

Backfilling material shall be compacted as required in Section 3 of the General Specification for Building.

Trench supports shall be removed as filling proceed. No vibrating extractors shall be used to remove trench supports.

When backfilling over pipes with concrete bedding or surround, the backfilled trench shall not be used for traffic within 72 hours of placing concrete.

Backfill for subsoil and cut off drains shall be Types A or B material as Table 14.1.2.6.2 or other material as specified.

Filter materials to consist of hard, clean, crushed rock or gravel having a grading within the limits of Table 14.1.2.6.2.

The aggregate crushing value of the material shall not exceed 30%. The material passing the 425μm BS sieve shall be non-plastic when tested in accordance with BS EN ISO 17892-12:2018.

Table 14.1.2.6.2 - Range of Grading

BS Sieve Size (Metric)	% by Weight Passing	
	Type A	Type B
64 mm	-	100
37.5 mm	100	85 – 100
20 mm	-	0 – 20
10 mm	45 – 100	0 – 5
3.35 mm	25 – 80	-
600 μm	8 – 45	-
75 μm	0 – 10	-

When Type A material is used with perforated pipes, at least 15% shall be larger in particle size than twice the maximum dimension of the perforations.

14.1.2.7 CUTTING PIPES

14.1.2.7.1 General

Pipes and pipe ends shall be cut and prepare in accordance with the manufacturer's recommendations by using purpose made equipment recommended by the manufacturer or otherwise approved and: -

(a) Cut ends of pipes square or to the correct angle;

(b) Do not damage the pipe coatings;

(c) Trim and chamfer the cut ends to suit the type of joint; and

(d) Cut pipes which terminate at the inside face of underground structure such that the end of the pipe is flush with the face.

14.1.2.7.2 Elastomeric Joints

Pipe ends shall be trimmed and chamfer in such a manner that elastomeric joint rings will not be damaged by them.

14.1.2.7.3 Closing Lengths

Do not cut pipes requiring to be cut to form closing lengths until adjacent pipes have been laid and jointed and the length to be cut can be accurately measured.

14.1.2.7.4 Precast Concrete Pipes

Cut reinforcement in precast concrete pipes which are to be cut, back flush with the concrete and protect with epoxy resin or by other approved methods.

14.1.2.8 JOINTING PIPES AND FITTINGS

14.1.2.8.1 General

Pipes shall be jointed in accordance with the manufacturer's recommendations, using approved equipment and materials recommended by the manufacturer and: -

(a) Inspect the pipes, joints, fittings and valves, including internal and external coatings, immediately before and after jointing. Remove deleterious material immediately before and after jointing. Clean surfaces which are to be jointed immediately before jointing and clean out pipes with clean water;

(b) Ensure all joints in pipelines are watertight;

(c) Ensure the width of gaps at joints are in accordance with the manufacturer's recommendations and achieved by marking the

outside of the pipe, by using metal feelers or by other approved methods. Check the position of elastomeric joint rings with by using metal feelers after jointing; and

(d) Protect gaps at joints in pipes, after jointing, using approved methods, to prevent dirt, stones or other material from entering the joint.

Joint pipes and fittings of different materials with adaptors as recommended by the pipe manufacturer.

Proprietary flexible joints shall be installed in accordance with manufacturer's instructions.

Junction pipes if not connected up immediately shall be covered with a temporary watertight plug. The position of all such junctions shall be clearly marked and labelled.

14.1.2.8.2 Jointing of Cast Iron Pipes and Fittings

Cast iron pipes and fittings shall have either lead run joints or cold caulking joints as follows as specified: -

(a) For lead run joints each pipe shall be properly lined and brought to the correct level, the spigot end shall be wedged up concentrically with its respective socket and the socket tightly caulked with tarred yarn leaving unfilled the required depth of socket for lead. The depth of tarred yarn caulking shall not exceed one quarter of the total depth of the socket. When the tarred yarn has been tightly caulked home, a jointing ring shall be placed around the barrel and against the face of the socket. Molten pig lead is then poured in to fill the remainder of the socket. The lead is then solidly caulked all round joint with suitable tools and hammers of not less than 1.8 kg weight. Pipes shall be perfectly dry before the run lead joints are made. The weight of the lead used in jointing the various sizes of pipes shall not be less than the following: -

(i) 100 mm Internal diameter 2.70 kg (6 lbs.)

(ii) 150 mm Internal diameter 4.10 kg (9 lbs.)

(b) Cold caulking shall be an approved proprietary brand. Cut cast iron pipes with suitable wheel type cutters to give a clean end square with the axis of the pipe.

14.1.2.8.3 Jointing of Grey Iron Pipes and Fittings

Grey iron pipes and fittings and ductile iron pipes and fittings shall have flexible joints of an approved gasket type.

14.1.2.8.4 Jointing of Plastic Pipes and Fittings

Plastic pipes shall be jointed and fitted in accordance with manufacturer's recommendations.

14.1.2.8.5 Jointing of Vitrified Clay Pipes and Fittings

Vitrified clay pipes and fittings for surface water drainage shall be jointed and fitted in accordance with BS 65:1991.

Vitrified clay pipes and fittings for foul water drainage shall be jointed and fitted in accordance with relevant parts of BS EN 295.

14.1.2.9 THRUST AND ANCHOR BLOCKS

14.1.2.9.1 General

Use thrust and anchor blocks to resist forces at bends, branches and stopends in pressure pipelines, except where self-anchoring joints are used.

14.1.2.9.2 Excavation

Cast the bearing faces or other faces as indicated on the drawings, directly against undisturbed ground and: -

(a) Trim the faces of excavations to remove all loose material before concreting;

(b) Carry out any excavation required for the block beyond the trench width after the pipe or fitting has been jointed;

(c) Fill any excess excavation beyond the face of the block with concrete of the same grade as the block.

14.1.2.9.3 Applying Pressure

Do not apply internal pressure to the pipeline until thrust and anchor blocks have developed the specified grade strength.

14.1.2.10 CONNECTION OF PIPES

14.1.2.10.1 Connection to Structures

Ensure that the joints between pipes and structures into which they are built are watertight. Remove protective coatings over the length to be built in and do not build pipe collars and sockets into structures.

Provide two flexible joints in pipelines adjacent to the outside faces of the structures into which they are built, with the distances from the outside

face of the structure to the first joint and from the first joint to the second joint as specified in Table 14.1.2.10.1.

Table 14.1.2.10.1 Flexible Joints at Structures

Diameter of Pipe	Position of First Flexible Joint from Structure		Distance of Second Flexible Joint from First Flexible Joint
	Minimum	Maximum	
Not exceeding 450 mm	150 mm	500 mm or diameter of pipe whichever is less	450 mm to 800 mm
Exceeding 450 mm but not exceeding 1050 mm			900 mm to 1200 mm
Exceeding 1050 mm			1500 mm to 1800 mm

Temporarily seal the ends of pipes which are built in to structures with a blank flange, brickwork or timber boarding as instructed by the Supervising Officer. The temporary seals shall be left in position until the Supervising Officer instructs their removal.

14.1.2.10.2 Saddle Connections to Concrete and Clay Pipes

Connect the saddle to concrete and vitrified clay pipes by bedding the saddle on a cement mortar bed and forming a cement mortar fillet to provide at least 50 mm cover to the base of the saddle.

14.1.2.10.3 Splay Cut Connections to Concrete and Clay Pipes

The following shall be followed where pipes are to be connected to concrete or clay pipes without a Y-junction or purpose made pipe saddle: -

(a) Cut the pipe on the splay to form a junction such that the incoming pipe is at an angle of between 30° and 60° to the main pipe, upstream of the joint. Cut the hole in the main pipe to an elliptical shape suited to the cut end of the branch pipe. Cut the branch pipe to a length such that: -

(i) The cut end of the pipe rests on the outside barrel of the main pipe; and

(ii) The cut pipe does not project inside the main pipe;

(b) Seal the joint between the cut pipe and the main pipe externally and unless otherwise approved, internally flush with the main pipe, with mortar.

14.1.2.10.4 Saddle Connections to UPVC Pipes

Fix UPVC pipe saddles to UPVC pipes using a purpose-made mechanical clip or solvent cement of a type recommended by the manufacturer and approved.

14.1.2.10.5 Branch Pipelines

Unless otherwise approved, connect branch pipelines to main pipelines using Y-junctions of the same type and strength as the stronger of the pipes being jointed and of an angle between 30° and 45°.

14.1.2.10.6 Recording Positions of Junctions

Measure the positions of pipe junctions relative to the manhole or structure immediately downstream and record before backfilling.

14.1.2.10.7 Connecting Pipes not Required for Immediate Use

Seal the ends of connecting pipes not required for immediate use with a blank flange, brickwork or other approved methods and measure and record their positions before backfilling.

14.1.2.11 MANHOLES, CHAMBERS, GULLIES AND CHANNELS

14.1.2.11.1 Manholes, Chambers and Gullies

Concrete work for manholes, inspection chambers, gullies, catchpits, surface channels etc. cast in-situ shall be structural concrete grade strength as specified in General Specification of Building and approved by the Supervising Officer. All internal faces of these structures shall be rendered with cement mortar so as to provide a smooth and impervious surface.

Step irons and ladders shall be built in as work proceeds.

Set precast concrete units for manholes and chambers vertically with step irons staggered and vertically aligned above each other.

A desilting opening for manhole shall not be smaller than 750 mm by 900 mm, and it shall be placed along the centre line of the stormwater drain to facilitate desilting.

A man access opening for manhole shall not be smaller than 675mm by 675mm. If cat ladders are installed in a manhole, the minimum clear opening shall be 750mm by 900mm. A man access opening shall be placed off the centre line of the stormwater drain for deep manholes and along the centre line of the stormwater drain for shallow manholes with depths less than 1.2 m.

Seal joints between precast units and lifting holes with cement mortar, removing any excess and pointing the joints.

Drop pipes to manholes shall be coated cast iron, provided with bolted access doors, or swept tee fitted with a capped end. If the pipe is external it shall be surrounded with concrete in appropriate grade strength as approved by the Supervising Officer, if internal it shall be secured with holderbats.

Fill concrete surround to gullies up to the sides of the excavation.

Set the frames for manhole covers and gully gratings to the same level of the surrounding surface, allowing for falls and cambers, using brickwork or concrete as shown on the drawings. Do not exceed three courses of brickwork below frames. Concrete shall be of appropriate grade strength as approved by the Supervising Officer.

Provide two keys for each pattern of cover used.

Ensure the manhole covers of incoming and outgoing services are located within the site boundary and can be easily accessible and free from obstacles to facilitate future maintenance.

14.1.2.11.2 Filling Around Manholes and Chambers

Fill excavations around manholes and chambers in carriageways using concrete in appropriate grade strength as approved by the Supervising Officer.

Fill around other manholes and chambers with fine fill material.

14.1.2.11.3 Channels

Provide and prepare formed joints in surface channels at maximum 10 m intervals and as specified.

Construct the top surfaces of side walls of concrete open channels to the same levels as the adjoining permanent works. Fill any excess excavation beyond the channel walls with concrete in appropriate grade strength as approved by the Supervising Officer.

Surface channels on walkways shall be positioned away from tactile guide paths and other essential markings on the walkway surface.

Channel covers shall be securely fixed and flush with the adjacent walkway surface.

Cover grating slots shall run perpendicular to the dominant direction of travel.

14.1.2.12 VALVES

14.1.2.12.1 General

Valves shall be installed in accordance with the manufacturer's recommendations and in the closed position.

14.1.2.12.2 Box-outs and Rebates

Fill box-outs and rebates for valve frames and other gaps between frames and concrete surfaces with cement mortar.

14.1.2.12.3 Cleaning and Checking

After installation, clean valves, lightly grease moving parts and check for ease of operation. Leave valves in the closed position.

14.1.2.12.4 Air Valves

Provide air valves with isolating gate valves.

14.1.2.13 PIPES AND MANHOLES TO BE ABANDONED

14.1.2.13.1 Installations Less Than 1m Deep

If the top of a pipe or culvert, or the bottom of a manhole, chamber or gully, which is to be abandoned is 1 m or less below the finished ground level, it shall be removed and disposed unless otherwise approved. Fill the void with foam concrete, granular fill material or special fill material as approved by the Supervising Officer. Recycled aggregate may be used for filling the void subject to the Supervising Officer's approval.

14.1.2.13.2 Installations Over 1 m Deep

If the top of a pipe or culvert, or the bottom of a manhole, chamber or gully, which is to be abandoned is more than 1 m below the finished ground level: -

(a) Demolish manholes, chambers and gullies to 1 m below finished ground level unless otherwise indicated on the drawings;

(b) Seal the lowest points of abandoned pipelines with concrete, bricks or other approved methods; and

(c) Fill abandoned pipes, culverts, manholes, chambers and gullies with foam concrete or grout, by pumping or by gravity, starting at the lowest point on the system and continuing until all voids are completely filled.

14.1.2.14 WORKS OUTSIDE SITE BOUNDARY

All necessary provisions for the connection of the last manholes of the drainage system to existing public sewer shall be made. The requirements by the Drainage Services Department for the connection shall be complied with.

14.1.2.15 PROTECTION

14.1.2.15.1 Hot Dip Galvanising

Unless otherwise specified, galvanised coatings to be applied by hot-dip galvanising to be in accordance with BS EN ISO 1461:2009. The coating thickness to comply with Table 14.1.2.15.1.

Table 14.1.2.15.1 Requirements of Hot Dip Galvanising

Article Thickness	Minimum Mean Coating Thickness
≥ 6 mm	85 μm
3 mm to < 6 mm	70 μm
1.5 mm to < 3 mm	55 μm
< 1.5 mm	45 μm

Unless otherwise approved, all components are to be galvanised after welding, drilling and cutting operations are complete. Hot dip galvanising, including the galvanising work specified in other sections of this Specifications, is to be carried out by galvanisers with accreditation of ISO 9001:2015 or equivalent quality management system. The name of galvanisers shall be submitted for approval.

Original invoice, delivery note and galvanising certification for each delivery shall be provided for examination. These documents shall include the following information: -

(a) Project title /contract number

(b) Name of galvaniser

(c) Types and dimensions of articles

(d) Quantities

A durable identification tape shall be attached to each batch of galvanised articles indicating the project title, galvanising certification number and name of galvaniser.

14.1.2.15.2 Anti-Corrosion Tape

Anti-corrosion tape shall be applied to all flanged joints, slip-on couplings and flange adapters.

14.1.2.16 CLEANING OF SYSTEM

14.1.2.16.1 General

After completion of the drainage system, and after testing, draw through each completed section of pipeline not greater than 300 mm diameter a mandrel 750 mm long and 12 mm less in diameter than diameter of the pipe. Remove any obstructions in the pipeline and make good any unevenness in the invert.

For pipelines greater than 300 mm, clean internally by high pressure water jetting, pigging or by other approved methods and clean and wash manholes and chambers.

On completion of work, flush out all manholes and drains from end to end with water and leave clean and free from obstruction.

14.1.2.16.2 Time of Cleaning

The cleaning shall be carried out when: -

(a) After the pipeline has been tested;

(b) After temporary works required for testing have been removed and any parts of the pipeline removed for testing have been reconnected; and

(c) Not more than 7 days before the pipeline is handed over.

14.1.2.17 SMART DRAINAGE DETECTION SYSTEM

The smart drainage detection system shall be provided, supplied and installed, where specified in the Particular Specification and if required to retrieve data from the entire, or part of the underground drainage system as provided within the project site. The collected data (i.e. water level, gases concentration inside the manhole, etc.) shall be able to detect the blockage condition and hazardous gas. The smart drainage detection system shall be able to provide real-time analysis of the collected data for early warning and recommend appropriate corrective measures by harnessing the power of artificial intelligence algorithms and big data analytics.

The normal water level and gas concentration are recorded as baseline condition while there are any sudden change of conditions (i.e. water level rises up quickly but falls down slowly, increase of gas concentration, etc.) indicated that there are possible blockage of underground pipework and give early warning to the operator.

Full smart drainage detection system, when specified, shall interface with the building Central Control and Monitoring System (CCMS) or other centralised monitoring system.

SUB-SECTION 14.1.3

WASTE WATER HANDLING EQUIPMENT

14.1.3.1 GENERAL

The installation details shall be in accordance with the instruction prepared by the manufacturer.

Pumps shall be "Type-tested" in accordance with the requirement of BS EN ISO 9906:2012. Test certificates with performance curves shall be submitted to the Supervising Officer.

Pumps and their drives shall be segregated such that failure of pump seals shall not result in damage to the drive motors.

14.1.3.2 STORAGE

The equipment shall be stored in a dry space when they are delivered to Site. Special rust preventive measures to protect the internal parts of pumps shall be applied if the equipment must be stored for an extended period of time. Such provisions shall be removed completely before final installation and the bearings shall then be re-lubricated.

14.1.3.3 PUMPS

14.1.3.3.1 Centrifugal Water Pumps

Common Installations for Waste Water Pumps, Storm Water Pumps and Sewage Pump

(a) Driving Arrangements

The pump and motor shall be direct coupled and mounted on a substantial machined bedplate; accurately aligned, and fitted with guards. The whole assembly including the bedplate shall be supplied by the pump manufacturer. Coupling with spacer shall be used for end suction pumps so that the impeller may be dismantled from the motor side for servicing without neither disrupting the pipework nor dismounting the motor.

(b) Stand-By Pumps Arrangement

Where stand-by pumps are specified with automatic changeover provision, the changeover shall be initiated by means of flow sensing devices of an approved pattern. The necessary non-return valves shall be incorporated in the pipework to interconnect such pumps.

14.1.3.3.2 Sump Pumps

The sump pumps shall be of vertical centrifugal type suitable for dry sump or wet sump installation. Each pump shall be constructed with double mechanical shaft seal and close-coupled to a submersible electric motor.

The sump pumps shall operate automatically under level control with an alarm to alert the operator when extra low or high water level is being exceeded.

Each pump shall be equipped with factory built-in suspension device and a factory mounted discharge elbow shall be provided for wet sump installation, and cast iron or steel base for dry sump installation to provide correct pump alignment for wet sump pump installation, the disconnection shall simply consist of easy removal of each pumping unit for inspection, repairs and services. The pumps when lowered into the pits shall automatically be connected to the discharge piping. There shall be no need for the maintenance or operation personnel to enter the wet well to carry out the work. Each pump shall be complete with guide bars, cable supports and lifting chains.

The pump discharge shall be fitted with a resilient seal that provides a positive hydraulic seal for maximum pump efficiency. Each impeller shall be trimmed to meet the specified flow requirements.

For installation in flammable zones, each sliding guide bracket shall have non-sparking material to prevent ignition of explosive wet well gases.

14.1.3.3.3 Sewage Pump

The pumps shall be capable for handling sewage containing solid particles up to 60 mm diameter.

The pumps shall be capable for operation in completely or partially submerged conditions.

14.1.3.4 PLANT ROOM LOCATION

Adequate working space must be provided to access for maintenance and sufficient headroom to lift the parts for repairing. For large pumps, a hoist with travelling crane or other facility shall be provided over the pump location.

For an open loop system, the location of pump shall be sited so that it will use the shortest and most direct suction and smallest vertical lift. Where possible, the pump centreline shall be placed below the level of the liquid in the suction tank.

14.1.3.5 VENTING VALVES FOR PUMP-SET

Venting valves shall be installed at one or more points of the pump-casing waterway to provide a means to escape for air or vapour trapped in the casing. These valves shall be connected so as not to endanger the operation staff in handling toxic, inflammable or corrosive liquid.

14.1.3.6 INSTRUMENTATION

Each pump installation shall include flow meters cum transmitters, pressure gauges and a gas cock to measure the system pressures and pressure drop.

All measuring and isolation instruments, such as the pressure gauges, check valves, globe valves, gate valves and strainers, etc., or as specified in the Particular Specification shall be installed properly to maintain a close check on control on the performance and condition of the pumps.

Instruments shall be mounted in a suitable location so that they can be easily observed.

SECTION 14.2

MATERIAL AND EQUIPMENT SPECIFICATION

SUB-SECTION 14.2.1

ABOVE GROUND DRAINAGE SYSTEM

14.2.1.1 PIPES AND FITTINGS FOR SURFACE WATER DRAINAGE

14.2.1.1.1 Cast Iron Rainwater Pipes, Gutters and Fittings

Cast iron rainwater pipes and fittings for use internally shall be to BS 416-1:1990 with Type A or B sockets without ears.

The pipes and fittings shall be coated internally and externally to prevent corrosion. When cold applied bitumen-based coating is proposed, the coating material shall comply with BS 3416:1991 or other equivalent international standards. External coating shall contain anti-corrosion inhibitors normally used on metallic structures.

The pipes shall be in a state to permit the application of additional external finishing coatings.

Branch and bend fittings shall have bolted access doors or inspection units with gunmetal bolts and rubber gaskets fitted into the fittings.

Trap shall be of anti-siphon type with bolted access door.

Gutters shall be to BS 416-1: 1990 with half round or ogee section or as specified.

14.2.1.1.2 UPVC Rainwater Pipes, Gutters and Fittings

UPVC rainwater pipes, gutters and fittings shall be to BS EN 1329-1:2020, BS EN 12200:2000 and BS 4514:2001 where applicable.

UPVC pipes and fittings shall have solvent welded spigot and socket joints.

14.2.1.1.3 Rainwater Outlets

Cast iron rainwater outlets shall be to BS 416-1:1990 with removable dome shape strainer or flat grating to stainless steel BS EN 10088-2:2014 number 1.4401 or SAE Grade 316. The strainer or flat grating shall be screwed onto a cast iron collar fitted into the cast iron rainwater outlet body. Assembly of the collar to the rainwater outlet body shall be by stainless steel bolts and nuts.

Cast iron rainwater two-way side outlets shall be to BS EN 1561:2011 grade 150 with removable stainless steel to BS EN 10088-2:2014 number

1.4401 or SAE Grade 316 elbow grating. The grating shall be screwed onto a cast iron clamping collar fitted into the cast iron rainwater outlet body. Assembly of the collar to the rainwater outlet body shall be by stainless steel screws.

UPVC rainwater outlet shall be to BS EN 12200-1:2016. It shall be an approved proprietary type complete with sealing flange and screw fixed flat or domed grating.

Stainless steel rainwater outlet shall be of flat removable grating type. The body and base frame shall comply with BS EN 10088-3:2014 number 1.4301 or SAE Grade 304.

14.2.1.1.4 Surface Channels

Cast iron channel gratings shall be of BS EN 1561:2011 Grade EN-GJL-150.

The slots in the channel cover gratings as well as the gap between grating segments shall be less than 13 mm wide and any hole in the channel cover or between such covers shall have a dimension of not more than 20mm so as to avoid trapping wheelchairs and canes.

14.2.1.1.5 First Flush Device / Vortex Filter

First flush device/vortex filter shall be installed at the downstream of rainwater pipe(s) before entering the rainwater collection tank to remove dirt such as fallen leaves from rainwater collected over roof. The minimum capacity of the first flush device shall be 20 to 25 litres per $100m^2$ of catchment area. The body of vortex filter shall be made of robust, tough and non-corrosive type material and equipped with a removable stainless steel bucket type with handle for lifting up, filter of minimum 95% filtering efficiency. The cover of vortex filter shall be securely locked to avoid flapping under pressure.

14.2.1.2 PIPES AND FITTINGS FOR FOUL WATER DRAINAGE

14.2.1.2.1 Cast Iron Soil, Waste and Ventilating Pipes and Fittings

Cast iron pipes and fittings of size not exceeding 150 mm diameter shall be to BS 416-1:1990 with Type A or B sockets without ears.

Cast iron pipes and fittings of size exceeding 150 mm diameter shall be to BS 437:2008.

The pipes and fittings shall be coated internally and externally to prevent corrosion. When cold applied bitumen-based coating is proposed, the coating material shall comply with BS 3416:1991 or other equivalent international standards. External coating shall contain anti-corrosion inhibitors normally used on metallic structures.

The pipes shall be in a state to permit the application of additional external finishing coatings.

Other than ventilating and anti-syphon pipes, branch and bend fittings shall have bolted access doors or inspection units with gunmetal bolts and rubber gaskets fitted into the fittings.

Trap shall be of anti-siphon type with bolted access door.

14.2.1.2.2 Galvanised Iron Pipes and Fittings

Galvanised iron pipes and fittings shall be to BS EN 10255:2004 medium grade and hot dip zinc coated.

Fittings for steel pipes shall be of malleable cast iron screwed fittings to BS 143 and 1256:2000 or BS EN 10242:1995, and hot dip zinc coated.

Other than ventilating and anti-syphon pipes, branch and bend fittings shall have bolted access doors or inspection units with gunmetal bolts and rubber gaskets fitted into the fittings.

14.2.1.2.3 UPVC Pipes and Fittings

UPVC pipes and fittings shall be to BS 5255:1989 or BS EN 1329-1:2020 for nominal pipe sizes from 32 mm to 150 mm except 80 mm diameter.

UPVC pipes and fittings for nominal pipe size of 80 mm diameter shall be to BS 4514:2001.

UPVC pipes and fittings shall have solvent welded spigot and socket joints.

The pipes and fittings shall be suitable for the intended use, particularly where non-domestic effluents or hot liquids in kitchens, laboratories etc. may be discharged into the foul water drainage system.

Anti-siphon traps except the resealing type traps shall be fitted with a one way valve disk of brass or stainless steel or silicon rubber as appropriate. The one way valve disk shall be affixed with a similar metal or alloy pin complete with a rubber gasket.

Waste outlets and traps including W-trap shall conform to BS EN 274-1:2002.

14.2.1.2.4 Balloon Grating and Vent Cowl

Unless otherwise approved, balloon grating and vent cowl shall be of galvanised steel wire or copper wire.

14.2.1.2.5 Cast Iron Floor Drain Outlet

Cast iron floor drain outlets shall be to BS 416-1:1990 with removable flat grating to BS EN 10088-3:2014 number 1.4401 or SAE Grade 316. The flat grating shall be screwed onto a cast iron collar fitted into the cast iron rainwater outlet body. Assembly of the collar to the rainwater outlet body shall be by stainless steel bolts and nuts.

The slots or holes in drain outlet grating shall be less than 13 mm.

14.2.1.2.6 UPVC Two-Way Floor Drain Outlet

UPVC two-way floor drain outlet shall comprise of UPVC horizontal drain pipe with sealing flange, UPVC adaptor unit for vertical grating and UPVC adjustable horizontal grating unit with sealing flange.

The UPVC adaptor unit shall have built-in drainage fall towards downstream and shall allow easy removal of vertical grating by unscrewing the fixing screws after the installation for maintenance purpose. Its spigot connecting to the drain pipe may also be cut short to suit the thickness of the wall finishes.

The UPVC horizontal grating unit shall have removable horizontal grating and shall allow for cutting low to suit finished floor level.

The UPVC gratings for vertical and horizontal use shall be fixed with stainless steel screw.

14.2.1.3 CAST IRON SOCKETLESS PIPES AND FITTINGS FOR SURFACE WATER AND FOUL WATER DRAINAGE

14.2.1.3.1 Cast iron socketless pipes, fittings and coupling shall comply with BS EN 877:1999+A1:2006.

14.2.1.3.2 Pipes and fittings shall be coated internally with tar-free epoxy with minimum thickness of 120 microns and 40 microns respectively. The internal epoxy coating shall have a resistance to exposure of salt spray test to clause 5.7.2.1 of BS EN 877:1999+A1:2006 for a minimum of 1000 hours if sea water is to be use in the flushing water system. Other factors such as resistance to waste water, chemical resistance, resistance to hot water, resistance to temperature cycling, etc. shall be considered to suit the application.

14.2.1.3.3 Pipe and fittings shall be coated externally with anti-corrosive coating with minimum thickness of 40 microns or other form of approved protections.

14.2.1.3.4 All joints must be mechanically connected. If such joints are subjected to thrust loads due to changes of direction and gradient, branches and plugs or overloading, securing clamps such as grip collars or high pressure couplings shall be used to prevent misalignment or disconnection of the

pipework. All submissions including drawings, equipment catalogues, technical hydraulic calculations and other information as required shall be submitted to the Supervising Officer for approval. Relevant structural calculations shall be endorsed by a Registered Structural Engineer prior to submission to the Supervising Officer for approval.

14.2.1.3.5 The coupling shall composed of stainless steel shield to BS EN 10088-3:2014 number 1.4401 or SAE Grade 316, clamp assembly and an elastomeric sealing sleeve conforming to the requirement of BS EN 681-1:1996 and also can resist the normal domestic effluents with thermal effects up to temperature of 70°C.

14.2.1.3.6 The piping system including pipes, fittings, sealing gaskets, coupling, bolt and nuts shall be of single proprietary product with a minimum product guaranty for 10 years from the manufacturer.

14.2.1.3.7 The piping system shall be properly supported and restrained in full accordance with the manufacturer's recommendations. Additional supporting brackets shall be provided for change of direction and gradient.

14.2.1.3.8 The piping system shall be followed manufacturer’s recommendations such as applying suitable anti-corrosive touch up paint or suitable cut edge protection on pipe cut surface as appropriate. The installation method shall be submitted to the Supervising Officer for approval.

14.2.1.3.9 Manufacturer’s training course shall be provided to workers who are responsible for pipe cutting. The detailed training course shall be submitted to the Supervising Officer for approval.

SUB-SECTION 14.2.2

UNDERGROUND DRAINAGE SYSTEM

14.2.2.1 PIPES AND FITTINGS

14.2.2.1.1 Precast Concrete Pipes and Fittings

Precast concrete pipes and fittings shall be to BS 5911-1:2002+A2:2010 or BS EN 1916:2002 with flexible joints of spigot and socket or rebated type. Concrete pipes shall have wall thickness and strength not less than those stated in Table 14.2.2.1.1.

Table 14.2.2.1.1 Requirements of Concrete Pipes and Collars

Nominal Bore of Pipe (mm)	Minimum Crushing Test Load (kN/m of effective length) Extra Strength Pipes and Collars						Min.Thickness of Pipe Wall and Collar Wall (mm)		Min. Length of Collar
	Class L		Class M		Class H				
	Proof	Ult	Proof	Ult	Proof	Ult	Reinf	Unreinf	
150	20	25	-	-	-	-	-	25	-
225	20	25	-	-	-	-	-	25	-
300	20	25	23	29	-	-	-	32	-
375	20	25	31	39	36	45	-	38	-
450	20	25	35	44	41	52	64	44	-
525	20	25	39	48	46	58	67	51	-
600	20	25	46	58	54	68	70	57	-
675	20	25	50	63	60	75	73	64	
750	38	48	53	67	65	82	76	70	225
825	41	52	58	72	69	87	81	-	225
900	46	58	67	84	85	107	86	-	225
1050	54	64	76	95	96	120	95	-	225
1200	57	72	87	109	110	138	102	-	225
1350	63	79	95	120	120	153	114	-	225
1500	69	87	104	130	132	165	127	-	225
1650	75	94	116	145	146	183	140	-	300
1800	82	103	124	155	158	198	152	-	300
1950	88	110	135	169	169	212	165	-	300
2100	96	120	146	183	184	230	178	-	300
2250	102	128	155	194	195	244	190	-	300
2400	108	135	165	207	210	263	203	-	300
2550	116	145	177	222	223	279	216	-	300

Class and nominal internal diameter of concrete pipe shall be as specified.

14.2.2.1.2 Vitrified Clay Pipes and Fittings

Vitrified clay pipes and fittings for surface water drainage shall comply with BS 65:1991. The pipes and fittings shall be glazed and shall be the normal chemical resistant type.

Vitrified clay pipes and fittings for foul water drainage shall comply with relevant parts of BS EN 295 with flexible spigot and socket joints.

14.2.2.1.3 Cast Iron Pipes and Fittings

Cast iron pipes and fittings shall be to BS 437:2008 with flexible joints of spigot and socket type.

Cast iron pipes and fittings for use in pressurised drainage system with pipe size larger than 150 mm diameter shall be to BS 598:2007+A1:2009 with flexible joints of spigot and socket type.

The pipes and fittings shall be coated internally and externally to prevent corrosion. When cold applied bitumen-based coating is proposed, the coating material shall comply with BS 3416:1991 or other equivalent international standards. External coating shall contain anti-corrosion inhibitors normally used on metallic structures.

The pipes shall be in a state to permit the application of additional external finishing coatings.

Other than ventilating and anti-syphon pipes, branch and bend fittings shall have bolted access doors or inspection units with gunmetal bolts and rubber gaskets fitted into the fittings.

14.2.2.1.4 Ductile Iron Pipes and Fittings

Ductile iron pipes and fittings shall be to BS EN 598:2007+A1:2009 with high alumina cement mortar lining internally and zinc coating with a finishing layer of a synthetic resin (epoxy, polyurethane, etc.) externally.

Unless otherwise specified, ductile iron pipework shall be of push-in type flexible joint with rubber sealing gasket. It shall be capable to withstand a minimum angular deflection complying with BS EN 598:2007 + A1:2009 and an allowable spigot withdrawal of minimum 38mm.

Flanged joints and gasket anchor joint, if specified, shall be of PN16 rating complying with BS EN 1092-2:1997.

Pipes that are to be built in to structures shall have puddle flanges welded on or cast on.

14.2.2.1.5 UPVC Pipes and Fittings

UPVC pipes and fittings for gravity sewage and surface water drainage shall be to BS 4660:2000 or BS EN 13598-1:2020 for pipe sizes from 110

mm to 160 mm diameter, and to BS EN 1401-1:2019 for pipe sizes from 200 mm to 630 mm diameter. They shall be socket joint type with elastomeric joint rings.

UPVC pipes and fittings for use in pressurised drainage system shall be to BS 3506:1969 with class suitable for the design pressure rating. Joints and fittings shall comply with relevant parts of BS 4346-1:1969 or BS EN ISO 1452-1:2009, BS EN ISO 1452-2:2009, BS EN ISO 1452-3:2010, BS EN ISO 1452-4:2009 or BS EN 1452-5:2009.

Interchangeability shall not be allowed between different UPVC pipe manufacturer's products.

14.2.2.1.6 Sub-soil Drain Pipes and Fittings

Unless otherwise specified, sub-soil drain pipes and fittings shall comply with the following: -

(a) For vitrified clay pipes and fittings, to BS 65:1991 and of the normal glazed, chemical resistant type with plains ends and flexible sleeved joints;

(b) For concrete porous pipes, to BS 5911-1:2002+A2:2010;

(c) For unglazed clayware field drain pipes and junctions, to BS 1196: 1989; or

(d) For perforated plastic pipes and fittings, to BS 4962:1989.

14.2.2.1.7 High Density Polyethylene (HDPE) Pipes and Fittings

(a) HDPE pipes and fittings for gravity sewage and surface water shall be to BS EN 12201-1:2011, BS EN 12201-2:2011+A1:2013 and BS EN 12201-3:2011+A1:2012.

(b) The pipes shall be made from virgin material.

(c) The external identification stripe and colour shall be to BS EN 12201-1:2011 and BS EN 12201-2:2011+A1:2013.

(d) Interchangeability shall not be allowed between different HDPE pipe manufacturer's products.

14.2.2.2 VALVES

14.2.2.2.1 General

Handwheels and tee keys shall turn in a clockwise direction to close the valve.

Handwheels shall have a smooth rim with the direction of opening and closing clearly cast in.

The opening effort required at any point on the handwheel shall not exceed 250N when operated against the full unbalanced pressure. If the full unbalanced pressure is greater than 250Nm, a gear box fitted in the valves shall be provided.

Extension stems shall be of the same grade of stainless steel as the stems and shall be connected by muff couplings.

Handwheels, tee keys, headstocks, guide brackets for stems, supporting brackets, surface boxes and other fittings shall be of cast iron to BS EN 1561:2011.

Assembly bolts and nuts shall be of stainless steel to BS EN ISO 3506-1:2020 of grade A4 and property class 80. Washers shall be of stainless steel equivalent to SAE grade 316 S31. For cast iron or ductile iron valves, materials for assembly bolts and nuts shall be in according to manufacturer's recommendation.

14.2.2.2.2 Gate Valves

Gate valves shall be of double flange ended and solid wedge type to BS EN 1171:2015 or BS 5163-1:2004 in conjunction with BS EN 1074-1:2000 and BS EN 1074-2:2000, with a nominal pressure designation of PN16 and flange to BS EN 1092-1:2018 or BS EN 1092-2:1997 PN16.

The bodies and wedges shall be of cast iron to BS EN 1561:2011 Grade EN-GJL-250 or spheroidal graphite cast iron to BS EN 1563:2018 Grade EN-GJS-400-15 with removable seat rings made from gunmetal to BS EN 1982:2017 CuSn5Zn5Pb5.

Stem nuts shall be made from gunmetal to BS EN 1982:2017 CuSn5Zn5Pb5 or stainless steel.

Stems shall be of aluminium bronze to BS EN 12163:2016 grade CA 104 or stainless steel.

For valve size larger than 50mm diameter, an indicator to show the open and shut positions shall be provided.

Chains for chain operated gate valves shall be of mild steel to BS EN 10095:1999 and hot dip galvanised.

14.2.2.2.3 Flap Valves

Frame and flap shall be of cast iron to BS EN 1561:2011 Grade EN-GJL-220 or ductile iron to BS EN 1563:2018.

Sealing faces and hinge pins shall be of gunmetal to BS EN 1982:2017 CuSn5Zn5Pb5 or stainless steel to BS EN 10088-2:2014 number 1.4401 or SAE Grade 316.

The flap shall be hung with double hinges and secured with hinge pins.

Flange for mounting of flap valves shall be of PN16 to BS EN 1092-2:1997.

14.2.2.2.4 Sludge Valves

Bodies and valve sections shall be of cast iron to BS EN 1561:2011 Grade EN-GJL-220.

Sealing faces and stem nuts shall be of gunmetal to BS EN 1982:2017 CuSn5Zn5Pb5.

Stems shall be of aluminium bronze to BS EN 12163:2016 grade CA 104. It shall be operated through non-rising stem nuts and housed in bridges bolted over the body sections.

The outlet flanges shall be of PN16 to BS EN 1092-2:1997.

14.2.2.2.5 Air Valves

Air valves shall be of dual orifice elongated body type with small orifice valves for releasing air at working pressure and a large orifice valve for allowing air to pass at atmospheric pressure during emptying and filling of the pipework.

The pressure rating of the air valves shall be min. 3 bars.

The bodies and covers shall be of cast iron to BS EN 1561:2011 Grade EN-GJL-220, or ductile iron to BS EN 1563:2018 or stainless steel to BS EN 10088-2:2014 number 1.4401 or SAE Grade 316.

The trim and float shall be of stainless steel to BS EN 10088-1:2014 number 1.4401 or SAE Grade 316.

14.2.2.3 MANHOLES, CHAMBERS AND GULLIES

14.2.2.3.1 General

Cast iron covers, gratings, overflow weirs and frames shall be clean, free from air holes, sand holes, cold shuts and chill, neatly dressed and carefully fettled. Castings shall be free from voids, whether due to shrinkage, gas inclusions or other causes.

Particulars of the proposed materials for manholes, chambers, gullies and channels shall be submitted to the Supervising Officer for examinations and approvals: -

(a) A certificate for each type of manhole and chamber unit, for each type of gully and for each type of channel accessories showing the manufacturer's name, the date and place of manufacture and showing that the materials comply with the requirements stated in the Contract and including results of tests required in accordance with the Contract;

(b) A certificate for step irons showing the manufacturer's name, the date and place of manufacture and showing that the step irons comply with the requirements stated in the Contract, and including results of tests required in accordance with the Contract; and

(c) A certificate for each type of manhole cover, gully grating, kerb overflow weir and channel cover showing the manufacturer's name, the date and place of manufacture and showing that the materials comply with the requirements stated in the Contract and including results of tests in accordance with the Contract.

14.2.2.3.2 Precast Concrete Manholes

Precast concrete manholes shall be constructed to BS 5911-3:2010 and BS EN 1917:2002 with cover slabs and reducing slabs reinforced as required to comply with the load test requirements and with rebated joints.

14.2.2.3.3 Precast Concrete Chambers and Gullies

Precast concrete chambers and gullies shall be constructed to BS 5911-3:2010 and BS EN 1917:2002 with cover slabs reinforced as required to comply with the load test requirements.

Rebated joints shall be provided between precast units.

Types of cement used in manufacturing shall be either as stated in BS EN 1917:2002 or a combination of precast concrete to BS EN 197-1:2011 and PFA /PFAC in which the PFA does not exceed 40% by mass of the total cementations content.

14.2.2.3.4 Vitrified Clay Gullies

Vitrified clay gullies shall be to BS 65:1991.

14.2.2.3.5 Step Irons

Manhole steps shall be to BS EN 13101:2002 of malleable iron to BS EN 1562:2019 hot dip galvanised in accordance with BS EN ISO 1461:2009. Minimum zinc coating thickness shall be 610 g/m^2.

14.2.2.3.6 Cast Iron Manhole Covers, Gully Gratings and Overflow Weirs

Cast iron manhole covers, gully gratings and overflow weirs shall be to BS EN 1561:2011 Grade EN-GJL-150. They shall be cleanly casted and

free from air holes, sand holes, voids due to shrinkage, gas inclusions or other causes. The dimensions and construction of cover shall in accordance to the Drawings.

Nuts and bolts shall comply with BS 4190:2014.

The units shall be coated with 2 layers of black non-toxic water-based bituminous coating to BS 3416:1991 or 2 layers of black non-toxic coal-tar based coating to BS 4164:2002 after thoroughly cleaned to remove moulding sands, rust or any other impurity. The coating shall be free of bare patches or lack of adhesion.

The test loads which the covers and gratings are required to withstand, and the minimum masses of covers gratings and weirs, shall be as stated in Table 14.2.2.3.6 (1) to Table 14.2.2.3.6 (3).

Table 14.2.2.3.6 (1) Minimum Test Load and Mass of Manhole Cover and Frame

Type	Minimum Mass (kg)	Grade (Duty)	Test Requirements	
			Diameter of Block (mm)	Test Load (t)
Manhole cover and frame	180	Medium	100	5
Manhole cover for sewers	130	Heavy	300	30
Frame	105	Heavy	300	30
Desilting manhole cover for sewers	290	Heavy	300	30
Frame	165	Heavy	300	30

Type	Minimum Mass (kg)	Grade (Duty)	Test Requirements	
			Diameter of Block (mm)	Test Load (t)
Double seal terminal manhole for sewers				
Type MA2-29/29A & B	-	Heavy	300	20
Type MA2-45/45A & B	-	Heavy	300	20
Type MC2-29/29A & B	-	Medium	100	5
Type MC2-45/45A & B	-	Medium	100	5

Table 14.2.2.3.6 (2) Minimum Test Load and Mass of Gully Grating and Frame

Type	Minimum Mass (kg)	Grade (Duty)	Test Requirements	
			Diameter of Block (mm)	Test Load (t)
Grating for hinged gully grating Type GA2-325	28.0	Heavy	300	20
Frame	24.5	Heavy	300	20
Grating for gully grating Type GA1-450	57.5	Heavy	300	20
Shallow frame:				
- Adjacent to kerb	33.5	Heavy	300	20
- Away from kerb	36.5	Heavy	300	20
Deep frame:				
- Adjacent to kerb	40.5	Heavy	300	20
- Away from kerb	44.0	Heavy	300	20
Grating for hinged gully grating Type GA2-450	61.5	Heavy	300	20
Frame	37.0	Heavy	300	20

Table 14.2.2.3.6 (3) Details of Kerb Overflow Weirs

Type	Minimum mass (kg)
1-325	39.5
3-325	31.5
1-450	44.0
3-450	36.5
4-450	33.0

14.2.2.3.7 Ductile Iron Manhole Covers and Frames

Ductile iron manhole covers and frames shall comply with BS EN 124-1:2015. Grade of ductile iron shall be of EN-GJS-500-7 to BS EN 1563:2018.

Bolts for loosely coupling separate sections of covers shall be stainless steel hexagon headed complete with hexagon nuts to BS EN 10088-1:2014 number 1.4301 or SAE Grade 304 with dimensions complying with BS 4190:2014.

The units shall be cleanly cast, free from air holes, sand holes, voids due to shrinkage, gas inclusions or other causes, cold shuts, chill and any surface defects and neatly dressed and fettled.

The units shall have dimensions as indicated on the Drawings and have sharp edges removed.

The construction of cover shall be in accordance to the Drawings. All markings shall be clearly legible.

The units shall be coated with 2 layers of black non-toxic water-based bituminous coating to BS 3416:1991 or 2 layers of black non-toxic coal-tar based coating to BS 4164:2002 after thoroughly cleaned to remove moulding sands, rust or any other impurity. The coating shall be free of bare patches or lack of adhesion.

The units shall compatible with their seatings which shall be manufactured in such a way to ensure stability and quietness in use.

Bedding material for manhole frames shall be non-shrinkage with compressive strength exceeding 30 N/mm^2.

The units shall be capable of withstanding the minimum test loads and having the minimum masses given in Table 14.2.2.3.7.

Table 14.2.2.3.7 Minimum Test Load and Mass of Ductile Iron Manhole Cover and Frame

Type	Minimum Mass (kg)	Test Requirements	
		Diameter of Block (mm)	Test Load (t)
Class E600 standard 675 square ductile iron manhole cover	110	250	60
Frame	58	250	60

SUB-SECTION 14.2.3

WASTE WATER HANDLING EQUIPMENT

14.2.3.1 WASTE WATER PUMPS

14.2.3.1.1 These pumps shall be utilised for pumping waste water or storm water or grey water/treated effluent water wherever these applications apply.

14.2.3.1.2 Materials of Construction

Unless otherwise specified, the materials of construction for saline water pump shall be as follows: -

Casing	:	Cast iron
Impeller	:	Zinc free bronze (*Stainless steel)
Shaft	:	Stainless steel
Sleeves	:	Bronze (*Stainless steel)
Casing rings	:	Stainless steel
Shaft nuts	:	Bronze
Stuffing box housing	:	Cast iron
Glands	:	Carbon steel
Lantern rings	:	Bronze

*Alternative materials subject to the approval of the Supervising Officer

14.2.3.1.3 Standards

(a) Casing

Unless otherwise indicated, the casing shall be of cast iron to BS EN 1561:2011 or ISO 185:2020 or better and approved.

(b) Impeller and Shaft Sleeve

Impeller and shaft sleeve of waste water pumps shall be of one of the materials as below: -

(i) Zinc-free bronze to BS EN 1982:2017 CC480K or CC481K; or ISO 197-4:1983;

(ii) Austenitic cast iron to BS EN 13835:2012 Number 5.1500; or ISO 2892: 2007/Cor 1:2009; or

(iii) Stainless steel to BS EN 10283:2010 Grade 1.4408.

(c) Shaft and Sleeves

The shaft shall be of stainless steel to BS EN ISO 683-3:2018, BS EN ISO 683-4:2018 and BS EN 10088-3:2014 Grade 1.4408, ground and polished.

Bronze sleeves shall comply with BS EN 1982:2017 or ISO 197-4:1983 and shall be provided through the sealing glands to protect the shaft from wear. The sleeves shall be keyed to prevent rotation and secured against axial movement.

(d) Stuffing Boxes and Drain Piping

Stuffing boxes shall be of cast iron housing and ample length completed with bronze lined gland and necks bushes, fitted with approved packing and bronze lantern ring water seal. Drain piping to the nearest builder's drain for gland leakage shall be provided. Alternatively, a mechanical seal may be offered. Mechanical seals shall be of leak free operation. The mechanical seal shall be the product of specialist proprietor and the materials used shall be suitable for the pumped liquid.

14.2.3.2 SUMP PUMPS

14.2.3.2.1 Materials of Construction of Dry Pit Pumps

Unless otherwise specified, the materials for dry pit non-clog pumps areas shall be as follows: -

Pump casing	:	Cast iron
Impeller	:	Cast iron (*Stainless steel)
Shaft	:	Stainless steel
Shaft sleeve	:	Stainless steel (*Bronze)
Packing gland	:	Ductile iron (*Bronze)
Casing bolts	:	Steel
Cap screw and washer, impeller	:	Stainless steel
Key, impeller	:	Steel

*Alternative materials subject to the approval of the Supervising Officer.

14.2.3.2.2 Materials of Construction of Submersible Pumps

Unless otherwise specified, the materials for submersible non-clog pumps shall be as follows: -

Pump casing	:	Cast iron
Impeller	:	Cast iron (*Stainless steel)
Motor casing	:	Cast iron
Shaft	:	Stainless steel
Impeller screw	:	Stainless steel
Mechanical seals	:	Carbon (*Ceramic faces)
Base plate	:	Steel
Discharge elbow	:	Cast iron
O-ring seal	:	Neoprene

*Alternative materials subject to the approval of the Supervising Officer.

14.2.3.2.3 General Requirements

The stainless steel material shall comply with BS EN ISO 683-3:2018, BS EN ISO 683-4:2018, BS EN 10088-3:2014 Grade 1.4404, BS EN 10283:2019 Grade 1.4408 and BS EN 10250-1: 1999 & 4:2000 Grade 316.

All bolts, nuts and fasteners shall be of stainless steel and electric cable entry shall be of watertight construction.

Sump pumps for storm water application shall generally be of materials complying with standards as specified in Clause 14.2.3.1.3. Sump pumps for pumping other fluids shall be of materials compatible with the fluid that is being handled. The sump pumps shall operate automatically by float level control.

The guide bars and brackets for wet sump installation shall be of stainless steel to AISI 316.

Cable supports shall be of stainless steel. A safety provision shall be incorporated for automatic electrical disconnection of the supply in case of cable entry seal failure.

Pumps for flammable zones shall be equipped with flameproof submersible motor in compliance with BS EN IEC 60079-0:2018 and BS EN 60079-1:2014.

14.2.3.3 SEWAGE PUMPS

14.2.3.3.1 Materials of Construction of Sewage Pumps

Pump casing	:	Cast iron
Impeller	:	Austenitic cast iron (*Stainless steel)
Shaft	:	Stainless steel
Bearing	:	Ball/Ball, no regreasing required for 3 years continuous operation
Seals	:	Carbon/Tungsten carbide
Bolts, nuts, screw washer	:	Stainless steel
Hold-down bolts	:	Stainless steel

*Alternative materials subject to the approval of the Supervising Officer.

14.2.3.3.2 Standards

(a) Casing

Unless otherwise indicated, the casing shall be of cast iron to BS EN 1564:2011 Grade 220.

(b) Impeller and Shaft Sleeve

Impeller and shaft sleeve of waste water pumps shall be of one of Austenitic cast iron to BS EN 13835:2012 Grade L – Ni Cu Cr 1563.

(c) The shaft shall be of stainless steel to BS EN ISO 683-3:2018, BS EN ISO 683-4:2018, BS EN 10088-3:2014 Grade 1.4404, and BS EN 10250-1:1999 & 4:2000 Grade 431S29.

(d) Bolts, nuts, screw, washer and hold-down bolts shall be of stainless Steel to BS EN ISO 683-3:2018, BS EN ISO 683-4:2018, BS EN 10088-3:2014 and BS EN 10250-1:1999 & 4:2000 Grade 316.

14.2.3.3.3 General Requirements

The stainless steel material shall comply with BS EN ISO 683-3:2018, BS EN ISO 683-4:2018, BS EN 10088-3:2014 Grade 1.4404 and BS EN 10250-1: 1999 & 4:2000 Grade 316.

The sewage pump shall meet the design capacity on normal operation.

The sewage pump shall be arranged with flanged connection to the discharge pipe. Each pump shall be closely coupled to the totally enclosed built-in submersible electric motor suitably rated for the pump.

Two mechanical seals, made of the material specified in above, shall be provided to seal off the leakage of sewage from the pump to motor.

The hydraulic efficiency of the pump shall be within the highest efficiency range at the specified operating point.

Pumps for flammable zones shall be equipped with flameproof submersible motor in compliance with BS EN IEC 60079-0:2018 and BS EN 60079-1:2014.

14.2.3.3.4 Pump Motor

The motor shall comply generally with relevant parts of BS EN 60034-1:2010 and shall operate on a 3 phase, 380 volt, 50 Hz supply.

The motor shall be of the squirrel cage, totally enclosed type with insulation of Class "F" to IEC60085:2007. Enclosure type of IP68 to ISO 185:2020 shall be used.

The motor shall be capable of supplying its rated output at rated speed at any voltage in the range 94% to 106% of the nominal voltage and shall satisfactorily operate continuously at its rated duty without excess temperature rise within this range.

The motor shall have its own built-in cooling system which shall enable the motor to operate continuously at its rated current regardless of whether the electric motor is above or below the surface of the liquid.

14.2.3.4 PUMP CONTROL PANEL

The cubicle of the pump control panel shall be vermin proof and lockable. The thickness of sheet steel shall not be less than 2 mm and shall be properly reinforced with angle iron. The cubicle shall be constructed to conform to IP44 to IEC 60529:2013 for indoor use and IP65 for outdoor use. All indicators, relays, control switches, push-buttons, fuses and other auxiliary apparatus shall be provided with labels clearly stating their function. The labels supplied shall be inscribed in English and Chinese characters.

14.2.3.5 VIBRATION ISOLATORS

The bases shall be mounted on plinth using anti-vibration spring mountings that shall be individually selected according to load distribution and shall have an additional free travel equal to one half of the rated deflection as specified in the requirements of Plant/Equipment Vibration Isolation under Part 6 of this General Specification.

14.2.3.6 GAUGES

Pressure gauges shall comply with BS EN 837-1:1998 calibrated in kPa from zero to not less than 1.3 times and not more than twice the operating pressure of the respective equipment/system and shall be accurate to 1.5% of full scale reading, unless otherwise specified.

The dials of gauges shall not be less than 100 mm diameter and the cases shall be of polished brass or chromium-plated or anti-corrosive painted mild steel with optical sight glass. Pressure gauges used solely to indicate the head and pressure of water shall be provided with an adjustable red pointer set to indicate the normal working pressure.

14.2.3.7 DRAIN AND VENT

The drain vent shall be built-in completed with a drain plug except where the pump is inherently self-venting, the drain and drip connection valves and air cock shall comply with Part 6 of this General Specification.

14.2.3.8 FLANGED CONNECTIONS

Pumps shall have flanged connections conforming to the Table of BS EN 1515-1:2000, BS EN 1092-1:2018, ISO 7005-1:2011 or ISO 7005-2:1988 as appropriate to the maximum working pressure. Taper pieces shall be provided where necessary for connection to pipework.

SECTION 14.3

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 14.3.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

14.3.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

14.3.1.2 INSPECTION AND TEST REQUIRED BY THE AUTHORITES

All mandatory inspection, testing, to meet the statutory requirements and to the satisfaction of the relevant Authorities, including DSD, EPD and Statutory Compliance Checking Unit (SCCU) of the ArchSD, etc. shall be carried out. All necessary applications to the Authorities well in advance shall be made and tests conducted by their representatives shall be attended.

SUB-SECTION 14.3.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

14.3.2.1 GENERAL

On top of the requirements stipulated in Part 1 of this General Specification, the operation and maintenance of the Installations shall also meet the requirements specified in this Sub-section.

14.3.2.2 REQUIREMENTS OF ROUTINE MAINTENANCE DURING MAINTENANCE PERIOD

Routine maintenance for the Installations as specified in this Sub-section shall be carried out during the Maintenance Period. A maintenance programme shall be prepared and submitted before the commencement of the Maintenance Period for the approval of the Supervising Officer. The dates for routine and periodic inspection, servicing and maintenance of the installations shall be indicated.

The routine services shall in include, but not limited to, the following: -

14.3.2.2.1 Monthly Routine Maintenance Services

(a) Check the general condition of the whole installation to ensure the system are satisfactorily performed as required by the Contract;

(b) Check proper positioning of all manhole, gully and channel covers;

(c) Check any water leakage from the pipework and to repair if required;

(d) Examine the condition of joints, stop valves, covers and seals for leaks, repair as required; and

(e) Check drains are not clogged and rectify if necessary.

14.3.2.2.2 Quarterly Maintenance Services

(a) Works as required in monthly routine maintenance services;

(b) Clean all strainers; and

(c) Check manholes and gully and rectify clogged conditions if necessary.

14.3.2.2.3 Half-yearly Maintenance Services

(a) Works as required in monthly and quarterly routine maintenance services; and

(b) To inspect the condition of pipe fittings, supports, etc. for sign of corrosion. Remove the rust and repaint with primer and finish coating as necessary.

14.3.2.2.4 Annual Maintenance Services

(a) Works as required in monthly, quarterly and half-yearly routine maintenance services; and

(b) To conduct drain test to verify the drainage performance at selected stacks, branches and underground drainage.

PART 15 - SWIMMING POOL WATER TREATMENT INSTALLATION

SECTION 15.1

INSTALLATION AND EQUIPMENT REQUIREMENTS

SUB-SECTION 15.1.1

WATER CIRCULATION

15.1.1.1 GENERAL

15.1.1.1.1 Pool Water Circuits

A typical pool water treatment plant consists of the following aspects:-

(a) water circulation;

(b) filtration;

(c) pH control and chemical treatment;

(d) disinfection; and

(e) optional heating.

A pool water circuit consists of pumps, filters, disinfection plant, chemical dosing system, and heating plant if heating is provided.

15.1.1.1.2 Water Turnover Rate

Unless otherwise specified, the pool water turnover rate shall be not less than once in every 4 hours in the case of an indoor swimming pool or once in every 6 hours in the case of an outdoor swimming pool as required under Chapter 132 – Swimming Pools Bylaws Subsidiary Legislation, or revised turnover rate as revised by the HKSAR Government.

15.1.1.1.3 Water Balancing

In the case that 1 circuit is used to serve more than 1 pool, water balancing for each pool is important to maintain the turnover rate and the water level of each pool. The use of level sensors, flow meters, surge or balance tank and automatic control system to maintain the water balancing shall be facilitated. Refer to the Particular Specification for the water balancing methodology to be used.

15.1.1.1.4 Surge Tank

Surge tank is required to hold the displacement water via the perimeter overflow system. The retention capacity of the surge tank shall be designed to cater for the maximum expected bather surge. Surge tank may

be integral with the pool construction as trenches of a separate chamber into which the perimeter overflow is piped.

15.1.1.1.5 Balance Tank, Level Control and Infill Tank

Balance tank is used to compensate automatically the loss of water through the perimeter overflows, backwashes, evaporation and water carried by bathers leaving the pool. It is desirable to restore water level in less than 2 minutes after a surge. The compensating function of a balance tank shall be achieved by an automatic level control mechanism, with manual bypass fill valve provided. The pumping rate shall be large enough to reduce the recovery time.

Automatic infilling fresh water shall also be provided to the balancing system. Manual infill shall be included in case of automation failure. Balance tank may be combined with the surge tank with automatic infill level control to measure a preset minimum water level in the surge tank.

15.1.1.2 WATER PUMP

15.1.1.2.1 All pump motors higher than 120 W shall be with the motor efficiency of IE4 or better.

15.1.1.2.2 Main Circulating Water Pump

(a) Type

Pumps for pool water circulation or other fresh water pumping duties unless otherwise specified, shall be of one of the following types: -

(i) centrifugal type with volute casing split on the centreline of the shaft with suction and delivery connections flanged and fitted to the non-removable half of the casing;

(ii) end suction type, the pump set shall be installed with spacer type coupling so that the pump impeller can be dismantled from the motor side for servicing without disruption of the pipework nor dismounting the motor; or

(iii) vertical centrifugal pump.

Where large static heads have to be pumped against, the end suction type or vertical centrifugal type shall be used in multi-stage configurations. Generally the type of pump required will be specified in the Particular Specification and/or in the Tender Drawings. However, if this is not so, the end suction type shall be adopted.

The pneumatic booster pump set shall comprise of a duty and standby pump complete with a pneumatic vessel and control unit.

The pumps shall be vertically mounted, with direct drive motors. If necessary, the pumps shall be of multi-stage construction and each stage/section shall be interchangeable.

(b) Materials of Construction

Unless otherwise specified, the materials of construction of the pumps shall be as follows: -

Casing	:	Bronze to BS EN 1982:2017/ Cast iron to BS EN 1561:2011/ Stainless steel to BS EN 10088-3:2014
Impeller	:	Stainless steel to BS EN 10088-3:2014/ Bronze to BS EN 1982:2017
Shaft	:	Stainless steel to BS EN 10088-3:2014
Sleeves	:	Stainless steel same as shaft or cast bronze
Wearing rings	:	Copper-tin alloy to BS EN 1982:2017

(c) Standards

Stuffing Boxes shall have material same as the casing. Housing of cast iron stuffing boxes shall comply with ISO 185:2020 or BS EN 1561:2011 and shall be of ample length with bronze lined gland and neck bush, fitted with approved packing and lantern ring water seal. Drain outlet and piping to remove gland leakage shall be provided. Alternatively, a mechanical seal may be offered. The mechanical seal shall be of leak free operation. The mechanical seal shall be the product of a specialist proprietor and the materials used shall be suitable for the pumped liquid.

For vertical in-line pump, suction and discharge flanges shall be of equal size. The impeller shall be dynamically balanced. The shaft shall have stainless steel/bronze sleeves keyed to prevent rotation and secured against axial thrust. For multi-stage pump, each stage/section shall be interchangeable.

15.1.1.2.3 Cooling Water Pump

In case the ozonator is water cooled, where pool water is pumped through the generator for cooling purpose, the cooling water pump shall be one of the above types as deemed necessary unless otherwise specified in the Particular Specification.

15.1.1.2.4 Water Equipment Pumps

Pumps for water play equipment, make-up water, and other use shall be one of the above types as deemed necessary unless otherwise specified in the Particular Specification.

15.1.1.2.5 Sewage Sump Pump

(a) General Requirements

All bolts, nuts and fasteners shall be of stainless steel and electric cable entry shall be of watertight construction.

Materials for sump pumps shall be suitable for the pumping fluid being conveyed, such as, neither reacting to any parts in the pump by its fluid nor changing the content of the fluid by the pump. The sump pumps shall operate automatically by float level control. The guide bars for wet sump installations shall be of stainless steel of Grade 316.

Cable supports shall be of stainless steel. A safety provision shall be incorporated for automatic electrical disconnection of the supply in case of cable entry seal failure. Pumps for flammable zones shall be equipped with flameproof submersible motor in compliance with BS EN 60079-0: 2018, BS EN 60079-1: 2014 and IP 68 of BS EN 60529: 1992 + A2: 2013.

(b) Materials of Construction of Dry Pit Pump

Unless otherwise specified, the materials for dry pit non-clog pump shall be as follows: -

Casing	:	Cast iron to BS EN 1561:2011
Impeller	:	Cast iron to BS EN 1561:2011 or stainless steel to BS EN 10293:2015 grade 316
Shaft	:	Stainless steel to BS EN 10088-3:2014
Casing bolts	:	Stainless Steel
Cap screw and washer, impeller	:	Stainless steel
Key	:	Stainless Steel

(c) Materials of Construction of Submersible Pump

Unless otherwise specified, the materials for submersible non-clog pump shall be as follows: -

Casing	:	Cast iron to BS EN 1561:2011
Impeller	:	Cast iron to BS EN 1561:2011 or stainless steel to BS EN 10293:2015 grade 316
Shaft	:	Stainless steel to BS EN 10088-3:2014
Double Mechanical seals	:	Silicon Carbide; Carbon or ceramic faces
Discharge elbow	:	Cast iron to BS EN 1561:2011

15.1.1.2.6 Bore Well Pumps

All bolts, nuts and fasteners shall be of stainless steel and electric cable entry shall be of watertight construction.

Unless otherwise specified, bore well pumps specified shall be of all Grade 316 stainless steel construction.

The level switch shall be of the maintenance free mercury type or electrode type.

15.1.1.2.7 Pump Base-plate

When pump base-plate is necessary, the base-plate shall be proprietary made with the pump. The material of the base-plate shall be same as the pump.

15.1.1.2.8 Pump Vibration Connectors

Vibration connectors shall be fitted to the inlet and outlet connections of other vibrating equipment as deemed necessary.

Vibration connectors shall be full line size of the equipment connection and fitted as close to the source of vibration as is practicable.

Vibration connectors shall be provided with end restraint to counteract the pressure thrust should the piping be subjected to longitudinal movement.

Manufacturers' recommendations on restraints, pressure, and temperature limits shall be strictly followed during the installations.

15.1.1.2.9 Flexible Metallic Hose

For higher operating temperatures and pressures, vibration movement generated by pumps, shall be accommodated by braided flexible metallic hoses.

The lengths of the flexible metallic hoses shall be in accordance with manufacturer's recommendation.

Two hoses at right angles to each other shall be provided when major vibration motions to be isolated exist in two planes.

15.1.1.2.10 Flexible Rubber Connectors

Flexible connector shall consist of a single or twin-sphere body manufactured with reinforced rubber, the ends of which are raised and wire reinforced to form the cuffs for sealing purposes. The cuffs shall be backed by floating steel flanges.

The rubber body shall be reinforced by multi-layered nylon tire cord fabric.

The rubber membranes shall have an indelible identification system to clearly identify the model and hence the suitability for the application and working conditions and have the date of manufacture moulded into the cover to ensure that no units that have exceeded the recommended shelf life are used.

Straight connectors shall be of the twin-sphere construction whilst elbow connectors shall be of the single-sphere construction.

Straight connectors connected to resiliently supported equipment shall be equipped with rods to prevent excessive elongation of the connectors if the system operating pressure is in excess of the value recommended by the manufacturer.

Acoustical control rods assembly shall consist of not less than 4 large triangle anchor plates, 2 control rods with large wedged-on end fittings and 13 mm thick acoustical washer bushings of sufficiently large load bearing area to isolate the end fittings, axially and laterally.

15.1.1.3 GENERAL WATER PUMP INSTALLATION REQUIREMENTS

15.1.1.3.1 Pumps at 5 kW motor capacity and above shall be "Type-tested" in accordance with the requirements of BS EN ISO 9906:2012 or approved equal. Test certificate for each pump shall be issued and signed by the manufacturer and submitted for checking. The certificate shall clearly record the pump model, serial number and the materials of the casing, shaft and impeller. Any certification with requirements not in strict compliance with BS EN ISO 9906:2012 shall be submitted to the Supervising Officer for approval prior to pump ordering.

15.1.1.3.2 Each pump or each batch of pumps shall also be provided with a certificate on their place of manufacture. The certificate shall be issued by a recognised Chamber of Commerce of the place of manufacture concerned. A certification issued by an organisation other than the recognised Chamber of Commerce shall be submitted to the Supervising Officer for approval prior to pump ordering.

15.1.1.3.3 Pumps and their drives shall be segregated such that failure of pump seals shall not result in damage to the drive motors.

15.1.1.3.4 The installation details shall be in accordance with the instruction prepared by the manufacturer.

15.1.1.3.5 The pump shall be stored in a dry space when they are delivered to site. Special rust preventive measures to protect the internal parts shall be applied if it must be stored for an extended period of time. Such provisions shall be removed completely before final installations and the bearings shall then be re-lubricated.

15.1.1.3.6 Centrifugal Pump

(a) Driving Arrangement

The horizontal pump and motor shall be direct coupled and mounted on a substantial machined bedplate; accurately aligned, and fitted with guards. The whole assembly including the bedplate shall be designed and supplied by the pump manufacturer. Coupling with spacer shall be used for end suction pump so that the impeller may be dismantled from the motor side for servicing without neither disrupting the pipework nor dismounting the motor.

For vertical pump, the driving motor and the pump shall be factory aligned before shipment.

(b) Stand-by Pumps Arrangement

Where stand-by pumps are specified with automatic changeover provision, the changeover shall be initiated by means of flow sensing devices of an approved pattern. The necessary non-return valves shall be incorporated in the pipework to interconnect such pumps.

15.1.1.3.7 Sewage Sump Pump

The sump pump shall be of vertical centrifugal design suitable for dry sump or wet sump installations. Each pump shall be constructed with double mechanical shaft seal and close-coupled to a submersible electric motor.

The sump pump shall operate automatically under level control with an alarm to alert the operator when high water level is being exceeded.

Each pump shall be equipped with factory built-in suspension device, and a factory mounted discharge elbow shall be provided for wet sump installations. Cast iron or steel supporting base shall be provided for dry sump installations. The pump unit itself shall be able to be easily removed from its base for inspection, repair and service. The pump for wet sump installations when lowered into the pit shall automatically be connected to the discharge piping, such that there shall be no need for the maintenance personnel to enter the wet pit to carry out the work.

The pump discharge shall be fitted with a resilient seal that provides a positive hydraulic seal for maximum pump efficiency. Each impeller shall be trimmed to meet the specified flow requirements.

For installations in flammable zones, each sliding guide bracket shall have non-sparkling material to prevent ignition of explosive gases.

15.1.1.3.8 Bore Well Pump

The bore well pump, normally used in water feature system, shall be vertical multi-stage centrifugal construction that is suitable for submersible installations. Each pump shall be of a single-shaft non-shaft-coupling type. The pump suction shall complete with a perforated strainer. The pump bearings shall be water lubricated and shall not cause any contamination to the water handled. The submersible motor shall be cooled by water moving around the motor casing.

Each pump shall be equipped with a non-return valve located between the pump discharge and rising main to prevent from the flow back of water in the rising main. A level switch shall be provided for the automatic cut-off of the pump as dry running protection when the water level inside the pit falls below the pump safety suction lift. The type of level switch shall be selected free from maintenance as practicable.

Except for water feature application, the bore well pump shall be installed vertically in the pit. No foundation shall be required for the pump on the bottom of the pit. Instead, the pump shall be hung from the pit cover which seals the pit and absorbs all stress resulting from the weight of the bore well pump, cable, rising main and water column. The length of each section of the rising main shall be limited to 3 m long to facilitate the withdrawal of the pump from the pit for maintenance.

Except for water feature application, the bore well pump shall be installed vertically in the pit. No foundation shall be required for the pump on the bottom of the pit. Instead, the pump shall be hung from the pit cover which seals the pit and absorbs all stress resulting from the weight of the bore well pump, cable, rising main and water column. The length of each section of the rising main shall be limited to 3 m long to facilitate the withdrawal of the pump from the pit for maintenance.

15.1.1.3.9 Plant Room Location

It shall be checked and assured that adequate working space shall be provided to access for maintenance and sufficient headroom to lift the parts for repair is provided. For large pump, a hoist with travelling crane or other facility shall be provided over the pump location.

For an open loop system, the location of pump shall be sited so that it will use the shortest and most direct suction and smallest vertical lift. Where possible, the pump centreline shall be placed below the level of the liquid in the suction tank.

15.1.1.3.10 Pump Foundation

The foundation shall be of sufficient size and rigidity to properly support the full area of the pump base-plate, to absorb any normal strains and to maintain correct alignment for the pump assembly.

Space between the pump unit and the foundation bolts shall be allowed in

accordance with the manufacturer's recommendation.

For vertical pump, the foundation shall be of sufficient size and rigidity to properly support the full base area of the pump. The foundation shall be surrounded by 50 mm thick cork and housed in a 100 mm thick concrete plinth. The cork shall enclose the 4 sides and the bottom of the foundation to isolate vibration generated by the pump to the floor structure. The cork and the concrete plinth and foundation shall be filled up with bitumen.

For horizontal pump, an inertia block shall be provided, with minimum mass of concrete not less than 2.5 times the mass of the pump assembly and with at least 100 mm thick and 150 mm wider than the pump base-plate. Unless otherwise specified, the pump base shall be mounted on the raised housekeeping plinth using appropriate anti-vibration spring mountings. Each spring shall be individually selected according to load distribution and shall have an additional free travel equal to one half of the rated deflection. Spring mounts shall have a levelling bolt and shall be mounted to the concrete inertia block via height saving brackets that allows a base clearance of 50 mm. When the horizontal pump motor size is less than 5.5 kW and the pump is located in a pump room which is not susceptible to structural bond noise, the use of inertia block may not be necessary subject to Supervising Officer's approval.

15.1.1.3.11 Pump Alignment

The pump unit shall be accurately aligned in accordance with the manufacturer's instructions prior to operation. The alignment shall be rechecked after the suction and discharge piping have been bolted to the pump to test the effect of piping strains. The pump and driver alignment shall be rechecked and adjusted correctly within ±0.05 mm tolerance.

15.1.1.3.12 Support for Piping

Suction and delivery pipes shall be supported independently of the pump. The connecting pipes to a pump shall not strain the pump. Pipes installations shall match up to the respective flanges without being strained into position. The faces of the coupling shall be checked with a straight edge to make sure that they are parallel and concentric.

15.1.1.3.13 Connection Piping to Pump

(a) Suction Piping

The suction piping shall be properly installed for a satisfactory pump operation. This shall be achieved by keeping as direct and as short as practicably possible with a minimum number of bends, and by avoiding air pockets forming. Concentric reducers shall not be used on suction branch.

The size of the suction pipe shall be larger than the pump inlet and when applicable eccentric reducer may be used. If the source of

supply is located below the pump centreline, the reducer shall be installed straight side up. If the source of supply is above the pump, the straight side of the reducer shall be at the bottom.

A straight section piping at least 4 to 6 diameters long at the pump inlet with long radius bend shall be used for suction pipeline installations to create less friction and provide more uniform flow distribution as deemed necessary.

(b) Delivery Piping

Unless otherwise specified, the size of the delivery pipe shall be at least one size larger than the pump delivery. The check valve shall be installed between the pump and the gate valve. The gate valve shall be installed close to the pump discharge for pump priming and repairing.

Air release valves shall be installed at the highest points on each rise to allow accumulated air or vapour or other gases to escape from the pipe.

Adequate support and anchorage shall be provided if the pipes are laid above or below ground. For this purpose, it is acceptable to have thrust blocks in either corner type or puddle flange type that are designed to absorb reactions or turning forces to ensure no mechanical and hydraulic forces are imposed on the pump.

(c) Pipe Flanges

Pipe flanges shall match with the sizes of pump flanges with full-face gaskets.

(d) Expansion Joints

Expansion joints shall be installed in suction and delivery pipelines to avoid transmitting any piping strains. A suitable pipe anchor shall be installed between the expansion joint and the pump.

If expansion joints are not specified, expansion loops that are formed by looping the pipe shall be provided to prevent the transmission of strains to the pump.

(e) Intake

The installation work shall be carried out properly to prevent air being entrained as bubble within the water. The intake pipe shall run well below the sump tank level. High level entry into the sump tank shall be avoided as air may be entrained by the falling jet.

Vortex inhibitor shall be installed inside the water tank to prevent air being drawn from bottom of vortex into the intake. Vortex inhibitor is not required for chemical or brine tank.

15.1.1.3.14 Flushing Strainer

The suction strainer shall be installed as close as practicably possible to the pump and shall not be used for flushing the pipe. A temporary strainer fitted with a finer mesh than the permanent strainer shall be used for flushing all piping and cleaning thoroughly all possible mill scale and other foreign matter. The temporary strainer shall be removed afterwards.

15.1.1.3.15 Venting Valves for Pump-set

Venting valves shall be installed at one or more points of the pump-casing waterway to provide a means to escape for air or vapour trapped in the casing. These valves shall be connected so as not to endanger the operation staff in handling toxic, inflammable or corrosive liquid.

15.1.1.3.16 Drains for Pump-set

All drain and drip connections shall be piped to a point where the leakage can be disposed of or collected for reuse if specified.

15.1.1.3.17 Instrumentation

Each pump installations shall include pressure gauges and a gauge cock to measure the system pressures and pressure drop.

All measuring and isolation instruments, such as pressure gauge, check valve, globe valve, gate valve and strainer, etc., or as specified in the Particular Specification shall be installed properly to maintain a close check on control on the performance and condition of the pumps.

Instruments shall be mounted in a suitable location so that they can be easily observed.

15.1.1.4 PIPEWORK

15.1.1.4.1 Connections in Pipework

For non-welded pipework, connections shall be by means of screwed fittings, flanges or unions. The use of "long screws" will not normally be permitted.

Unless otherwise specified, flanges complete with appropriate gaskets, steel nuts, bolts and washers together with spring washers, all of stainless steel, shall be used to connect up all equipment, valve or device such that the pipework, equipment, valve or device can easily be removed for servicing or replacement.

15.1.1.4.2 Change in Pipe Size

Change in pipe size can be facilitated at tees by reduction on branch or outlet. Reduction on bend elbow or by bush is not permitted without prior permission of the Supervising Officer. Reduction by means of straight through reducing socket is permitted.

Care shall be taken in carrying out reduction to ensure that air is not entrapped at high points. In such case, it shall be necessary to install eccentric reducing sockets with the "flat" at the top for horizontal pipework and concentric reducer for vertical pipe riser.

15.1.1.4.3 UPVC Pipe

(a) Unplasticised polyvinyl chloride (UPVC) pipe shall comply to ISO 3127:1994 and ISO 1452-1:2009 to ISO 1452-5:2009, or DIN 8061:2016/DIN 8062:2009, or BS EN ISO 1452-1:2009 to BS EN ISO 1452-2:2009, BS EN ISO 1452-3:2010, BS EN ISO 1452-4:2009 to BS EN ISO 1452-5:2009 (300 mm diameter and below).

(b) All pipes and fittings shall be manufactured by the same manufacturer of the same standard. Should different types of pipe are joined together, they shall be joined with suitable proprietary adaptor. Modification to the pipe or fitting to fit different pipe materials or standards is not acceptable. Bending of pipe to form elbow shall not be allowed.

(c) When UPVC pipe is installed at outdoor, it shall be protected from ultra-violet radiation by shielding or painting with suitable primer to prevent degradation.

(d) Where it is required to form a spring in the pipe run, the pipe shall be softened by immersion in (or by pouring on) heated brine, glycerine oil or water as recommended by the pipe manufacturer. The use of a naked flame on the pipe surface will not be accepted.

(e) Joint and Fitting for UPVC Pipework

(i) Joint for UPVC pipe and fitting shall be solvent joint for pipes at 65 mm and below.

(ii) Within plant room, joint for UPVC pipe and fitting at 80 mm and above shall be flanged connection or of stub flange assembly. For pipes under pool deck, spigot and socket rubber ring joint shall be used, or otherwise as specified in the Particular Specification.

(iii) Flanged connection of pipework, for either chemical or non-chemical system, shall be of steel bolt, nut & washer together with spring washer, all of stainless steel.

(iv) Fittings shall be of the same material as the pipework to

which they are joined. They shall be made or approved by the pipe manufacturers and suitable for the solvent welding process. Where screw threads are required (e.g. at connections to metal valves, strainers, etc.), a factory made threaded adapter shall be used. Adapters shall be made from heavy weight tube with an appropriate thread at one end; the other end shall form part of a socket and spigot solvent welded to the plastic pipe. As a general rule UPVC pipe shall only be made threaded and screwed into metal "Female" threaded fittings.

(v) Joints between pipe and pipe fittings shall be made by the solvent welding process. No cleaning fluid or solvent cement other than that supplied or recommended by the pipe manufacturer shall be used.

(vi) Unless otherwise specified, connections to items of plant such as pumps shall be made by means of flanged joints. The plastic pipe shall terminate with a socket flange of the full face or stub type welded on by the solvent process and having a loose metal backing ring; the ring and the flange shall be drilled to match the mating flange. The joint shall be made with a neoprene or similar gasket.

(vii) Where UPVC is used for inlet and outlet to pumps, it shall be effectively isolated from the vibration of the machine. This shall be achieved by the insertion of flanged synthetic rubber vibration de-couplers installed between UPVC pipework and plant on all connections.

15.1.1.4.4 Ductile Iron Pipe

Ductile iron pipe shall comply with one of the following standards subject to the applications: -

ISO 2531: 2009/ Corr1: 2010	Ductile iron pipes, fittings, accessories and their joints for water applications
BS EN 545: 2010	Ductile iron pipes, fittings, accessories and their joints for water pipelines. Requirements and test methods
BS EN 598: 2007 + A1: 2009	Ductile iron pipes, fittings, accessories and their joints for sewerage applications. Requirements and test methods

Cement lining shall be provided for all ductile iron pipe and fitting. Lining inside shall be cement mortar lined in compliance with BS EN 545:2010, BS EN 598:2007+A1:2009, BS EN 969:2009 or Type A – Portland pulverised fuel ash cement (PFAC) in accordance with BS EN 197-1:2011 with a minimum pulverised fuel ash content of 25%.

Joints and Fittings for Ductile Iron Pipework: Class K9 and K12 pipes joint shall either be flanges screwed or flanges welded-on subject to Supervising Officer's selection.

15.1.1.4.5 Polyethylene Pipe

(a) The following specifications apply to polyethylene pipes and fittings: -

Description	Specification	Nominal Size	Application
Medium Density Polyethylene Pipe (MDPE)	BS EN 12201-1: 2011, BS EN 12201-2:2011+A1:2013, BS EN 12201-3: 2011 + A1: 2012, BS EN 12201-4: 2012, BS EN 12201-5: 2011, ISO 4427-1:2019 and ISO 4427-2:2019,	20 mm - 1000 mm	water pipe for underground and above ground (blue pipe and black pipe)
High Density Polyethylene Pipe (HDPE)	ISO 4427-1:2019 and ISO 4427-2:2019,	90 mm – 1000 mm	water pipe for underground and above ground (blue pipe and black pipe)
Electrofusion fitting for use with MDPE pipe	*WIS 4-32-14:1995	20 mm – 355 mm	Fittings for underground and above ground (blue and black colours)
Spigot fitting for butt fusion or electrofusion jointing	*WIS 4-32-15:1995	63 mm – 315 mm	Jointing of pipe

(b) The pressure rating of the MDPE and HDPE pipes shall not be greater than 10 bar and 16 bar respectively.

(c) When polyethylene pipes are installed at outdoor, they shall be protected from ultra-violet radiation by shielding or painting with suitable primer to prevent degradation.

(d) Joints and Fittings for Polyethylene Pipework: The polyethylene socket and spigot fittings, saddles and drawn bends for fusion jointing shall be in compliance with WIS 4-32-15:1995. When flanges and bolting for pipes, valves and fittings are used, they shall be in compliance with BS EN 1092-1:2018, BS EN 1092-2:1997 or BS EN 1515-1:2000.

(e) Electrofusion of Pipes

(i) Pipes and fittings can be joined by electrofusion. The socket of the fitting incorporates an electrical heating coil. When energised by electricity, the coil causes the material adjacent to it melt and fuses into contact with the surface of the pipe. The heating coil shall be wound on to a moulded pre-form section of the fitting.

(ii) An electrofusion control unit recommended by the pipe manufacturer shall be used to power the electrofusion process.

(iii) Pipe ends to be jointed shall be thoroughly scraped to remove the outer surfaces and burrs. Scraped surfaces shall be protected from contamination before jointing. Fit the electrofusion socket fitting into both pipe ends and connect the control unit leads to the terminals onto the fitting. Energise the control unit as guided by the manufacturer until the fusion process has been completed. Leave the joint cooling before use.

(f) Butt-fusion jointing shall not be used unless as specified by the Supervising Officer.

15.1.1.4.6 ABS Pipe

Acrylonitrile Butadiene Styrene (ABS) pipes shall have sizes detailed in ISO 161-1:2018 and ISO 727-1:2002 from 16 mm up to 315 mm outside diameter, which can be used under a wide temperature range from –40°C to +80°C. Pipes and fittings shall be rated at or above 10 bar at 20°C.

The pipe fitting joint shall be of solvent welding, flanges, stub flanges, shouldered pipe couplings, or unions and thread: -

(a) Solvent cement welding

Chemically softening in the outside of the pipe and the inside of the fitting. The pipe end over a length equal to the depth of the socket fitting and the socket internal surface shall be abraded thoroughly using clean coarse emery cloth. Remove dust from surface and apply solvent cement to both matching surfaces, and push fit the socket onto the pipe end by using longitudinal strokes.

(b) Thread joint may be applied to small diameter pipe that connect valve or fitting. The male threads shall be wound by PTFE tape prior to joining the fittings.

(c) Flanges and bolting for pipe, valve and fitting shall be in compliance with BS EN 1092-1:2018, BS EN 1092-2:1997 or BS EN 1515-1:2000.

15.1.1.4.7 Copper Pipe

Copper tube shall be in accordance with BS EN 1057: 2006 + A1: 2010 for pipe size smaller than 80 mm, capillary joint to BS EN 1254-1: 1998, 1254-2: 1998 & 1254-3: 1998 for 50 mm and below, flange joint for 65 mm and above.

Copper tube up to and including 54 mm diameter bore shall be assembled with capillary fittings with solder suitable for pipe and water condition.

Joints on copper pipe and fitting of 67 mm diameter and over are to be made with copper slip-on bosses brazed to the pipes in accordance with BS EN 14324:2004, BS EN 12797:2000, BS EN 12799:2000, BS EN ISO 13585:2012, BS EN 13134:2000 and copper alloy flanges of BS EN 1092-1:2018, BS EN 1092-2:1997 or BS EN 1515-1:2000 bolted together including bolts.

Flange shall be flushed and aligned and shall utilise full faced corrugated grooves.

15.1.1.4.8 Stainless Steel Pipe

Stainless steel pipe shall comply with BS 6362:1990 or BS EN 10312:2002, all with material grade 316.

(a) BS 6362:1990 stainless steel pipe ranging from 15 mm to 150 mm shall comply with the following: -

Nominal size (mm)	Designation of thread	Outside diameter (mm)		Nominal wall thickness (mm)
		Maximum	Minimum	
15	1/2"	21.8	21.0	2.6
20	3/4"	27.3	26.5	2.6
25	1"	34.2	33.3	3.2
32	1-1/4"	42.9	42.0	3.2
40	1-1/2"	48.8	47.9	3.2
50	2"	60.8	59.7	3.6
65	2-1/2"	76.6	75.3	3.6
80	3"	89.5	88.0	4.0
100	4"	115.0	113.1	4.5
125	5"	140.8	138.5	5.0
150	6"	166.5	163.9	5.0

(b) BS EN 10312:2002 stainless steel pipe ranging from 15 mm to 54 mm shall comply with the following: -

Nominal size (mm)	Outside diameter (mm)		Nominal wall thickness (mm)
	Maximum	Minimum	
15	15.045	14.940	0.6
22	22.055	21.950	0.7
28	28.055	27.950	0.8
35	35.070	34.965	1.0
42	42.070	41.965	1.1
54	54.070	53.840	1.2

(c) BS EN 10312:2002 stainless steel pipe covered with polyethylene and foam coating shall comply with the following:-

Nominal size (mm)	Outside diameter (mm)		Nominal wall Thickness (mm)	Polyethylene and foam coating thickness (mm)		
	Maximum	Minimum		Foam	PE	Total
15	15.045	14.940	0.6	1.5	0.8	2.3
22	22.055	21.950	0.7			
28	28.055	27.950	0.8			

(d) Jointing for BS EN 10312:2002 stainless steel pipe shall be facilitated by suitable solvent cement as recommended by manufacturer. Jointing for BS 6362:1990 stainless steel pipe shall be of either argon welding, compression fittings or screwed fittings as recommended by manufacturer.

15.1.1.4.9 Lined Galvanised Steel Pipe

Galvanised steel pipe shall be UPVC internally lined with screw joints for pipe connections. All fittings shall be beaded with built-in plastic core. Lined galvanised steel pipe shall comply with BS EN 10255:2004 medium grade.

Unions or flanged joint shall be used for joint subject to disconnection for future maintenance near to the connections of the equipment.

No yarn shall be permitted in any joint, plastic plumber's PTFE tape shall be used throughout the installations or as recommended by manufacturer.

For jointing of faucets, use faucet elbows and sockets of the same galvanised pipe manufacturer. Cutting of pipe shall be facilitated by metal saw, and no cutting of pipe by pipe cutter is allowed. When cutting, avoid over-speed the saw to damage the internal lining.

Threading of pipe shall follow the relevant standard of the pipe manufacturer. Pipe chamfering of the inner wall lining of pipe shall be facilitated by proprietary reamer or scraper specifically for the lined galvanised pipe.

Jointing of threaded pipe shall be facilitated with anti-corrosive sealant and seal tape.

15.1.1.5 PIPEWORK INSTALLATION DETAILS

15.1.1.5.1 General

(a) The Tender/ Drawings indicate the size and general layout of the required pipework. The exact positions may not be indicated on the Drawings, as for the purpose of clarity, they are generally shown separately spaced out from one another as if they were at the same plan level. Various pipelines in the installations shall be accurately set out in compliance with the Particular Specification or so specified elsewhere in this General Specification.

(b) Where drawings with details for pipework supports and brackets, vibration connectors, expansion joints and anchor points are issued with the Contract, the standard details referred shall be followed "in-principle" but adjusted as to the detail in order to suit the particular circumstances. Such adjustments shall be indicated on the Installations/ Shop drawings and be approved by the Supervising Officer before work commences.

(c) Generally, the clearance between pipework (or the lagging) and the wall and any other fixtures shall not be less than 25 mm. Pipework shall not run near to or above electrical appliances, cables, trunkings and conduits.

(d) Where two or more pipes run follow the same route, all pipes shall run parallel with one another and to the building structure. Any pipework which requires subsequent insulation shall be adequately spaced to allow for individual finish.

(e) Movements of the pipework due to changes in temperature shall be accommodated by the natural flexibility of the pipework run or by bellow expansion joints, in either case allowable stress levels shall not be exceeded.

(f) Tubes shall be reamed after cutting and shall be free from burrs, rust, scale and other defects and shall be thoroughly cleaned before erection. Pipe ends left open during the progress of work shall be temporarily closed with purpose-made metal or plastic plugs or caps, or blank metal flanges and protect from corrosion.

(g) Joints shall not be made in the thickness of any wall, floor or ceiling and pipework shall not be embedded in the structure of floors. Where pipework passes through walls, floors or ceilings, sleeves shall be provided. Pipework passing through floors shall, where specified, be provided with approved type floor and ceiling plates and fastened securely to the sleeve. Sleeves shall be of the

same metal as the pipe. The space between pipework and sleeve shall be plugged with an approved sealant.

(h) All entry and exit holes to or from a building for a pipework service shall be sealed and plugged. The sealant shall be a mastic compound or silicone rubber. Where the pipework enters the building through a large hole or duct, which cannot be backfilled, a mild steel blanking plate not less than 6 mm thick shall be built into the wall of the hole or duct. The service pipes shall pass through clearance sockets welded to the plate. The space between pipe exterior and socket interior shall be sealed and plugged.

15.1.1.5.2 Elbows and Bends

(a) Elbows shall be used, where practicable, in preference to bends. However, square elbows will not be permitted. Unless otherwise specified, long radius elbows shall be used in order to minimise hydraulic resistance.

(b) For forming bends in small bore copper pipe up to size 25 mm, pipe bending springs may be used but again there shall be no distortion of the pipe involved.

(c) In the case of all bends formed in the pipe, these shall constitute long radius bends. Short radius elbows shall only be used at the discretion of the Supervising Officer where long radius elbows will not fit or are not manufactured.

15.1.1.5.3 Jointing

(a) Galvanised pipes which are to be screwed shall be galvanised before servicing. Pipes which are to be fitted with welded flanges shall be flanged before galvanising. Galvanised treatment on all welding joints shall be required after welding.

(b) Joints on all permanently concealed mild steel and galvanised pipework shall be welded unless otherwise agreed by the Supervising Officer. Other mild steel and galvanised pipework may be of screwed or welded joints. When screwed joints is used, at least one of the two engaging components shall be taper-threaded to ISO 7-1:1994/ Corr 1:2007 and the joints between them shall be made with approved jointing material, and selected to suit the appropriate type of services. For pipework without anti-rust threaded joints, it shall be patched up with galvanised painting before making such joints.

(c) Pipework connections to the suction and delivery outlets of pumps and other vibrating machines shall be isolated from such sources of vibration by means of anti-vibration connectors. The vibration connectors shall be capable of attenuating the vibration of the plant such that the bulk of the vibrations are prevented from being transferred to the pipework. Wherever vibration connectors are

installed, the adjacent pipework shall be adequately supported by guide type brackets.

(d) All flanged connections for pipeworks shall be fixed by stainless steel bolts, nuts & washers with spring washers.

(e) At dismantling points or where the pipework is connected to an appliance, ground-in spherical seated unions shall be used for pipework up to 50 mm size, and flanges shall be used for pipework at 65 mm size and above. The flanges shall be to ISO 7005-1: 2011 and ISO 7005-2: 1988 or BS EN 1092-1: 2018, BS EN 1092-2: 1997, BS EN 1515-1: 2000 of appropriate type. Flanged joints shall be made with flat ring gaskets suitable for the pressure and temperature and extending to the inside of the bolt circles.

(f) Screwed fittings, other than sockets, shall be malleable cast iron, banded or beaded pattern. Standard but welding fittings shall be used on welded pipework. Use of mixed joints shall be prohibited.

(g) Flanges for mild steel pipework shall be forged steel and machined over the raised or flat faces. Headers shall be of flanged mild steel tube with flanged outlets welded on, and spare outlets shall be blanked off with bolted flanges.

(h) Where specified, and/or subject to the Supervising Officer's written agreement, in plant rooms and building ducts where pipework appearance is not considered so critical, mechanical pipe couplings may be employed for pipe connection.

(i) Mechanical pipe couplings shall be self-centred, engaged and locked in place onto the grooved or shouldered pipe and pipe fitting ends. The pipe connection shall result in a positive watertight couple providing reasonable allowance for angular pipe deflection, contraction and expansion. The coupling housing clamps shall consist of two or more malleable iron castings or rolled steel segment holdings with a composition water sealing gasket so designed that the internal water pressure will increase the water tightness of the seal. The coupling assembly shall be securely held together by two or more track head track head square or oval-neck heat treated carbon steel bolts and nuts. All pipe fittings connected to mechanical pipe couplings shall have groove and shouldered ends and shall be malleable iron castings. Flanged or threaded end valves may be used with grooved adapters.

(ii) Before couplings are assembled, pipe ends and outsides of gaskets shall be lightly coated with grease or graphite paste to facilitate installations.

(iii) Pipe grooving shall be formed in accordance with the pipe coupling manufacturer's latest specification. Pipes may be cut-grooved or roll-grooved except for those pipes with wall thickness less than the minimum recommended by the manufacturer. The cut-grooving shall be roll-grooved without the removal of any metal.

(iv) The entire coupling installations shall be in accordance with manufacturers' recommendations.

(v) Couplings or flange adapters for plain ended pipework shall be steel, slip-on type as approved by the Supervising Officer.

(vi) Coupling shall consist of sleeve (without centre register), end flanges, sealing rings and bolts and nuts.

(vii) Flange adapter shall consist of end flanges/sleeves, sealing rings, and studs and nuts.

(viii) To provide hard and durable protection against impact, abrasion, chemicals and low temperature, all couplings and flange adapters shall be coated with Rilsan Nylon 11 or equivalent and approved by the Supervising Officer, by either a dip process giving a coating thickness of 250-375 microns or an electrostatic spray process giving a coating thickness of 150-250 microns.

15.1.1.6 PIPEWORK BRACKETS AND SUPPORTS

15.1.1.6.1 All outdoor brackets and supports for non-copper pipes shall be stainless steel except otherwise as specified in the Contract. The fixing bolts and nuts for the brackets and supports shall have the same materials with the brackets and supports that are used.

15.1.1.6.2 All indoor brackets and supports for non-copper pipes shall be hot dip galvanised iron except otherwise as specified in the Contract. The fixing bolts and nuts for the brackets and supports shall be galvanised.

15.1.1.6.3 Brackets for copper pipes shall be brass, which shall be mounted on stainless steel supports. Fixing of copper to steel shall be separated by insulated sheet to avoid the occurrence of galvanic corrosion. Details shall be submitted for Supervising Officer's approval.

15.1.1.6.4 Pipework shall be supported so as to permit free movement due to expansion and contraction. Pipework supports shall be installed as near as practicably possible to joints and changes in direction. Each support shall take its due proportion of the load. The spacing of the supports shall not exceed the centres given in Clause 15.1.1.8. Where there are two or more pipes, the spacing shall be based on the centres required by the smallest bore pipework.

15.1.1.6.5 Vertical rising pipework shall be supported at the base or, as indicated, to withstand the total weight of the riser. Branches from risers shall not be used as a means of support for the riser. If such base has to be rested on an intermediate floor slab, Supervising Officer's attention shall be drawn for structural reinforcement to the floor slab and also allow for additional treatment to the base as required by the Supervising Officer.

15.1.1.6.6 Where pipework up to 50 mm size is fixed to solid wall, brackets may be of the screw-on or long shank built-in type; in case the walls are plastered, only the long shank built-in type shall be used. For fixing to woodwork and lightweight partitions or walls, brackets shall be of the screw-on pattern of adjustable two-piece type. Brackets for copper pipework shall be brass or gunmetal. The upper half of the pipe clip shall be detachable without disturbing the fixing.

15.1.1.6.7 Brackets screwed to walls shall be secured by expanding plugs. Other purpose designed fixing devices shall be submitted for Supervising Officer's approval.

15.1.1.6.8 Unless otherwise specified, hangers for horizontal pipework at high level shall be supported from steel angle or channel sections or approved proprietary devices supplied by the supplier, suitable for building-in or otherwise securing to the structure by the Building Contractor. Adjustable steel hangers shall be used. Pipe rings shall be of stainless steel or galvanised fabricated steel, made in halves and secured by bolts or screws of the same materials. Caliper type hooks will not be permitted.

15.1.1.6.9 Where pipework is fitted in service duct or trenches or where it is of 65 mm size or greater and supported from walls, the design of the pipe supports, guides and anchors shall be in accordance with the Drawings. Otherwise, details and proposal shall be supplied to the Supervising Officer for approval. Where roller supports are required, they shall be of an approved type. If insulation is on the outer shelf, the preformed insulation shall be kept free of the rolling surface. Load-bearing insulation at supports, where required, shall be fitted at the time of erecting the pipework.

15.1.1.6.10 All cleats, brackets and steelwork required for anchor points shall be supplied, and fixed in position ready for building-in. Anchor steelwork secured to the bottoms of ducts or trenches shall be coated with hot-poured bitumen to inhibit future corrosion.

15.1.1.6.11 Supports for non-metallic pipework may be of any approved pattern that prevents free axial movement of pipe at all temperatures and have radial edges to prevent cutting into the pipe. All bearing surface shall be sufficiently wide to prevent indentation.

15.1.1.6.12 Valves, meters and other heavy "in-line" equipment shall be rigidly supported or independently supported as deemed necessary.

15.1.1.6.13 Supports for pipes shall be such that no compression or deformation of the insulation occurs.

15.1.1.6.14 Provision for movement due to expansion and contraction shall be generally as indicated and/or shall be by changes in direction of the pipework, by loops or by other approved expansion devices. Supports and guides shall be arranged to ensure that all movement is taken up by the change in direction of the pipework or by the loop or device.

15.1.1.6.15 Cold bridge shall be prevented between the insulated pipework and the associated hangers and pipework supports.

15.1.1.7 PIPEWORK EXPANSION JOINTS, ANCHORS AND GUIDES

15.1.1.7.1 Expansion Joints

(a) Where expansion joints are utilised, they shall be manufactured in accordance with the design philosophy for thin walled bellow membranes as laid down by the Expansion Joint Manufacturers Association (EJMA latest Edition).

(b) Axial movement bellow expansion joints on all services shall comprise of thin wall multi-plied omega formed convoluted bellows of stainless steel material to BS EN 10029:2010, BS EN 10051:2010 and BS EN ISO 9445-1:2010 to 9445-2:2010 of appropriate type. Bellows shall be argon arc welded to carbon steel end fittings utilising a stainless steel seal ring to reinforce the bellow cuff end.

(c) The bellow expansion joint shall be provided with a close fitting stainless steel internal liner to reduce turbulent flow.

(d) End termination of expansion joints shall be carbon steel threaded male to ISO 7-1:1994/Corr 1:2007 or carbon steel flanges to ISO 7005-1:2011 and ISO 7005-2:1988 Standard to suit the line pressures.

(e) For copper or non-ferrous pipework systems, expansion joints shall be manufactured in stainless steel throughout. The bellow expansion joints shall be installed with pre-cool/heat setting to their required length to suit the temperature condition at the time of installations. The joints shall be rated suitable for the required amount of designed axial movement. Mild steel outer protection sleeves shall be fitted to the bellows only when the units are open to the environment and exposed to risk of damage or when it is necessary to carry lagging over the joint.

(f) Expansion joints shall be installed in strict accordance with the manufacturer's recommendations. The manufacturers of the expansion joints shall be approved to ISO 9001:2015.

(g) Expansion joints shall be designed to meet the required angular movement or the required movement in all directions perpendicular to the axis of the bellows.

(h) Expansion joints shall be provided, wherever appropriate, with hinge and shackle or centre joining tube, tie bars and spherical nut arrangement, which shall be of carbon steel to ISO 9692-1:2013 and ISO 9692-2:1998 fully designed to contain the pressure thrust. End termination shall be flanged to ISO 7005-1:2011 and ISO 7005-2:1988 to suit the line pressures.

15.1.1.7.2 Anchors

Anchors shall be installed according to the recommendations of the expansion joint manufacturer and the details shall be submitted to the Supervising Officer for approval before manufacture commences.

(a) Allowances shall be made for anchors capable of withstanding the maximum stresses created within the pipework system, and have adequate safety margin. These shall be positioned as indicated on the layout drawings or as necessary shop drawing/details.

(b) On steel pipework, the pipe shall be welded to the anchors via heavy steel straps. On copper pipework, the pipe shall be brazed to the anchors via heavy copper straps.

15.1.1.7.3 Guides - Axial Movement Pattern

(a) Pipework shall be guided along its length and the guides shall be capable of withstanding not less than 15% of the maximum stresses created within the pipework with adequate safety margin.

(b) Guides shall be adjustable in both directions in the lateral plane, so that pipework can be aligned with the expansion joint.

(c) Each guide shall not be less than 2 pipe diameters long and shall have a minimum manufacturing clearance of the pipe diameter.

(d) Distance from expansion joint to the first guide shall not be greater than 4 pipe diameters, and the distance between the first guide and the second guide shall not be more than 14 pipe diameters. Guides thereafter shall be spaced in accordance with normal pressure performance requirements as a minimum standard.

15.1.1.7.4 Guides for Angular or Lateral Movement Pattern

Directional guiding shall apply, such as side plates, local to the expansion joint, the remainder of the pipework shall be supported in the nominal way, by roller or frictional supports, or pipework hangers.

15.1.1.8 PIPEWORK SUPPORT SPACING

Support for pipework shall be spaced in accordance to the following:-

Table 15.1.1.8 (1) Supports for Steel Pipework

Size of tube	Intervals for Horizontal runs		Intervals for Vertical runs
	Bare	Lagged	Bare and Lagged
mm	m	m	m
15	1.8	1.8	2.4
20	2.4	2.4	3.0
25	2.4	2.4	3.0
32	2.7	2.4	3.0
40	3.0	2.4	3.7
50	3.0	2.4	3.7
65	3.7	3.0	4.6
80	3.7	3.0	4.6
100	4.0	3.0	4.6
125	4.5	3.7	5.5
150	5.5	4.5	5.5
200	8.5	6.0	8.5
250	9.0	6.5	9.0
300	10.0	10.0	10.0

Table 15.1.1.8 (2) Supports for Copper Pipework

Size of tube	Intervals for horizontal runs		Intervals for vertical runs
	Bare	Lagged	Bare and lagged
mm	m	m	m
15	1.2	1.2	1.8
22	1.2	1.2	1.8
28	1.8	1.5	2.4
35	2.4	1.8	3.0
42	2.4	1.8	3.0
54	2.7	1.8	3.0
65	3.0	2.4	3.7
76	3.0	2.4	3.7
108	3.0	2.4	3.7
133	3.7	3.0	3.7
159	4.5	3.7	3.7

Table 15.1.1.8 (3) Supports for Non-metallic Pipework

Nominal Bore of Pipe (mm)	Intervals for horizontal runs (m)	Intervals for Vertical Runs (m)
15	0.75	1.5
22 to 28	1	1.8
28 to 35	1	2
42	1.2	2.4
53 to 65	1.4	2.8
76	1.8	3.5
108 and over	2	4

15.1.1.9 WELDING AND BRAZING

15.1.1.9.1 The procedure and the competence of the operator shall be in accordance with the recommendations contained in the following British HVCA publications: -

(a) "Welding of Mild steel Pipework"; and

(b) "Code of Practice - Brazing and Bronze Welding of Copper Pipework and Sheet".

15.1.1.9.2 Welding operations which are beyond the scope of B1.9.1 shall comply in particular with:-

(a) BS 2633:1987 and BS 2971:1991 - relevant subsections for metal-arc welding (steel pipe);

(b) ISO 9692-1:2013 and ISO 15609-2:2019 -relevant subsections for gas welding (steel pipe); and

(c) ISO 5187:1985 - Brazing (copper pipe).

15.1.1.9.3 Where the visual inspections and tests reveal those welding joints which are reasonably believed to be unacceptable, the Supervising Officer shall be entitled to have such welding examined by radiography or other approved inspection method and independently assessed. The cost of the tests and the subsequent remedy work to the satisfaction of the Supervising Officer shall be included in the Works if tests prove the welding joints to be non-compliance with the specification.

15.1.1.10 VALVES, COCKS AND STRAINERS

15.1.1.10.1 General

(a) All valves and fittings that are used for chemicals applications for swimming pool shall be capable to resist the corrosion of such chemicals. For pool water, all valves and fittings shall be capable

of handling salt water application.

(b) Provision such as a sprocket rim wheel and chain shall be provided for manually operated valves that are difficult to access.

(c) All plant room valves and circuit control valves shall be provided with approved plastic labels.

(d) A circuit control diagram of appropriate size showing the location of each isolating, regulating and control valve shall be provided and fixed in a glazed hardwood frame in a position indicated by the Supervising Officer.

15.1.1.10.2 Ball Float Valve

(a) Equilibrium ball valves to BS 1212-1:1990 & BS 1212-2:1990 shall be provided to the water tanks.

(b) Fresh water ball valves up to 50 mm shall be bronze with copper ball float to BS 1968:1953. Fresh water ball valves 65 mm and above shall be cast iron with nickel alloy working parts and copper ball float.

(c) Salt or pool water ball valves up to 50 mm shall be bronze, 65 mm and above shall have cast iron body and stainless steel or zinc free bronze trimming with construction entirely suitable for use with sea water. Ball float shall be in stainless steel or in zinc free bronze or rubber lined to prevent corrosion.

15.1.1.10.3 Butterfly Valves

Butterfly valves shall have resilient seats which are (in-the-field) replaceable with moulded-in O-rings to serve as a flange gasket. For sizes of 50 mm diameter to 150 mm diameter inclusive, a notched plate handle shall be provided for the control of the valve and indication of disk position. For sizes of 300 mm diameter and above, gear actuator shall be used. All butterfly valves shall be capable of bubble tight shut off. Butterfly valves shall comply with the recognised international standards.

(a) The manufacturer shall provide independent laboratory tests by independent regulatory/testing bodies, organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognized by HOKLAS or HKAS or elsewhere as approved such as Underwriters Laboratory or Factory Mutual Research for pressure rating. All testing records and data shall be submitted to the Supervising Officer for approval.

(b) Bodies shall be made of ductile iron grade 400-18, completely coated with polyamide or products having equivalent functions or performance against corrosion, suitable for the temperature range

of 0°C to 50°C. The valve shall provide dead end service at maximum rating.

(c) The discs shall be made of stainless steel to Grade 316.

(d) The shafts stems shall be made of stainless steel to Grade 316.

(e) The control handles and the gear operators shall be suitable for locking in any position. The micro switches shall be built in the actuators and factory adjusted at full or partly open and full closure. Manufacturer shall provide certificate of factory adjustment.

(f) Valve electric operators shall be mounted on valves and tested at factory.

(g) The valves shall have marking tag in accordance with ISO 5209:2019 standard.

(h) The valves body and seat shall be designed for the maximum working pressure of at least 10 bar.

(i) The valve disc shall be able to protrude into the pipework on either side of the valve without damaging the disc or the lining on the pipes. Pipework either side of the valve shall be so designed that the valve can be removed even when jammed in the fully open position.

(j) Where specified for manual operation valves shall be provided with hand wheels fitted with reduction gearing to enable one man to operate the valve, in a reasonable time, when it is subjected to the maximum unbalance pressure.

(k) Grooved ends butterfly valves shall be bubble tight closing to ISO 5208:2015 standards, enabling quick assembly with mechanical grooved coupling on ISO standard pipes.

15.1.1.10.4 Isolating Valves

(a) Pool Water and Non-fresh Water Application

(i) Up to and including 50 mm bore

PVC diaphragm valves to BS EN 13397:2002 with reinforced spindle, rising stem. All parts of the valve shall be suitable for use with salt water equivalent to sea water. Ends of the valves shall be suitable for flanged connection to PVC pipe flanges.

(ii) Above 50 mm bore

Full way gate valves shall be constructed of cast iron

body with zinc free bronze trim, bolted cast iron bonnet, malleable iron hand wheel, zinc free bronze stuffing box, gland, thrust, plate, yoke, wedge, seat and yoke sleeve with nickel alloy faces, stainless steel spindle with outside screw of rising stem or of inside screw of non rising stem, whichever is specified, gunmetal nuts, and graphite packing compressed fibre packing.

(b) Fresh Water Application

(i) Up to and including 50 mm bore

Full way gate valve of bronze body construction to BS EN 12288:2010 wedge and valve seat shall be in bronze, non-rising spindle and screw collar in high tensile bronze. Valves shall have screwed female ends for taper treads to BS EN 10226-1:2004.

(ii) Above 50 mm bore

Full way gate valve of bronze body construction to BS EN 12288:2010 bolted bonnet, wedge and valve seat in bronze, rising or non-rising spindle and screw collar in high tensile bronze. Valves shall have flanged connection to BS EN 1092-1:2018, BS EN 1092-2:1997 and BS EN 1515-1:2000.

15.1.1.10.5 Regulating Valves

Regulating valves in fresh water systems shall have gunmetal body to BS EN 12288:2010 with screwed female connections for sizes up to 50 mm bore, and shall be of flanged connections for size above 50 mm.

Regulating valves in salt water system shall be similar materials as the cast iron gate valves and suitable for use with sea water. Valves shall have parabolic shaped discs to give a "straight line" characteristic of water flow to spindle lift. All valves shall be lock-shield type.

15.1.1.10.6 Motorised Control Valves and Solenoid Valves

For pool water application, valve suitable for sea water application is required.

Motorised valves shall be of the modulating type with a turn down ratio of at least 50 to 1. Valve bodies shall be cast gunmetal, brass cast iron or as otherwise indicated. Seat and inner valve material shall be brass, stainless steel or as otherwise indicated. Valve sizes 50 mm and smaller shall be screwed and supplied with union fittings. Valve sizes 65 mm and larger shall be flanged. Valves shall be of the straight-through type as required by the sequence or shown on the Drawings. Valves actuator shall be equipped with manual opener to allow manual positioning of valve in the absence of control power. Valves shall have authority of at least 0.5

(50%) and shall have suitable actuator to close against full pump head. Valve body shall be rated for differential pressure stroke less than 20 mm.

For valves that are incorporated within the system or units, they shall fit for the purpose and applications.

Valves schedules for all valves modulations/on-off shall be submitted detailing the maximum allowed and actual pressure drops, authority, turndown ratio, maximum pressure the actuator will close against and other valve data.

15.1.1.10.7 Check Valves

The body of the check valves shall be made of cast iron to BS EN 1561:2011 and ISO 185:2020 while the flaps/discs shall be made of bronze to ISO 197-4:1983 or ductile cast iron. The discs of swing check valves shall be of light construction and pivot on a spindle secured by 2 phosphor-bronzed hangers. Each valve shall be fitted with a stop to prevent undue movement of the flap and shall be as silent as possible in operation.

The discs of lift check valves shall be provided with means of guiding the discs and preventing components from becoming detached in services.

Recoil check valves with size 100 mm and above shall have removable cover on top of the outlet body casing to facilitate inspection of bearings and movement door.

Silent check valves shall have large bearing surfaces, functions equally well in all positions, drop-tight seating, and stainless steel trim.

For chemical handling, ball type UPVC check valves at 50 mm diameter or below may be used.

15.1.1.10.8 Stainless Steel Valves and Accessories

Where stated in the Particular Specification, valves and accessories for use with ozone or ozonated water such as valves and accessories for reaction tanks, carbon filter tanks, etc. shall be made of stainless steel materials to Grade 316 (BS EN10088-3:2014). This includes body, stem, disc, cover and spring of gate valves, check valves, globe valves and other accessories as specified in the Particular Specification. The gasket shall be made of PTFE. Butterfly valves shall be in accordance with the requirements of Clause 15.1.1.10.3 of this General Specification.

15.1.1.10.9 Cocks

Cocks, taps and other accessories shall be of the type and working pressure suitable for the applied system and shall be supported by valid documents with approval from the appropriate authority. They shall be in accordance with the appropriate ISO Standard with marks.

Bodies of cocks of up to and including 50 mm size shall be of cast gunmetal or bronze; approved valves having hot-pressed bodies may be offered as an alternative. For carbon and reactions tanks, size of drain cock shall be 50 mm and above which shall be of UPVC cocks with UPVC pipes below union end.

Except otherwise specified all cocks that convey ozonised or chemical fluid shall be chemical resistant types.

15.1.1.10.10 Strainers

Strainers shall be of screwed thread connection for bores of up to and including 50 mm, and of flanged connection for bores of 65 mm and above.

Strainers of up to 50 mm shall be of gunmetal or bronze. The bodies of single strainers of 65 mm bore and above and all double strainers shall be of cast iron.

Strainer cages and their supporting structure shall be stainless steel with 1.5 mm diameter perforations or as specified in the Particular Specification. Cage shall be at least 5 times the cross-sectional area of the pipe.

Double strainers shall incorporate a changeover device to enable either strainer to be selected and to isolate the idle strainer from the fluid flow.

In case where the strainers have to be frequently cleaned, such as the strainers for the main circulation pumps, a bucket type strainer with clamp type cover to facilitate quick removing of cages without the need for wrench or other special tool shall be used. The flanged cast iron bucket type strainers shall have grade 316 stainless steel screen cage with perforations to suit fluid handled. 1 set each of spare screen cages shall be provided for alternate replacement.

15.1.1.10.11 Foot Valves with Strainers

Foot valves with strainers shall be used for chemical dosing systems when diaphragm pumps have been used. The body shall be corrosive resistant material and strainers shall be stainless steel to resist the chemical fluids.

15.1.1.10.12 Automatic Air Vents

Automatic air vents for general venting of air shall have gunmetal or brass bodies, non-ferrous or stainless steel floats and guides, and non-corrodible valves and seats. Each automatic air vent shall be controlled by a lock-shield valve. Air release pipes shall be run to discharge at the nearest suitable and visible point and agreed by the Supervising Officer.

Whether indicated on the drawings or not, automatic air vent shall be installed at the top of all risers as well at high points in pipework systems.

For venting of ozone at carbon and reaction tanks, automatic air vent complete with cocks shall be provided at all high points on water circulating pipework and tanks. Body of the automatic air vents shall be of stainless steel. The venting capacity and operating pressure shall meet the venting requirements of the ozonators as informed by the manufacturer.

Proprietary made automatic venting system for carbon and reaction tanks may be accepted subject to the approval of the Supervising Officer.

Automatic air vent on UPVC pipe shall be protected by guard. The guard details shall be submitted for Supervising Officer's approval.

Devices for air venting shall be provided at all high points in the pipework. They shall be installed in the highest points of the sections where they are intended for venting.

Vent valves from reaction and carbon tanks shall discharge gas to outdoor through an ozone destroyer.

15.1.1.10.13 Sight Glass

The sight glasses shall be corrosion resistant type which shall be securely fixed to the pipework. Inline inspection glasses shall be corrosion resistant type which shall be installed at the discharge of each chemical feed pumps. Protective guard shall be installed to protect the sight glass. Details shall be submitted for Supervising Officer's approval.

15.1.1.10.14 Valves for Drain

For flushing down cock or valve, 15 mm diameter key-operated drain cocks with hose unions shall be fitted to the lowest accessible points of the system pipework and also on individual items of plant to ensure complete drainage.

Larger drain valves will be required for rapid flushing down in connection with water tanks.

Drain valves for back washing of sand filters or carbon tanks shall have diameter equal to the inlet and outlet pipes.

15.1.1.10.15 Pressure & Temperature Gauges, Orifice Plate, Flow Meter and Energy Meter

(a) Pressure Gauges

Pressure gauges fitted to plant and pipework shall comply with BS EN 837-1:1998 calibrated in kPa from zero to not less than 1.3 times and not more than twice the operating pressure of the respective equipment/system and shall be accurate to 1.5% of full scale reading, unless otherwise specified. Gauges for ozone or chemical application shall be stainless steel.

The dials of gauges shall not be less than 100 mm diameter and the cases shall be of polished brass or chromium-plated mild steel with optical sight glass.

Pressure gauges used solely to indicate the head and pressure of water shall be provided with an adjustable red pointer set to indicate the normal working pressure or head of the system.

(b) Thermometers shall be of the alcohol -in-glass type of at least 150 mm long with accuracy of ±0.5ºC. Thermometers shall be complete with cylindrical brass case, be of straight or angle type, and be installed in pockets. Unless otherwise specified, material of thermometer pocket shall be of stainless steel grade 316.

(c) Where orifice plate metering are to be installed, the orifice plates shall be of stainless steel and of proven performance characteristics in compliance with ISO 5167-1:2003 and ISO 5167-2:2003. The resistance across the orifice shall not exceed 5 kPa. The plate shall have 2 stainless steel valve tappings for connection to manometer or responder meter.

(d) Electromagnetic and Ultrasonic Flow Meters

(i) The flow meter shall be of the direct reading type, i.e. in l/s, and shall be suitable for the chemical and physical properties of the fluids to be measured and suitable for both horizontal and vertical installations.

(ii) Each flow meter shall consist of the flow sensor, an integral signal converter/transmitter and a digital display unit. The flow sensor shall be installed on the water pipework without obstructing the flow. The protection class of the sensor and converter/transmitter housing shall be at least to IP 67 and IP 65 respectively. The flow meter shall have a constant accuracy to a maximum error of ±0.5% of the actual flow for flow velocity of greater than or equal to 0.5 m/s. The Installations of the flow meter shall be as per the manufacturer's recommendation with sufficient length of straight pipe run both at the upstream and downstream piping.

(iii) The flow meter shall conform to BS EN IEC 61000-6-1:2019 to 61000-6-2:2019, BS EN 61000-6-3: 2007 + A1: 2011 and BS EN IEC 61000-6-3:2019 or similar international standards on Electromagnetic compatibility (EMC) compliance for industrial and commercial applications.

(e) Energy Meters

The calculation of water enthalpy shall be based on flow rate and

change of water temperature. The energy meter shall calculate and display digitally the water enthalpy consumption in kWh with accuracy to a maximum error of 1.5% throughout the range of measurement. The number of digits of accumulated enthalpy consumption display shall not be less than 6. The housing protection for the microprocessor and calculator unit shall not be less than IP 54. The requirement for the temperature sensors and the flow meter shall be as specified elsewhere in this General Specification.

Signal connection facilities to the central control shall be provided for displaying the energy consumption computed and the flow rate and temperature readings.

15.1.1.11 FIBREGLASS WATER TANKS

15.1.1.11.1 General

(a) Wherever indicated on the drawings, all non-concrete tanks shall be supplied and installed except water storage tanks constructed by concrete which shall be casted by the Building Contractor.

(b) All fibreglass water tanks shall be of removable panel construction and bolted to form the required tank size by flanges.

(c) Each tank shall be provided with the following:-

(i) one 500mm x 500 mm or 500 mm diameter access opening with lockable cover to prevent the ingress of dirt;

(ii) the required numbers of inlets, outlets, drains, vents, overflow and electrode connections, positions of which shall be determined and submitted for approval; and

(iii) one internal and external cat ladder for maintenance. (Ladders shall be constructed in stainless steel)

(d) All connections in the tanks shall be made by flanges to BS EN 1092-1: 2018, BS EN 1092-2: 1997 and BS EN 1515-1: 2000 and the materials of the flanges shall be identical to that of the pipework to be connected.

(e) All bolts, nuts and washers used in the tanks, whether or not in contact with water, shall be of stainless steel and shall not deteriorate due to chemical or atmospheric actions.

(f) Proper gaskets shall be used in all joints at panel flanges and pipe flanges. Details of gaskets shall be submitted for approval by the Supervising Officer.

(g) Tank construction shall follow the WSD's requirements.

(h) Fittings including puddle flange for all necessary pipework connections and controls shall be supplied and installed.

(i) All cast-in fittings shall be ensured correctly positioned.

(j) The dimension of the tanks shown on the drawings are indicative only, exact sizes of all tank shall be adjusted to suit site conditions as well as to suit the manufacturing tolerance.

(k) Materials of the fibreglass tanks shall be of the type approved by Water Authority, Buildings Department and FSD. Details of materials shall be submitted for approval.

(l) Details of construction method of non-concrete tanks shall be submitted for approval.

15.1.1.11.2 Tank Panels

(a) In general, each panel of the tank shall have uniform dimensions of 1000mm x 1000 mm or 1000mm x 500 mm or 500mm x 500 mm modules and shall be interchangeable between tanks for the same application.

(b) The panel pattern shall be of "F" panel design to give extra strength to the wall of the panel to withstand water pressure. Alternative patterns may be considered and shall be submitted for approval.

(c) Thickness of each panel shall be adequate to withstand at least 3 times the static pressure likely to be created by the depth of the water stored therein. Adequate bracings shall be provided to maintain the tanks in shape when fully charged with water. Any leakage /rectification work resulted from inadequate bracing /supports shall be responsible under the Works. Damages to other trades and to the owner’s properties resulted from flooding will also be chargeable to the contractor responsible for the Works.

(d) Tank panel shall be of reinforced glass fibre with a minimum thickness of 10 mm. The material of the tank shall not deteriorate due to chemical, atmospheric or thermal action when in contact with water treated with relevant chemicals for disinfection. Special attention shall be paid to the temperature of the water which will be as high as 35°C. The jointing material shall also be suitable for the chemical and temperature conditions of the water.

15.1.1.11.3 Supports

(a) Adequate supports shall be made to all connecting pipework from the building structure. The tank body shall not be used for supporting the pipework in any case.

(b) In general, tanks shall be supported on steel channels placed on top of concrete plinths. The steel channels shall be anchored to the concrete plinths and in turn bolted to the flanges of the panels as shown on the Drawings.

(c) Fibreglass tanks shall only be supported at the panel flanges and adequate anchoring points shall be provided to prevent movement.

(d) Adequate bracing shall be provided in the fibreglass tanks to eliminate vibration caused by the closing float valves and any other external sources.

15.1.1.12 POOL FITTINGS

15.1.1.12.1 Inlet Fittings

The inlet fitting for swimming pool shall be of adjustable type with full range of flow adjustment by turning the internal plate. Total opening area of the grating shall not be less than cross-section area of the connection pipe. It shall be constructed of ABS or chrome plate cast bronze.

The inlet fitting for water feature shall be of chrome plate cast bronze construction, adjustable "eyeball" type with smooth rounded exposed surface. The minimum orifice diameter shall be 25 mm.

15.1.1.12.2 Hydro Spa Jet

Hydro spa jet shall be provided inside Spa pool to create an agitation on water surface. The hydro spa jet shall be complete with socket end or threads for pipe connection. The hydro spa jet shall be of ABS constructed, the intensity of flow shall be fully adjustable from front with minimum 25 mm connection for water supply and 25 mm for air inlet. The flow of hydro spa jet shall be capable to be defected at 15o at any direction to the horizontal axis.

15.1.1.12.3 Gutter Drains

Gutter dome scum drain shall be installed wherever so specified, in the gutter channel. Gutter dome scum drain grating shall have opening area 1.5 times the cross-section area of the connection pipe. The grating shall be designed to prevent entrapment of bather’s toes or fingers. It shall be constructed of ABS or chrome plated cast bronze.

15.1.1.12.4 Main Drain Grating

Wherever so specified, main drain grating shall be installed and be of square type.

Multiple suction outlets system shall be adopted. The main drain grating shall be installed on a concrete sump pit constructed by Building Contractor. It shall be installed at the lowest point of the swimming pool,

water features and spa pool, of adequate size and design to ensure a maximum velocity of 0.3 m/s even if one of the suction outlets becomes blocked.

The distance between the nearest points of the perimeters of outlets shall be at least 2 metres. Should there be any physical constraints that this requirement cannot be met, i.e. small pool size, justifications and proposed distance apart shall be submitted for Supervising Officer's approval.

The opening area in the grates shall be of such design to prevent vortex and physical entrapment of fingers, toes, etc. The cover for the main drain grating shall be designed so that it cannot be removed except with tools. The main drain grating shall be constructed of ABS or chrome plated cast bronze. Twin drain outlets shall be provided in accordance with CIBSE Guide G Chapter 10.

15.1.1.12.5 Vacuum Fitting

The vacuum fittings shall consist of body and plug. The fittings shall be constructed with ABS or chrome plated cast bronze and shall have connection for flexible vacuum hose. The plug shall be provided with mating threads at the hose adaptor connection and shall have 2 integral cast recessed finger gripping ribs for ease of removing from body. The selected adaptor shall be PVC or ABS construction with 38 mm FIP for connection to pipework, or as specified by the Supervising Officer.

15.1.1.12.6 Overflow Drain

Overflow drains shall be provided in form of skimmer box at location shown on the Drawings. All drain outlets shall be of streamlined ABS gratings, and completed with thread for UPVC overflow drain pipes connection, or as specified by the Supervising Officer.

15.1.1.12.7 Channel Outlets

The selected outlets and the associated gratings shall be of PVC or ABS construction with 50 mm diameter connection. The grate free area of the drain grating shall be minimum 1.5 times the transverse area of the connecting pipe, or as specified by the Supervising Officer.

15.1.1.12.8 Skimmers

Skimmers shall be installed as indicated on the Drawings. This shall be moulded type of 5 mm thick rugged ABS construction, or as specified by the Supervising Officer.

15.1.1.12.9 Pool Ladders and Water Depth Indicators

Unless otherwise specified, pool ladders constructed of grade 316 stainless steel tubing shall be provided by the Building Contractor. The number and the arrangement of the ladders for the pool shall be as shown

in the Drawings. The width of ladder shall be 508 mm, unless otherwise specified.

Water depth indicators would be provided on the side walls of the pool by the Building Contractor.

15.1.1.12.10 Safety Vacuum Release System

The Safety Vacuum Release System (SVRS) shall be installed as indicated on the Drawings and complied with the BS EN 13451-3:2011+A3:2016.

By measuring the suction pressure mechanism, the performance requirements to automatically shut off circulation pumps shall comply with the ASME A112.19.17. A test report regarding this standard shall be submitted to the Supervising Officer for approval.

Alternatively, by measuring the flow mechanism, the ultrasonic transducer shall be capable to measure the flow as the specified pipe material/size and the design temperature adopted in the swimming pool. The measuring accuracy of the provided ultrasonic transducer shall be within+/-1%.

SUB-SECTION 15.1.2

SAND FILTER

15.1.2.1 GENERAL REQUIREMENTS

15.1.2.1.1 Sand filter shall be air scoured sand pressure type. Each sand filter shall comprise a steel electrically welded shell complete with supported nozzle, balance tank, adequate strength stainless steel nozzle plate and filtering media supports, internal distribution and draw-off trough, flanged inlet and outlet, wash-in, drain and air connections, adequately sized "McNeil" type manholes (minimum 4 nos. for each filter), filter supporting feet, necessary filtering media and sundry accessories. The design and position of manholes shall be convenient for maintenance staff entering the shell to service, replace internal parts and repaint the internal surface wherever necessary. For each horizontal filter, two numbers of 250 mm diameter hand doors complete with shell fixing bolts shall be provided along the longitudinal side just above the nozzle plates. For each vertical filter, two numbers of 250 mm diameter hand doors complete with shell fixing bolts shall be provided on the opposite sides just above the nozzle plates. Sight glasses shall also be provided just above the level of filtering media. Detailed Drawings with design stress calculation of sand filters construction (at least 2 times above design working pressure) including the tank, nozzles, tank supports and sand filter bed & supports shall be submitted to the Supervising Officer for approval. Special attention shall be given to the methods of supports for the nozzle plates. These shall have adequate supports so that no bending of any of the support members will occur.

15.1.2.1.2 The tanks shall be treated as follows: -

(a) Interior Surface

(i) Surface Preparation:-

Blast cleaning shall be carried out in accordance with BS EN ISO 12944-1:2017 to BS EN ISO 12944-4:2017, BS EN ISO 12944-5:2018, BS EN ISO 12944-6:2018, BS EN ISO 12944-7:2017, BS EN ISO 12944-8:2017,BS EN ISO 14713-1:2017, BS EN ISO 14713-2:2009 2020 and BS EN ISO 14713-3:2017. The quality of blast-cleaning shall be to second quality as given in BS 7079:2009 "General introduction to standards for preparation of steel substrates before application of paints and related products".

(ii) Coating System:-

Primer: one coat of heavy duty epoxy paint up to a dry film thickness of 80 microns. It shall be epoxy orange primer or approved.

Undercoat: one coat heavy duty epoxy paint with light yellow finish. It shall have a dry film thickness up to 100 microns, and epoxy white primer (undercoat) or approved.

Finish: two coats of heavy duty epoxy paint with blue finish. It shall have a dry film thickness up to 30 microns per coat and epoxy sky blue or approved.

(b) Exterior Surface (unexposed)

Before placing the filter tank in position on the concrete plinths, the areas that will be in contact with the concrete shall be wire brushed and applied a thick coat of bitumen. For horizontal tank, the tank shall be laid on a pack of bituminous felt such that the interface between concrete and filter tank is adequately protected against corrosion for all times. Any bitumen between remaining on the exposed areas outside the interface shall be cleared off in preparation for the protection described below.

(c) Exterior Surface (exposed)

On completion of filter tank fabrication, wire brush the whole of the external surface thoroughly to remove all scale rust, dirt and grease. The outer surfaces and attachments shall be treated as follow:-

Primer: as for interior;

Undercoat: one coat of good qualities undercoat paint of colour consistent with finishing coat; and

Finish: one coat of good quality heavy duty epoxy green paint or approved.

(d) Painting Precaution

Submit detailed painting methods and procedures recommended by the paint manufacturer. These instructions shall then be followed without deviation unless instructed by the Supervising Officer. These instructions shall be submitted to the Supervising Officer for approval. All paints used shall be of the same brand from the same manufacturer. All shot-blasted surfaces shall be inspected by site representative of the Supervising Officer immediately after blasting. Primer shall be applied immediately after the inspection.

(e) Tank Assembly

Factory assembled, pressure tested and certified filter tanks to be offered as practical as possible. Unless, in view of the actual

difficult site conditions and to the approved of the Supervising Officer, the tanks may be shipped in small plates formed and ready for electrical welding on Site. Finished filter tanks shall be subjected to a pressure test for 6 hours of not less than 2 times the design working pressure or 600 kPa whichever is higher, in the presence of a Registered Professional Engineer (Mechanical) appointed by the contractor responsible for the Works and the Supervising Officer's Representative on Site.

(f) Test Certificates

Test certificates issued by an Appointed Examiner under the Boilers and Pressure Vessels Ordinance, (Cap. 56) and other testing documentation as required by Labour Department and other relevant authorities shall be submitted to the Supervising Officer for each filter tank. Detailed design report of the filter tank regarding its strength shall also be submitted to the Supervising Officer for approval before fabrication which shall be certified by the Appointed Examiner.

15.1.2.2 FILTER BED

Filter bed shall consist of at least two but preferably more layers of filter media, each having a different particle size properly supported by a suitable under drain. Where nozzles are provided as a form of under drain, they shall be completely manufactured from poly-propylene or UPVC screwed into a high quality heavy gauge steel plate and shall not have any metal screws or holding bolts. The steel plate shall have adequate support and shall be strong enough to withstand the weight of the filter bed plus the water pressure differential across the bed when dirty. A margin shall be provided to take the additional pressure in the event that any other filter is temporarily valved off. Manufacturer's fully dimensioned shop drawings together with details of the nozzles and filter media shall be submitted for approval prior to fabrication. 10% spare nozzles shall be provided for each filter tank.

15.1.2.3 FILTERING MEDIA

The filtering media shall consist of accurately and even graded quartz sand with at least one layer of 0.4 to 0.8 mm grain and one layer of 0.71 to 1.25 mm grain. The depth of sand shall be sized according to the plant capacity and the manufacturer's recommendation for low to medium filtering rate. 0.3 mm water free board shall be provided above the sand.

15.1.2.4 WELDING REQUIREMENTS

All welding shall be carried out by metal arc or gas process and shall conform to the requirements to BS 2971:1991, BS 4515-1:2009 and BS 2633:1987. Undercutting and hammering of completed welds are not permitted. Arc welding of carbon and carbon manganese steels shall conform to BS EN 1011-2:2001. The welding process shall be submitted to the Supervising Officer for approval.

All welder employed shall be holder of a valid certificate of competency which has been issued by an approved authority. Copies of these certificates shall be submitted for inspection before any welding is to be proceeded.

Allow 5% of the total welds when selected by the Supervising Officer be examined by X-ray non-destructive test carried out by an independent testing body approved by the Supervising Officer. All test result shall be submitted. In the event of any welds proving unsatisfactory, the weld shall be rectified by approved welding process until a satisfactory test result is obtained. Extra cost for the repair and non-destructive X-ray test shall be included under the Works.

15.1.2.5 OTHER REQUIREMENTS

In the case the filter tanks/vessels are manufactured outside Hong Kong, the hydraulic pressure test and X-ray test shall still be required to be carried out on Site after delivery. In addition, test report and certificate shall be submitted which is endorsed by the manufacturer professional engineer that hydraulic pressure test and X-ray test to the same requirements as that on Site have been carried out in the factory before delivery and all test results are satisfactory. All defects on the vessels found on Site after delivery shall be rectified. Where defects are found on any vessel which in the opinion of the Supervising Officer is substantial, the whole filter vessel shall be removed and replaced at no extra cost. Rectification on Site shall not be accepted.

Service platform and cat ladders shall be designed and provided for all filter tanks. The platforms and cat ladders shall be designed and painted for future maintenance of all instruments and parts of vessels and access to the manholes. The platform and cat ladders shall be made of mild steel, steel chequer plates and accessories of adequate strength to facilitate servicing. Details of these fabrications and shop drawings shall be submitted to the Supervising Officer for approval prior to erection. The platforms and cat ladders shall be painted in accordance to relevant parts of this General Specification.

Internal inspection of each of the filter tanks shall be required towards the expiry of Maintenance Period. Drain down and open up to facilitate this inspection shall be carried out at the expiry of the Maintenance Period at no cost. Any defects found at this stage shall be rectified at no additional cost to the Employer. For the purpose of this inspection it will not be required to remove the filter media unless it is found to be in an unsatisfactory condition.

SUB-SECTION 15.1.3

OZONE GENERATION SYSTEM

15.1.3.1 GENERAL REQUIREMENT AND PRINCIPLE

15.1.3.1.1 Ozone generating system comprising of ozonator, mixing equipment, ozone analyser, reaction tank, carbon filter tank/vessel, control panel, and associated piping & wiring for the system shall be supplied and installed.

15.1.3.1.2 Disinfection of the filtered water shall be achieved by inducing ozone gas into an injected water supply to form ozonated water and then into the delivery main of pool. Ozone is generated by passing an oxygenated gas (commonly air) through a high- energy electric field of corona discharge. It is then introduced into the circulated pool water in the plant room and given sufficient time to react with the contaminants. Any residual ozone is removed by means of activated carbon filters following the ozonation process before passing back into the pool area.

15.1.3.1.3 Ozone generator shall comply with DIN 19627:2018. Ozone concentration in the ozonated air mixture shall be in accordance with the requirement of the Particular Specification. Ozone shall be added constantly to water while the system is in operation, at a concentration according to the Particular Specification. The reaction time of ozone after mixing with water shall exceed 3 minutes.

15.1.3.1.4 Ozone leakage alarm system and devices shall comply with Dangerous Goods Ordinance, (Cap. 384). Ozone detectors shall be located at low level inside the ozone generator room and near the destructor. Local alarm in the plant room and remote alarm shall be provided.

15.1.3.1.5 The ozone leakage alarm system inside the ozone generator room shall be activated if the ozone concentration reaches 0.1 ppm inside the room. Activation of the ozone leakage alarm system shall automatically switch off the ozone generator and switch on the mechanical ventilation system inside the room.

15.1.3.1.6 Manual switches with clear labels and instructions shall be provided outside the ozone generator room for direct on/off control of the ozone generator and mechanical ventilation system inside the room during emergency.

15.1.3.1.7 To minimise the volume of air injected into the pool water, use of multiple smaller capacity ozone generators with step control operating at nearly full load for duty disinfection level and the others acting as booster is recommended.

15.1.3.2 OZONATOR

15.1.3.2.1 Unless otherwise specified, ozonator shall be of full vacuum unit. Ozone production and transport shall be effected under vacuum to exclude any risk of ozone escaping from the system such that in the event of breakage of pipe containing ozone, air is sucked in rather than ozone escaping. The ozonator shall comprise the following: -

(a) Two air dryers (one duty one standby) shall be used to remove any contaminants and moisture from the ambient air prior to the ozone generation process. Two dryers shall be operated in such a way that one is operating in drying mode for a preset period of time while the second is in regenerating mode to expel the absorbed moisture with an automatic change-over function. The dryer shall be designed such that regeneration of the dryer can be in operation even when the ozonator is stopped. Air supplied to the air drier will be through an air duct.

(b) Ozone Generator shall consist of electrodes to which a high alternating voltage is applied. For tubular type electrode, the grounding or earthing electrode shall be formed by the cooling media surrounding the dielectric gap of glass/ceramic through which dried air is drawn under vacuum. A proper design for protecting glass tubes from potential damage due to thermal stress induced by the contact with coolant is to be featured. One spare ozone generator module shall be provided.

(c) High Tension Transformers of air cooled, dry type to provide high voltage for the electrodes in order to produce corona discharge across the dielectric gap rendering bi-atomic oxygen molecules O2 to regroup to form tri-atomic ozone molecules O3. The variable ozone production shall be achieved by varying the input to the high tension transformer so as to vary its output. In any case, no harmonic frequency shall be generated from the transformer, which could adversely affect the operation of the generator.

(d) Control panel with control components for automatic air-drying, ozone generation and safety features as depicted in Clause 15.1.3.2.5.

15.1.3.2.2 The ozonator shall have controls to allow automatically adjustment of ozone output in response to the redox signal from ozone sensor placed after the discharge of reaction tank by varying the transformer output voltage. Manual adjustment of ozone output by same principle shall also be facilitated.

15.1.3.2.3 The ozonator shall be of compact construction cabinet with lockable doors at the front, side and/or rear for access to all parts for maintenance. All panels shall be easily removable. Voltmeter, ammeter, indications lamps and control switches shall be provided on the front panel with polycarbonate windows for continuous observation and monitoring of the operation of the ozone generation units, air dryers and air flow indication.

All individual units, such as dryers/absorbers, ozone generators, and transformers shall be separated from one another by safety compartmentation. Moreover, the compartment housing the electrical equipment and air drier shall be separated from compartment housing the ozone generator. The generator shall be suitable for operation up to a room temperature of 40°C and suitable for continuous operation. Materials in contact with ozone shall be resistant to ozone attack.

15.1.3.2.4 The dielectric glass tube housing the electrodes in the ozonator shall be of robust and reliable construction to withstand the temperature and thermal stress during discharge. It shall be of a proven design with little chance of glass tube breakage and/or control failure. The whole ozonator shall be replaced at no extra cost if glass tube breakage occurs for more than two times during the Maintenance Period. During glass tube breakage in any one glass tube module/bank, the ozonator shall be able to allow for individual isolation of the module/bank of glass tubes to allow the generator to continue to function. Not less than 20% of total numbers of new glass tubes per ozone system shall be supplied as spare, which shall be handed over to the Employer 1 month before expiry of Maintenance Period.

15.1.3.2.5 The following minimum controls and safety features are required for the ozonator with visual indications, regardless of whether shown on Drawings or not: -

(a) Ozonator shall shut down completely on the following conditions: -

(i) air drier failure;
(ii) air flow failure;
(iii) cooling water (if applicable) failure and/or high water temperature;
(iv) excess air pressure or loss of vacuum in the air and ozone lines;
(v) excess or low current;
(vi) low water flow in main water stream/stopping of main water circulation pumps;
(vii) glass tube breakage (on one unit);
(viii) activation of the external cut-off device of the generator; and
(ix) other abnormal conditions that may lead to abnormal function of the ozonator.

(b) Interlock shall be provided such that ozonator can only be energised after the main circulation pumps are energised.

(c) Interlock with the cabinet door shall be provided to shut down power supply to the high tension transformer in case the cabinet door is opened.

15.1.3.2.6 A cooling circuit shall be included to cool down the ozone generator for water- cooling unit. The cooling water shall come from the main flow

and return to the pump header. Allow for the supply of cooling water pumps as recommended by manufacturer. Additional chiller units for cooling as recommended by the manufacturer to maintain the temperature within acceptable limit shall be allowed. Make allowance for any decrease of generator capacity due to high cooling water temperature from swimming pool in hot summer weather and increase the plant capacity accordingly.

15.1.3.2.7 In addition to the local control panel provided on the ozonator, the signals of the ozonator shall be wired to the supervisory control panel in the control room wherever so specified to indicate the following:-

(a) Fault indication lamps for each ozone generator which shall light up with buzzer alarm when there is any fault/tripping/stopping of the ozone generator (buzzer alarm can be muted); and

(b) Start/stop switches for each ozone generator with visual indication.

15.1.3.2.8 A warning lamp with buzzer shall also be provided on the supervisory control panel wherever so specified to warn operators to shut down or to reduce ozone output of the ozone generator in case the ozone sensor located at pool supply pipe detects ozone after deodorisation.

15.1.3.2.9 The system control shall be incorporated with an earth leakage detector, which shall provide fail-safe protection for bathers, and system operators working on the equipment.

15.1.3.3 MIXING EQUIPMENT

After the ozone is produced in the ozone generator, it shall be mixed with the water flow through an injector stream which shall then mix with the main flow. The mixing equipment shall consist of a mixer, a sight glass in the mixing chamber, an ozone eductor, booster pumps, manometers, piping, valves and accessories to help mixing and dissolving ozone into the water stream. The mixer shall be of material resistant to ozone attack such as reinforced UPVC, PTFE, or stainless steel Grade 316 (low carbon) as specified in the Particular Specification. The sight glass shall be able to withstand the test pressure of the system.

The eductor shall comprise of a nozzle followed by a venturi. A proportion of the water to be treated shall be drawn off by a suitable booster pump and fed under pressure and a high velocity to the nozzle. The emerging jet of water shall cause a vacuum which in turn draw air through the ozone generator where it is entrained in the venturi together with the water jet. The quantity of ozone gas to be mixed with water by suction can be regulated by means of the flow regulating and shut off valve in the gas line at the eductor. There shall be 2 non-return valves on both side of the shut-off valve and other safety protections to prevent water from entering the gas line. Pressure gauge shall be fitted upstream and downstream of the eductor.

15.1.3.4 ORP ANALYSER

An ORP analyser including a sensor shall be provided to measure the ozone concentration in the water and control the ozone generation of the ozonator. The reading shall be shown on a liquid crystal display. Extra output shall be provided to transmit the ozone concentration and water temperature signals to the supervisory panel wherever so specified.

15.1.3.5 REACTION TANK

15.1.3.5.1 The reaction tank shall be made of electrically welded mild steel of sufficient thickness to withstand the system pressure.

15.1.3.5.2 The reaction tank shall be designed to allow ozonated water to stay in the vessel for at least 2 minutes with careful planning of the inlet and outlet piping position. It shall be made of materials suitable for contact with ozonated water and shall be resistant to electrolytic corrosion and chemical attack. Some acceptable materials are: -

(a) Electrically welded mild steel with proper coating, the coating manufacturer's recommendation on pre-treatment procedures shall be strictly followed; or

(b) Stainless steel Grade 316 (low carbon)

15.1.3.5.3 The surface of tank shall be required to undergo the same pressure test and test standard on electrical welding for steel tank as the pressure sand filter tank.

15.1.3.5.4 Test certificates issued by an Appointed Examiner under the Boilers and Pressure Vessels Ordinance, (Cap. 56) shall be submitted to the Supervising Officer for approval. All other tests and certificates as required by Labour Department and other relevant authorities shall as well be done and provided.

15.1.3.5.5 The reaction tank shall also comply with all other requirements of sand filter tanks where relevant except with no nozzle plate and sand. The reaction tank shall be complete with all necessary accessories such as stainless steel automatic air vent connected to ozone destroyer, drain, valves, flow meter at inlet and outlet pipe, maintenance platform, supports, etc., all similar to sand filter tank.

15.1.3.6 CARBON FILTER TANK

The carbon filter tank (deozonising filter) shall have pellet activated carbon for complete removal of all ozone in water. It shall be made of approved material resistant to the attack of ozonated water same as reaction tank. It shall comprise an electrically welded shell with adequate strength nozzle plate on which carbon are placed, internal distribution, filtering media supports, flange inlet and outlet, drain, air connection and manholes for maintenance. The internal and external surface shall be treated as the

reaction tank. Distribution inlet and outlet pipes which cross the whole length of filter shall be UPVC pipes with holes.

The pellet activated carbon filter shall be able to completely remove ozone in water including the carbon depth, carbon media and filtration rate. Dimensions shown on the drawings are minimum requirements only.

Volume of carbon shall be adequate to ensure ozone removal time within 1.5 minutes.

The pellet activated carbon shall have diameter 3 – 4 mm with 4 – 8 mm mesh, hardness greater than or equal to 95%, moisture content less than or equal to 5%, iodine number greater than or equal to 950 mg/g, carbon tetrachloride activity (CTC) 45 - 55, specific surface area 800 - 850 m^2/g, ash content less than or equal to 15%, bulk density 450 – 550 g/litre, and pH value 7 - 9.

The carbon filter tank shall be required to undergo the same pressure test and test standard on electrical welding for steel tank as the pressure sand filter tank. Test certificates issued by an Appointed Examiner under the Boilers and Pressure Vessels Ordinance, (Cap. 56) shall be submitted to the Supervising Officer for approval. All other tests and certificates as required by Labour Department and other relevant authorities shall as well be done and provided.

The carbon filter tank shall comply with requirements of sand filter tanks where relevant. The carbon filter tank shall be complete with all necessary accessories such as stainless steel automatic air vent connected to ozone destroyer, drain, valves, pressure gauges, flow meter at inlet and outlet pipe, strainer, sight glass at filter media level, maintenance platform, supports and so on similar to sand filter tank.

15.1.3.7 RESIDUAL OZONE AND EXHAUST GAS TREATMENT

Air and undissolved ozone escaping from the vents and air release valves of the reaction tanks and deozonising carbon filter tanks shall pass through ozone destroyer (residual ozone catalytic/chemical converter) to remove the ozone in the air and the condensate shall drain down via trap. The ozone destroyer shall contain activated carbon filling, thermal or a heated catalytic destructor. It shall be of sufficient capacity of maintaining 8 to 12 months operation at design flow without replacement. More than one ozone destroyer for each group/bank in the system may need to install in addition to those shown on the Drawings to meet the 8 to 12 months operational criteria. Submit detailed calculation to the Supervising Officer for approval before ordering. In addition, 1 ozone destroyer in each group/bank shall be supplied and installed as standby which shall be used to maintain system operation if any one ozone destroyer in the bank has to be refilled/regenerated for any reason.

Exhaust vent pipe after ozone destroyer shall be led to an open position. Locations as shown on the Drawings are indicative only. Co-ordinate with other relevant parties on exact location of exhaust and allow for any change on Site to meet the exhaust criteria.

Vents of the reaction tanks and the deozonising carbon filter tanks shall have bypass to separate ozone destroyer. This bypass will normally be closed and shall assist the air bleed off on system start-up as required.

SUB-SECTION 15.1.4

SODIUM HYPOCHLORITE GENERATION SYSTEM

15.1.4.1 GENERAL REQUIREMENT AND PRINCIPLE

The sodium hypochlorite generator, rectifier/transformer, chemical metering pump, brine storage tank, hypochlorite storage tank, automatic pH & chlorine controller, control panel and all necessary piping & wiring for the system shall be supplied and installed.

The electrolytic hypochlorite generation shall work on the basis of partial electrolysis of sodium chloride contained in the brine solution flowing through the generating cells with DC current energising at the anodes and cathodes of the cells. Successive chemical reactions will take place in the brine solution between the products of the electrolysis.

In such chemical process, the brine solution shall be totally dissociated into Sodium and Chloride ions. Free chlorine shall be generated at the anode while hydrogen shall be evolved at the cathode with the corresponding formation of hydroxide ion. The migrated hydroxide ion from cathode shall be reacted with Sodium and Chloride ions near the anode to produce Sodium Hypochlorite solution.

The electro-hypochlorite generator shall be mounted on a separate pedestal assembly consisting of water flow meters with low-flow set point, brine flow meter with low-flow set point, water pressure regulating valve, cell electrolyte level switch, cell temperature switch, valve connections for acid cleaning and draining of cell, back pressure valve for brine inlet and epoxy-coated steel structural frame with points for securing to floor.

15.1.4.2 ELECTROLYTIC CELL

The cell body shall be constructed of non-corrosive and electrically non-conductive moulded polypropylene with integral inlet and outlet flanges. A transparent cell cover shall be provided to allow easy inspection of cell internals. Dimensionally stable anodes (DSA) such as anode of titanium substrate with ruthenium oxide coating, and corrosion resistant cathode shall be provided to minimise power consumption.

The cell is designated for one flow direction and high velocity flow to minimise hardness deposit.

Means shall be provided to prevent the cell from operating on low solution flow by having a flow switch at the outlets of the electrolytic cell. Flow switch shall be suitable for operation in the solution. (Flow switch made of stainless steel is not acceptable as it may suffer from pitting by the sodium hypochlorite solution generated.)

The cell shall be of plate type. Tube type is not acceptable as it requires high velocity of the flow switch which leads to erosion of the cell body easily. Transparent acrylic cell cover shall be used for visual inspection of the cell internals and also to check the effectiveness of the acid cleaning operation. Non transparent cell cover or casing shall not be acceptable.

15.1.4.3 RECTIFIER/TRANSFORMER

Power for the electrolysis of brine shall be provided by a solid-state controlled forced-air-cooled transformers/water-cooled rectifier.

The transformer/rectifier shall be of heavy duty industrial type suitable for input voltage of 380 V, 3-phase and 50 Hz.

The rectifier shall include self-monitoring with alarm contact output for cell voltage, thermal overload and internal faults.

The rectifier shall allow infinite adjustment of the hypochlorite production rate from zero to 100% of the rated capacity.

The transformer/rectifier shall be housed in a control cubicle c/w control components, measuring instruments, indicating lamps, etc.

Devices for high temperature and over current protection shall be incorporated for automatic shut down of the electrolytic chlorinator.

15.1.4.4 BRINE INJECTION PUMP

The brine injection pump shall be of bellows-type with adjustable stroke/diaphragm type with variable output.

The discharge volume shall be preset at the factory for normal operation but can be adjusted to fit different site operational conditions.

15.1.4.5 BRINE STORAGE TANK

The brine storage tank shall be constructed from reinforced concrete, reinforced fibreglass or high density polyethylene or equivalent materials.

The size of the tank shall be based on the numbers of working days, operating hours, circulation flow rate and chemical dosing concentration.

The tank shall be complete with outlets, valves, overflows to drain and accessories. Level indication such as level glass tube shall be provided.

15.1.4.6 METERING PUMP FOR HYPOCHLORITE & BRINE FEED

The hypochlorite metering pump shall be of the positive displacement type with a mechanically actuated diaphragm.

The pump shall be constructed with plastic and complete with clear plastic moulded cartridge-type check valves to facilitate service and provide integral sight flow indication. (Conventional threaded valves and external sight flow indicators are not acceptable.)

The pumping diaphragm shall be fabric-reinforced elastomer with an imbedded steel backing plate to ensure accurate repeatability for each stroke.

The output capacity for the chemical pump shall be manually infinitely controlled from 0-100% via a built in control knob.

The pump shall be complete with suction hose and accessories.

15.1.4.7 WATER SOFTENER

Water softener shall be an ion exchange resin that removes calcium and magnesium from the source water to reduce the deposits on the cathodes.

The softened water shall be used for dissolving salt in the brine tank, cooling the rectifiers and diluting the concentrated brine solution.

An automatic three-way control valve shall be provided for regeneration of the resin with the salt solution from brine storage tank.

A time delay flow switch in the outlet line from the water softener shall be installed to shut down the unit if the required flow is not present for a 5-second period.

15.1.4.8 HYPOCHLORITE STORAGE TANK

The hypochlorite storage tank shall be constructed from reinforced concrete, reinforced fibreglass or high density polyethylene or equivalent materials.

The tank shall be designed for ambient temperature and atmospheric pressure and suitable for indoor/outdoor installations.

The size of the tank shall be based on the numbers of working days, operating hours, circulation flow rate and chemical dosing concentration.

The tank shall be complete with outlets, valves, overflows to drain and accessories. Level indication such as level glass tube shall be provided.

The flanged connections for the inlet and outlet from the air dilution blower shall be provided.

Safe level control for start-stop operation of electro-hypochlorite generator, overflow alarm, low storage level alarm, stop operation of metering pump induced by low storage level alarm and disable metering pump signal shall be provided.

15.1.4.9 HYDROGEN BLOWER

The hydrogen blower shall be installed to force-ventilate the solution tank, reducing the concentration of hydrogen gas in the tank and interlock with electro-chlorinator.

A standby blower shall be installed to automatically start if the primary blower fails.

Both blowers shall be connected with a 'Y' piece to a common entry into the storage tank.

The blower shall be air-cooled explosion-proof type and the motor shall be of requisite size running at 1450 r.p.m. of the drip proof squirrel type totally enclosed.

Supply and fit range of PVC piping shall be complete with all necessary fittings between the air blower, filters and sodium hypochlorite tank, non-return valves and air inlet filters.

Automatic control shall be incorporated to shut the electro-chlorinator in the event of the failure of both blowers.

The blower shall at least remain operation for 15 minutes when the electro-chlorinator system is shut down.

The power supply cabling shall be of explosion-proof type.

15.1.4.10 HYDROGEN GAS DETECTION SYSTEM & AIR VENT

Hydrogen gas detection system shall be provided in sodium hypochlorite tank room. The required performance of the hydrogen gas detector shall be as follows: -

Measurement Range	:	0-100% of lower explosion limit of hydrogen (i.e. 4%) with initial alarm set to be 0.05% of hydrogen in air.
Life Expectancy	:	5 years
Operating Temperature	:	-5°C to +40°C (±10%)
Humidity	:	0-99% RH

The air vent for the hydrogen gas shall be installed with the air flow sensor which would provide actuation for the standby blower via a control panel in case of the failure of the primary blower.

The automatic air vent shall incorporate with no built-in valve and the discharge pipe shall be run to the nearest agreed terminal with mesh outlet in accordance with the Supervising Officer’s instruction.

The system completion shall be incorporated with explosive-proof type extraction fan and its accessories in accordance with FSD statutory requirement.

15.1.4.11 CHEMICAL CLEANING SYSTEM

An acid cleaning system shall be complete with recirculation pumps, fibreglass or PE chemical storage tank and other accessories to clean the electrolytic cell in a convenient manner.

All pipework connected shall be constructed of materials suitable for chemical resistance.

15.1.4.12 AUTOMATIC PH & CHLORINE CONTROLLER

The automatic chlorine and pH controller shall be installed to monitor and control the concentration of free chlorine and pH level within the specified range stated in the Particular Specification.

The automatic chlorine and pH controller shall be either installed at the return water pipe from the pool or be complete with the pH and ORP sensors at numerous sampling water return points at regular intervals around pool for the measurement purpose.

Standby pump with auto changeover shall be incorporated to ensure system reliability.

Alarm shall be provided upon failure of pump.

15.1.4.13 OTHER ACCESSORIES

The alarm sensors of the electrolytic assembly shall be complete with high & low temperature alarm, low electrolytic level, low dilution water flow and low brine flow.

PVC Y-type strainer shall be installed at the inlet of the electro-hypochlorite generator to filter any incoming water with particle size of 1 mm or more.

A pressure gauge and flow indicator shall be installed to show the electrolytic assembly system pressure and flow rate.

Ammeter and voltmeter shall be provided to display the electrolytic assembly current and voltage.

PVC pressure relief valve shall be installed to protect the electrolytic assembly from over-pressure.

Motorised/solenoid valves shall be installed at the inlet of the electro-hypochlorite generator to stop the incoming water flow through the cell when the system is switched off.

Sample valves shall be provided at the electro-hypochlorite generator outlet to facilitate the measurement of chloride concentration.

A local control panel shall be provided to provide on, off & modulating control, change-over control, and functions monitoring & status indication of the system components and to generate alarm signals.

15.1.4.14 TESTING & COMMISSIONING

15.1.4.14.1 This procedure is intended to lay down the general testing and commissioning requirements to be carried out r for the chemical dosing system prior to handing over.

15.1.4.14.2 Apart from the recommended procedures as suggested from the product manufacturers and the Testing & Commissioning Procedures as published by ArchSD, the following additional inspection, testing and commissioning requirements shall be satisfied.

15.1.4.14.3 General

(a) check if the emergency stop button is released;
(b) check if sodium hypochlorite line is connected to the Hypochlorite Tank;
(c) check if fresh water supply is connected to the system;
(d) check if all the alarms are reset;
(e) check and allow the system to run for 15 minutes;
(f) check if the DC voltage is below the rated value at full load; and
(g) check if the status of the pressure regulators and gauges in controlling the water supply to the dosing system is in proper condition.

15.1.4.14.4 Electrolytic Cell

(a) check for any damage or cracks on the cell box and clear acrylic cover;
(b) check whether the gasket of cell cover is in proper and secure position and any compression for the gasket under the faceplate;
(c) check whether the cell box bolts are tightened;
(d) check for any deposits and sludge accumulation in the cell; and
(e) check if the water flow meter readings are unchanged from the pre-set value.

15.1.4.14.5 Transformer/Rectifier

(a) check for any damage on the cabinet panels and meter faces;
(b) check if all the wirings are in proper connections;
(c) check if rectifier control panel is turned to "On" position;
(d) check the auto start of rectifier when the desired brine concentration has been achieved at the hypochlorite delivery point; and
(e) check the shutdown operator of rectifier upon the indication of high cell temperature or low water level.

15.1.4.14.6 Brine Injection Pump

check the injection pump to ensure it is rotating;
check if brine pump stops when level in Brine Tank reaches LOW LEVEL;
regulate the concentrated brine flowrate via the pump dial; and
check if the brine concentration has been achieved at the hypochlorite delivery point.

15.1.4.14.7 Brine Storage Tank

(a) check any impact damage for the tank and tank lid;

(b) check if the brine level assembly are in place and undamaged; and
(c) check if the mixing condition in the Brine Storage Tank is satisfactory.

15.1.4.14.8 Metering Pump for Hypochlorite & Brine Feed

(a) check if hypochlorite pump starts when the level in hypochlorite tank reaches its pre-determined operating level; and
(b) check if hypochlorite pump stops when the level in hypochlorite tank falls below its pre-determined cut-off level.

15.1.4.14.9 Water Softener

(a) check the shut down operation of the water softener when the required flow is not present for the pre-set period of the time delay flow switch; and
(b) check the time based operation of the auto control valve in regenerating softener into the unit.

15.1.4.14.10 Hypochlorite Storage Tank

(a) check the operation of the high/low liquid level for the Hypochlorite Storage Tank;
(b) check any impact damage for the tank and tank lid; and
(c) check if the brine level assembly are in place and undamaged.

15.1.4.14.11 Hydrogen Blower

(a) check and start the air blower; and
(b) check if hydrogen gas air vent connection to the atmosphere is proper.

15.1.4.14.12 Chemical Cleaning System

(a) check whether the cell is overfilled with acid cleaning solution;
(b) check if the acid level is just covering the top of the electrodes; and
(c) check the shut down operation of the acid pump when the liquid level in the cell is low.

15.1.4.14.13 Automatic pH & Chlorine Controller

(a) ensure the proper calibration of the pH and free chlorine sensors; and
(b) check pump start/stop operation when the pH level and free chlorine concentration fall within the pre-determined cut-in and cut-off levels.

SUB-SECTION 15.1.5

MIXED OXIDANT DISINFECTION SYSTEM

15.1.5.1 GENERAL REQUIREMENT AND PRINCIPLE

The mixed oxidant generation system shall be supplied and installed. The principle of mixed oxidant disinfection takes the advantage of various oxidant species to overcome the shortcoming of a single oxidant.

The mixed oxidant shall be generated by electrolysis of NaCl and the solution shall be safe and contain chloro-oxygen species with disinfection efficiency in term of CT values less than 120. (CT value is the function of disinfection concentration x time, the lesser the better.)

The mixed oxidant generator shall have proven history of satisfactory application in swimming pools.

15.1.5.2 GENERATION SYSTEM

The mixed oxidant generation system shall include electrolytic cell capable of providing streams of mixed oxidant and control panel with automated control system and diagnostic system for fault indication.

The mixed oxidant generator shall also include twin tower (one duty one stand by with auto change-over) softener, brine generator tank suitable of receiving salt and providing brine solution, pressure switch, solenoid valve, pressure regulator, oxidant tank and associated piping & wiring.

15.1.5.3 ELECTROLYTIC CELL

Mixed oxidant solution shall be generated by passing brine solution through an electrolytic cell. Flow control to cell shall be provided by solenoid valve.

The electrolytic cell shall be fully enclosed and constructed of plates composed of a suitable conductive metal with a catalytic coating contained within a plastic housing. The cell shall contain no membrane.

Brine shall be pumped to the electrolytic cell using a variable speed positive displacement gear pump. The material of construction for brine pump components in contact with brine shall be corrosion resistance. Mixed oxidant solution will be drawn from both anode and cathode side of the cell.

Prior to entry into the electrolytic cell, the saturated brine shall be diluted to the proper concentration for oxidant generation.

The mixed oxidants generated shall be stored in a holding tank and fed into the main water line by a venturi injection system or by metering pump system.

15.1.5.4 MIXED OXIDANT SOLUTION

The mixed oxidant solution generated shall include various chloro-oxygen oxidant species (e.g. hypochlorous acid is one of the various constituent) with disinfection function CT value less than 120 or equivalent proven disinfection capability.

The mixed oxidant solution shall be safe and not classified as dangerous good under FSD regulations. Material safety data sheet shall be provided for approval.

15.1.5.5 CONTROLS

15.1.5.5.1 General

The system control for the mixed oxidant generator shall automatically monitor system functions by means of a discrete logic controller and provide fault indications and electrical contacts for alarm system operation. A local control panel shall provide on, off & modulating control, change-over control, functions monitoring & status displays of the system components and generate alarm signals & displays. The control panel shall also have a display which monitor cell performance and indicate system operation and faults.

Amperage drawn by the cell shall be monitored by the discrete logic controller. In the event the amperage drawn by the cell falls outside acceptable operating limits, the logic controller shall cause the amperage drawn to return to within these limits.

Control voltage to operate the system will be provided by a transformer generating 24 V DC current.

Monitoring signal point and control points shall be provided to allow remote indication of fault condition and remote start/stop.

15.1.5.5.2 Diagnostics

Where specified in the Particular Specification, when an alarm condition has been activated, or a fault has been detected in the system, a diagnostics routine shall be executed from the control to determine the conditions of each of the inputs to the system.

15.1.5.5.3 Datalogging

Where specified in the Particular Specification, the logic controller shall include an on-board datalogging capability which supports 9600 band steaming serial data. The datalogging captures key operating parameters shall include cell amperage, brine pump signal voltage, cell voltage, and other operational parameters including a date and time stamp. The purpose of this datalogging is to capture long-term operational data that can be useful in diagnosing long-term trends in system operation.

15.1.5.5.4 Serial Data Port

Where specified in the Particular Specification, the controller shall have a serial data port that can transmit any data shown on the display as well as all fault indications and data not shown on the display.

15.1.5.6 BRINE TANK

The capacity of brine tank shall be capable for 2 weeks operation. The tank shall be equipped with float valve for high and low level control. The material of brine tank shall be reinforced concrete or high density polyethylene material. Overflow port shall be located at the top of the tank.

15.1.5.7 MIXED OXIDANT SOLUTION TANK

The sized of mixed oxidant storage tank shall have the capacity of providing at least 4-hour consumption unless otherwise specified.

The material of mixed oxidant solution tank shall be reinforced concrete or high density polyethylene material. The tank shall be equipped with liquid level switch for high and low level control.

Supply for mixed oxidant to the tank shall enter at the top and be fed through a drop tube to the bottom. Supply tube inlet shall include a vent at the entrance to the tank for venting. UPVC piping shall be attached to the top of the tube for venting to the atmosphere outside the building. A solution level indication tube and tank drain shall be provided.

15.1.5.8 SOFTENER

The softener shall be of automatic twin tower and self-backwash operation type. It shall provide continuous soft water and instantaneous switching of tanks. Check valve shall be provided to prevent backflow of water from the softener to the brine tank.

The water source shall be city main water. Other sources including pool circulating water shall not be used as water source. The feed water temperature shall be maintained between 10°C and 38°C.

15.1.5.9 HYDROGEN BLOWER

The hydrogen blower shall be installed to force ventilate the solution tank, reducing the concentration of hydrogen gas in the tank and interlock with mixed oxidant generator.

A standby blower shall be installed in parallel to the duty blower, which shall be connected with a 'Y' piece to a common entry into the storage tank. Control valves to enable the choice of air transfer from either one of the blowers shall be facilitated.

The blower shall be of air-cooled explosive-proof type and the motor shall be of requisite size running at 1450 r.p.m. of the drip proof squirrel type totally enclosed.

Supply and fit range of PVC piping shall be complete with all necessary fittings between the air blower, filters and mixed oxidant tank, non-return valves and air inlet filters.

Automatic control shall be incorporated to shut the generator in the event of the failure of both blowers.

The blower shall at least remain operation for 15 minutes when the generator system is shut down.

The power supply cabling shall be of explosion-proof type.

Hydrogen gas detection system shall be provided in mixed oxidant generation room. The required performance of the hydrogen gas detector shall be as follows:-

Measurement Range	:	0-100% of lower explosion limit of hydrogen (i.e. 4%) with initial alarm set to be 0.05% of hydrogen in air.
Life Expectancy	:	5 years
Operating Temperature	:	-5°C to +40°C (±10%)
Humidity	:	0-99% RH

The air vent for the hydrogen gas shall be installed with the air flow sensor which would provide actuation for the standby blower via the control panel in case of the failure of the primary blower.

The automatic air vent shall incorporate with no built-in valve and the discharge pipe shall be run to the nearest agreed terminal with mesh outlet in accordance with the Supervising Officer's instruction.

The system completion shall be incorporated with explosive-proof type extraction fan and its accessories in accordance with FSD statutory requirement.

15.1.5.10 OTHER REQUIREMENTS

The salt used for generating mixed oxidant solution shall be sodium chloride 99.5% pure coarse granular salt without additives or preservatives. Concentrations of calcium (Ca) shall be less than or equal to 0.03%, magnesium (Mg) be less than or equal to 0.02%, and manganese (Mn) be less than or equal to 0.005%.

The system control cabinet shall be incorporated with an earth leakage detector, which shall provide fail-safe protection for bathers, and system operators working on the equipment.

SUB-SECTION 15.1.6

ULTRA-VIOLET DISINFECTION SYSTEM

15.1.6.1 GENERAL REQUIREMENT AND PRINCIPLE

The in-line type Ultraviolet Disinfection System (hereafter called "UV system") shall be supplied and installed for use in disinfection and deozonisation, where applicable, of swimming pool water.

Ultra-violet (UV) is located in that part of the electromagnetic spectrum which extends beyond violet light, UV is invisible and kills micro-organism by destroying their DNA. In the wavelength region between 240 nm to 280 nm, UV is effective against bacteria, viruses, moulds and their spores. When swimming pool water is treated by an UV system capable of producing UV, the risk of transmission of stomach, skin and respiratory tract infections to bathers can be reduced. UV can also initiate photo-chemical and photo-oxidation reactions which destroys chloramines, a range of compounds responsible for unpleasant smells in swimming pools.

The UV system shall be capable of performing the above-mentioned requirements to suit the design swimming pool water turnover rate. UV wavelength shall cover spectrum 220 nm to 400 nm.

The UV system shall have proven history of satisfactory application in swimming pools.

15.1.6.2 UV CHAMBER

15.1.6.2.1 The UV system shall consist of a UV disinfection chamber (hereafter called "UV chamber"); the chamber shall be a self-contained unit including the following: -

(a) system control cabinet;

(b) flow and output safety control;

(c) an UV medium pressure arc tube capable of producing UV energy in wavelength from 220 nm to 400 nm;

(d) a quartz sleeve mounted axially to house the UV arc tube which permits replacement without interrupting the flow inside the UV chamber;

(e) an automatic, adjustable, electric motor driven quartz sleeve cleaning system; and

(f) an UV dose control system for controlling the quantity of UV delivered to the swimming pool.

15.1.6.2.2 The UV chamber shall be capable to operate continuously under a pressure rating at 10 bar. The UV chamber shall be hydraulically factory tested at 15 bar prior to delivery.

15.1.6.2.3 Unless otherwise stated, all materials exposed to UV light and in contact with water shall be stainless steel grade 316. The wetted surfaces shall be chemically inactive with all welds grounded to minimise corrosion.

15.1.6.2.4 Unless otherwise stated, the UV chamber shall be incorporated with the following features: -

(a) A temperature sensor shall be provided to turn off the UV arc tube automatically when there is inadequate water flow across the UV chamber.

(b) An UV intensity monitor shall be provided for monitoring the UV dosing level. The UV intensity monitor shall display real time UV lamp intensity on the system control cabinet in unit mW/cm^2, and initiate an alarm when the preset UV dosing level for proper operation cannot be achieved.

(c) The UV intensity monitor shall be wet probe type, wavelength specific to 240 nm - 280 nm and allow monitor probe to be cleaned by automatic wiper mechanism. Relative type UV intensity monitoring device or dry-probe type will not be accepted. The UV intensity monitor shall have been pre-calibrated against a traceable UV standard.

(d) UV chamber end plate where electrical cables accommodate shall be protected by a stainless steel cover. (Plastic cover or cap will not be accepted.)

(e) Water flow inside the UV chamber shall be laminar in order to provide maximum efficiency in the transfer of UV to the water. (Baffle plates or similar devices which create turbulent flow and dead spots inside the UV chamber will not be accepted.)

15.1.6.2.5 The connection of the inlet and outlet shall be flange type to PN 16 to BS EN 1092-1:2018, BS EN 1092-2:1997 or BS EN 1515-1:2000.

15.1.6.3 AUTOMATIC CLEANING SYSTEM

The quartz sleeve and the UV sensor probe for the UV chamber shall be cleaned periodically by an automatic cleaning system. The arrangement, operation principle and all the necessary technical details for the automatic cleaning system shall be submitted for approval by the Supervising Officer.

The automatic cleaning system shall travel the full length of the quartz sleeve twice per cleaning cycle.

The cleaning frequency shall be variable and nearly infinitely adjustable from 15 to 480

minutes to suit actual operational requirements.

The automatic wiper in its "parked" position shall not cover any portion of the arc tube that affects the efficiency of the UV lamp or create a "hot" spot on the arc tube.

15.1.6.4 ULTRA-VIOLET LAMP

The UV lamp shall be of medium-pressure high intensity type capable of emitting a continuous UV spectrum from 220 nm to 400 nm into the water.

Each lamp shall be capable of producing an UV spectral output at 245 nm, 297 nm and both 260 nm and 336 nm for destroying monochloramine, dichloramine and trichloramine respectively. A manufacturer's spectral certificate to demonstrate the accuracy shall be submitted to the Supervising Officer for approval prior to delivery. Each lamp shall be individually identified by part number and serial number.

The power per unit length of the UV lamp shall be limited to minimising risk of quartz sleeve shattering due to solarisation.

Warranty for the performance of the UV lamps shall be provided. The rated life of the UV lamp shall be a minimum of 4,000 hours, including the case when intermittent on/off occurs within the same day.

15.1.6.5 CONTROL AND MONITORING PROVISION

15.1.6.5.1 A system control panel shall be provided to provide on, off & modulating control, change-over control, and functions monitoring & status displays of the system components and to generate alarm signals & displays.

15.1.6.5.2 The system control panel shall be manufactured from stainless steel grade 316 and installed with cooling fan, louvre and replaceable filter for ventilation purpose.

15.1.6.5.3 The system control panel shall be protected to IP 55. Provision shall be made to ensure that power supplies to the control circuitry will cut off automatically when the panel door is being opened.

15.1.6.5.4 All internal wirings inside the system control panel shall be properly harnessed and the UV arc tube shall be powered via a constant wattage transformer.

15.1.6.5.5 The system control panel shall be provided with a microprocessor driven control module offering: -

(a) data logging of UV dosed, UV lamp operating hour, UV lamp intensity up to 12 months;

(b) a menu-driven interface;

(c) Local/Remote operation;

(d) digital display screen with real time display of performance parameters which shall include, but not be limited to the followings: -

- power on;
- UV intensity in either % or mW/cm^2;
- UV dose in mJ/cm^2;
- fluid flow rate inside the UV chamber in m^3/hr;
- UV arc tube ready; and
- automatic wiper system status and alarm;

(e) membrane key pad for system configuration; and

(f) capability of downloading with RS232 interface.

15.1.6.5.6 The system control panel shall be incorporated with an earth leakage detector, which shall provide fail-safe protection for bathers, and system operators working on the equipment.

SUB-SECTION 15.1.7

CONTROL SYSTEM

15.1.7.1 GENERAL

15.1.7.1.1 Scope of Work

The scope of work shall include, but not be limited to the design, supply, delivery, Installations, testing & commissioning and maintenance during the Maintenance Period of the control system including all the associated hardware, software, accessories, instrumentation and all the ancillary equipment & devices as specified in the Particular Specification and Drawings and as necessary for the satisfactory operation and maintenance of the swimming pool water circulation, filtration and disinfection plants and systems.

The interconnecting wirings among various control panels, equipment, pumps, valves, meters, and devices installed under this Contract shall be supplied, installed and terminated. Manual override to automatic control shall be provided on local control panels of all equipment and pumps, unless such is not desirable for reason of safe operation.

The control points under the control system shall include but not be limited to the points indicated in the Control Point Schedule in the Appendix to this Sub-section. Any additional points that are needed to provide the desired functions as specified, and include these points in the Installations shall be advised to the Supervising Officer.

15.1.7.1.2 Functions

The control system shall serve to enable the entire swimming pool water circulation, filtration and disinfection installations to function as specified in the Particular Specification, Drawings, and this General Specification unless otherwise indicated. The functions of each equipment, pump, valve, meter and device of the Installations shall include its start, stop, modulating operation wherever appropriate, and indications of start, stop and fault. The functions shall also include the sequenced start, stop and modulating operation of each equipment, pump, valve, meter and device whenever such sequence is required for the proper operation of the entire Installations; and the sequence shall, other than for a single equipment, pump, valve, meter, and device, include the operation of all other equipment, pumps, valves, meters, devices affected by the operation of the said equipment, pump, valve, meter and device.

The exact numbers of I/O points for the control system to provide the operation & maintenance functions of the entire swimming pool installations shall be designed and determined. The functions will be indicated in the Particular Specification or shown on Drawings.

Control facilities shall be provided to maintain the required pool surface

water levels through control of valves and pumps.

20% additional I/O points and wiring to facilitate the I/O in the control system for future extension shall be allowed.

15.1.7.1.3 Operation Voltage

The control system shall be operated on single-phase mains voltage or on extra low voltage such as 12 V or 24 V. Where a particular manufacturer's system is offered and accepted, the Installations shall be installed to comply with that manufacturer's recommended technical details and methods of Installations.

15.1.7.1.4 Sensors and Controllers

(a) The sensors shall be placed in transparent chambers, one chamber for each sensor, at various locations as shown on the Drawings and the flow rate shall be adjusted to meet with manufacturer's recommendation. For chamber installed on the return water pipe and sampling lines, y-type strainer shall be provided. The sensors shall detect and sense the return water of the pools in the sampling lines, in return water, after mixing chambers, after reaction tanks and before discharge to pool. Allow for all necessary equipment, piping and accessories to provide the control and indication functions including running of pipes and/or wiring to the sensors.

(b) All indication on controller shall be of LED type. Dial reading gauge is not acceptable. Measurement of chlorine and ozone level shall be made by redox potential philosophy or chemical means. Sensors shall be able to measure the chemical concentration as ppm. Running life of all sensors shall be of at least 1 year with no maintenance.

(c) Indicator meters for pool water quality shall be suitable for analogue input.

(d) The pH sensors and controllers shall be set at settings specified in this specification, with measurable range adjustable from 2-12. The residual free chlorine sensors and controllers shall be set at settings specified in this specification, with measurable range adjustable from 0.0-10.0 ppm, 0.0-5.0 ppm and 0.0-2.0 ppm with selection. The ozone sensors and controllers shall be able to be set at 0.4 ppm after reaction tank and 0.1 ppm before discharge to pool with measurable range adjustable from 0.0-3.0 ppm. All sensors and indication on controllers shall be able to give measurement down to 2 places after decimal point i.e. 0.01.

(e) Extra output signals shall be provided to transit the temperature signals and chemical levels such as residual chlorine and ozone concentration and pH value to the supervisory control panel if such panel is specified.

(f) Sensors shall also be included to measure ozone concentration in gas after ozone generator.

(g) Elements sensing liquid temperature in pipework shall be: -

(i) provided with means for withdrawal for calibration, servicing, etc., without the need for draining the system;

(ii) positioned so that the active part of the element is wholly within the liquid;

(iii) positioned so that the element is not less than 10 pipe diameters downstream from a point of mixing, unless otherwise recommended by the manufacturer;

(iv) positioned so that sufficient length of flexible conduit can be allowed to permit complete withdrawal of the element; and

(v) positioned downstream from the valve, after the pumps, for the control of mixed flow temperature using mixing valves.

(h) Elements sensing liquid flow in pipework shall be positioned so that: -

(i) the element is mounted in a section of pipe where there is a straight run of at least 5 diameters on each side of the flow switch;

(ii) the element is mounted so that the terminals or wire leads are easily accessible for wiring; and

(iii) the element shall not be subjected to water hammering. If a fast-closing valve is located downstream of the element, a suitable water hammer arrester shall be used.

(i) Sensing elements shall in all cases be installed in accordance with the manufacturer's latest recommendations and instructions.

(j) For sensors exposed to view, the precise location shall be approved by the Supervising Officer.

(k) All sensors shall be arranged to give convenient access for servicing.

(l) Suitable support and easy access facilities shall be equipped for all sensors, monitoring and measuring equipment. Suitable protection guard against damage shall be provided for equipment exposed to public contact. Temperature setting scales shall be clearly marked in °C.

15.1.7.1.5 Control Panels

Pump control panels shall be provided beside the group of pumps, for start & stop control and indication of fault. Push buttons shall be provided for start & stop, and LED lamps shall be provided for indications.

Panels to house the controllers for monitoring the water quality, alarms for detection of gas leakage, and control accessories for controlling of pool water level controls shall be provided. The panel material shall be stainless steel to Grade 316.

15.1.7.2 LEVELS OF CONTROL

15.1.7.2.1 General

There are 3 different levels of control, and the level to be adopted shall be as specified in the Particular Specification. The 3 levels of control are as follows: -

Level 1- Basically manual control;

Level 2- Centralised control; and

Level 3- Computer assisted centralised control.

15.1.7.2.2 Basically Manual Control

(a) All swimming pool water circulation, filtration and disinfection equipment shall be complete with local control panels for manual start/stop and control. The electrical and, if applicable mechanical, interlocks for maintaining the required sequence of operation of all the equipment, pumps, valves and devices shall be facilitated for proper starting, stopping, controlling, safety-alarming of pool water circulation, filtration, disinfection and heating (if heating is specified) in accordance to the pool performance requirements specified in the Particular Specification and the requirements for relevant equipment, valves and devices stipulated in this General Specification.

(b) Start & stop of equipment and pumps shall be facilitated on the corresponding local control panels. Push buttons shall be used, unless other means are required as recommended by the manufacturer or necessitated due to operational or safety needs. Electrical interlocks to ensure smooth start-up, stop and safe operation shall be provided.

(c) Remote fault indications shall be provided for all equipment, including disinfection systems and pumps. Remote fault indications shall be provided for all faults and alarms, as indicated in the Control Point Schedule in the Appendix. The remote fault indications shall be at designated locations approved by the

Supervising Officer. A panel shall be provided to house the indications. The panel shall be of stainless steel construction of 1.6 mm thick with side hinged opening with key lock. Coordination with other relevant parties shall be carried out on detailed arrangement to make neat and tidy Installations to the Supervising Officer's approval. Details of the layout and construction of the panel shall be submitted to the Supervising Officer for approval prior to fabrication and Installations. Buzzer alarms and visual indications shall be provided. Buzzer alarm for a fault shall be able to be muted by silencing switches while the visual indication remains on until the fault signals are rectified and the system is reset.

15.1.7.2.3 Centralised Control

(a) Level 2 control includes the manual controls in Level 1 and a central supervisory control. Wherever so indicated in the Particular Specification or Drawings, the supervisory control panel shall be supplied and installed in a designated location. The supervisory control panel, which incorporates the functions of the panel to house fault indications stipulated in 18.1.7.2.2, shall be able to fully communicate with the local control panels for individual equipment. The supervisory control panel shall have all major indications, controls, and alarm functions. The supervisory control panel shall house all visual and audible indications and controls for the proper functioning of the pool circulation, filtration and disinfection systems, controllers for monitoring the water quality, and alarm system for detection of gas leakage. Electrical interlocks to ensure smooth start-up, stop and safe operation shall be provided.

(b) The centralised control shall involve an automatic control system (ACS), which controls and monitors the proper, effective and efficient operation of the pool water circulation, filtration and disinfection equipment & devices. The ACS shall also control and monitor the operation of the heating equipment and associated pumps & accessories. The ACS shall incorporate the I/O provisions and functions indicated in the Control Point Schedule in the Appendix to this Sub-section.

(i) The ACS shall comprise of an electronic programmable logic controller (PLC) with built-in real time clock for scheduling. The PLC controller shall be located inside the supervisory control panel. The appropriate ACS shall be so designed to meet the requirements and operational needs of pool operation & management. The ACS shall have adequate capacity for scheduling all the operation needs per the Particular Specification.

(ii) The main function of the ACS is for on/off controls, monitoring of operation status and alarms generation of the water circulation, filtration and disinfection

equipment & devices. Comprehensive system controls and monitoring functions of individual equipment shall be carried out by the system controller of individual equipment. The ACS shall be so designed to achieve a reliable control in performing the control and monitoring functions set in the design criteria and shall be of micro-processor based electronic or direct digital control type.

(iii) All pool equipment and devices specified shall be able to be turned on and off in accordance with the time schedules pre-set in the built-in programme of the ACS including any holiday and special schedules so required by the users. A monitoring and alarm system shall be incorporated in the PLC in giving audio and visual status and alarm of faults for each equipment and device.

(c) The controllers serving different equipment shall be able to fully communicate with each other via the ACS to provide the functions as specified for the entire swimming pool Installations. The ACS shall be able to perform, but not be limited to, the following functions: -

- high speed logic control;
- full capability to handle PID loops as well as other control logic;
- real time multi-tasking and multi-programming functions;
- safety interlocking;
- analog alarm function;
- powerful floating-point calculation functions;
- connection to industrial Ethernet (redundant network);
- redundant I/O channel medium;
- full set electrical I/O modules, analog I/O modules and relative intelligent modules;
- clock instructions;
- analogue I/O shall support 4-20 mA;
- expandable to accept spare I/O; and
- operated from a voltage source of 220 V AC 50 Hz with sufficient output to support the requirement of the PLC plus the specified spare capacity.

(d) For easy programming, user-friendly I/O devices shall be provided for the setting and re-setting of the pool water quality and pool operation schedules.

(e) To prevent malfunctioning of the real time clock and losing of memory, 7-day back-up battery with power healthy indicator and alarm shall be provided.

(f) Indicators of pool water quality including pH level and free chlorine level, ozone level, turbidity, and water colour shall be provided.

(g) The supervisory control panel shall be of stainless steel construction of 1.6 mm thick with side hinged opening with key lock. Coordination with other relevant parties shall be carried out on detail arrangement to make a neat and tidy Installations to the Supervising Officer's approval. Buzzer alarms and visual indications shall be provided. Buzzer alarm for faults shall be able to be muted by silencing switches while the visual indication remains on until the fault signals are rectified and the system is reset. A mimic diagram with the entire system pool and piping schematic shall be engraved on the panel. Graphic of all pools, main piping, equipment, pumps, main valves, flow meters, enthalpy meters, thermometers, pool water quality indicators shall be shown on the mimic. LED lamps showing ON, OFF, malfunction, alarm, etc. for all equipment, pumps, motorised valves shall be provided on the mimic. Indication of duty/standby for relevant equipment and pumps shall be provided. Details of the layout and construction of the panel shall be submitted to the Supervising Officer for approval prior to fabrication and installations.

(h) Unregulated power supplies shall be filtered. Shielded cable shall be used when it is necessary to install DC signal leads in the same control wiring conduit.

(i) The detailed design of the control system shall be submitted to the Supervising Officer for approval before ordering and fabrication.

15.1.7.2.4 Computer Assisted Centralised Control

Level 3 control includes the Level 2 control and ACS, with the man-machine interface of the supervisory control panel carried out by a personal computer with LCD screen, keyboard and printer. Central interface with the control system shall be via the keyboard and graphic buttons or scales on computer graphics. On-screen graphics of system schematics shall be provided, including all pools, main piping, equipment, pumps, main valves, flow meters, enthalpy meters, thermometers, pool water quality indicators, etc. ON, OFF, malfunction, alarm, duty/standby status, equipment healthy status, power supply healthy status, etc. for all equipment, pumps, motorised valves, etc. shall be provided.

The computer configuration shall be as specified in 8.2.5.4 of this General Specification.

15.1.7.3 REMOTE MONITORING

For systems with Level 3 control, the control system shall be able to be accessed remotely via internet on computers, mobile phones, tablets, etc. for remotely monitoring. Related internet service shall be provided for three years and handover to maintenance team after three years. The remote access shall be protected by two levels of passwords. The user with 1st level password can monitor the system status. The user with 2nd level password

can monitor the system status and revise the time schedule and control set points. Parameters to be monitored and controlled shall be those in the Control Point Schedule in the Appendix to this Sub-section. In addition, message shall be sent the designated mobile phones whenever there is equipment fault or the water quality cannot fulfil the required standard.

15.1.7.4 INTERFACING WITH CCMS

For systems with Level 3 control, the control system shall be connected to the CCMS on the site via IP Local Area Network or BACNet. All parameters as specified in the Control Point Schedule in the Appendix to this Sub-section shall be fully accessible by the CCMS. All necessary information shall be provided to the contractor responsible for the CCMS installation works to enable the connection.

15.1.7.5 EQUIPMENT PERFORMANCE MONITORING AND DATABASE FOR CONTINUOUS COMMISSIONING

The control system shall monitor the perforce of equipment such as pumps. When the performance of the equipment deviates from the design value or its equipment performance (such as pump performance curve) by 20%, alarm message shall be issued.

Whenever vibration monitoring is specified for an equipment in particular specification or any drawing, vibration sensors shall be installed at the locations near bearings of pumps. Vibration analyser shall be installed to collect and analyse the signal from vibration sensor. Equipment status as good, satisfactory, unsatisfactory and damaging shall be analysed according to ISO 10816 or manufacturer's recommendation based on the measured vibration data. Equipment status shall be sent to CCMS for monitoring. When status of unsatisfactory is detected, alarm shall be trigged in CCMS. When status of damaging is detected, the equipment shall be stopped immediately.

All parameters as specified in the following control point schedule shall be stored on the computer for 3 years with the interval of 15 minutes for continuous commissioning.

Control Point Schedule

description	**analogue input (AI)**		**digital input (DI)**		**Analogue output (AO)**		**digital output (DO)**		**purpose**	**sensing/ control device**	**equipment/ device being controlled**
	points	Mode & Remark	points	Mode & Remark	Points	Mode & Remark	points	Mode & Remark			
pool level			2				2		monitor & control water level	level sensor	nil
make up water			2				2		monitor & control make up water	level sensor	nil
valves for pool level and make up water			2				2	from pool water level and make up water	monitor & control make up water	nil	valves, depending on design

description	analogue input (AI)		digital input (DI)		Analogue output (AO)		digital output (DO)		purpose	sensing/ control device	equipment/ device being controlled
	points	Mode & Remark	points	Mode & Remark	Points	Mode & Remark	points	Mode & Remark			
Surge /balance tank water level			4	hi, mid, low levels, overflow			2		control motorised valves and other controls	level sensors	valves, depending on design
strainers status			1	dirty			1 *	* only for auto-backwash	monitor block/clean status	differential pressure sensor	backwash if auto strainer
main circulation pump			3	on/off fault status			2	ON/OFF control	monitor & control pump on/off/fault	contactors/ relays	pump
pump flow switch			2	Standby / duty pump operation					monitor and control pump	flow switch	nil
flocculation			1	if turbidity meter used					flocculation	turbidity meter	injection pump
alum tank level			1	low level alarm					monitor alum level	level sensor	injection pump
alum dosing pump			3	On / off/ fault status			1	stops alum dosing pump when low level or water is not turbid	on/off control dosing pump	contactors/ relays	injection pump
backwash sand filter			1	differential pressure across sand filter			depend on valves quantity	Open /close respective valves with timer	open/close respective valves for backwash	differential pressure sensor	valves and air compressor
compressor for back wash			3	on/off/fault status			1	start/stop with timer	control compressor for back washing	contactors/ relays	on/off compressor
ozone booster pump			3	on/off/fault status			1	booster pump can operate only if main pump is running	monitor & control pump	contactors/ relays	booster pump
Ozone generator	3	O_3 quantity; no. of generators in operation; cooling air/water temperature condition, etc.	5	on/off/fault; cooling air/water temperature too high; no suction; air dew point temperature too high, etc.	1	control O_3 output	1	on/off control, and shut-off generator in case of O_3 leakage	monitor & control O_3 generator status and control O_3 output	ORP controller (mV); other status by contactors/ relays	ozone generator
oxidising reduction potential meter (ORP)	1	measure ions in water							monitor oxidising level (mV) for O_3 concentration indication	ORP controller	Ozone generator
ozone monitor			1	detect any ozone in water			2	stop main pump & O_3 generator and sound alarm	monitor ozone level in water	ozone monitor	pump & O_3 generator
flow meter	1	measure water flowrate in							measure water flowrate in main pipe	flow meter	nil

description	analogue input (AI)		digital input (DI)		Analogue output (AO)		digital output (DO)		purpose	sensing/ control device	equipment/ device being controlled
	points	Mode & Remark	points	Mode & Remark	Points	Mode & Remark	points	Mode & Remark			
		main pipe									
calorifier for pool heating	2	measure inlet and outlet temperature							monitor I/O temperatures and energy calculation	temperature sensors	heat source equipment
Heat pump for pool heating	2	measure inlet and outlet temperature							monitor I/O temperatures and energy calculation	temperature sensors	heat source equipment
Boiler for pool heating	2	measure inlet and outlet temperature							monitor I/O temperatures and energy calculation	temperature sensors	heat source equipment
Heat recover equipment for pool heating	2	measure inlet and outlet temperature							monitor I/O temperatures and energy calculation	temperature sensors	heat source equipment
flow meter for heating	1	measure flow rate for pool heating purpose							energy calculation	flow meter	nil
heat source equipment					1	to moderate heat source equipment	1	ON/OFF signal to heat source equipment	control and moderating heat source equipment	moderating device in heating source equipment	nil
pH and residual chlorine measurement	2	pH and residual Cl level							monitor & control pH & residual Cl	pH/Cl controller	NaOCl, HCL or NaOH dosing pumps with timer-set alarm
salt water level in brine saturator			1	DI for low level of salt water level					monitor salt water level	level sensor	electrochlorinator and brine pump, with timer-set alarm
water softener			2	ON/OFF status if available					monitor water softener operation	contactors/ relays	nil
brine pump			2	ON/OFF status			1	cut off pump in case of low salt water level; when NaOCl tank is full	monitor & control brine pump	contactors/ relays	brine pump
Electro-chlorinator			3	ON/OFF; fault status			1	cut off in case of brine pump stop; when H_2 content >1%	monitor NaOCl system operation on/off/fault	contactors/ relays	electrochlorinator and brine pump
NaOCl dosing pump			3	ON/OFF; Fault status			1	cut pump in case of tank low level; when residual Cl reach its preset value.	On/off control dosing pump	contactors/ relays	NaOCl dosing pump
HCL level			1	Low level alarm					monitor HCL level	level sensor	nil

description	analogue input (AI)		digital input (DI)		Analogue output (AO)		digital output (DO)		purpose	sensing/ control device	equipment/ device being controlled
	points	Mode & Remark	points	Mode & Remark	Points	Mode & Remark	points	Mode & Remark			
HCl dosing pump			3	ON/OFF; Fault status			1	cut pump in case of tank low level; when pH reach its preset value.	On/off control dosing pump	contactors/ relays	dosing pump
NaOH level			1	Low level alarm					monitor NaOH level	level sensor	nil
NaOH dosing pump			3	ON/OFF; Fault status			1	stop pump when NaOH level low; when pH reach its preset value	on/off control dosing pump	contactors/ relays	dosing pump
ozone leakage detector			3	3 levels leakage alarm depend on manufacturer product. To cut ozonator when leaking					monitor plant room if any ozone leakage	O_3 leakage detector	stops O_3 generator and sounds alarm
hydrogen detector			1	give alarm when H_2 level >1%; to cut electro chlorinator					monitor NaOCl tank room if H_2 present>1%	H_2 detector	stops electrochlorine generator and sounds alarm
pool water temperature	1	measure pool water temperature							modulate heating plant output	temperature sensor	heat source equipment
hydrogen blower			2	Operating / stop					monitor blower on/off & control	differential pressure switch	electrochlorinator
NaOCl tank level			3	high level to cut off brine pump; low level to give alarm; further low level to cut dosing pump					monitor level & control electrochlorinator & dosing pump	level sensors	electrochlorinator and dosing pump
backwash carbon tank			1	DI for differential pressure across carbon filter					open/close respective valves	differential pressure Switch	valves on/off
pump for footbath			3	ON / OFF / fault status			1	stop pump when main pump off	footbath shower curtain	contactors/ relays	pump
Pump Energy Consumption									Monitor pump energy consumption	Power analyser	
Water Pressure	1								Monitor pump pressure	Pressure sensor	Pump
Pump Vibration Frequency and velocity	2								Monitor pump vibration	Vibration sensor and vibration analyser	
Water colour	1								Monitor water colour	water colorimeter	

SUB-SECTION 15.1.8

ANCILLARY INSTALLATIONS

15.1.8.1 UNDERWATER LIGHTING INSTALLATIONS

Underwater lighting system shall comprise water proof and vandal proof light fittings, two-core submersible cables, watertight junction boxes with neoprene gaskets, conduit and accessories, separated extra-low voltage (SELV) power source with safety isolating transformer, rectifier and all necessary accessories, RCBOs, etc. as indicated on the Drawings and in compliance with BS 7671:2018+A1:2020. LED light fittings shall be used for underwater lighting. For competition pools, underwater lighting is installed at the longitudinal sides of the pools and never be placed in the centre of a racing lane at the end of pool to avoid glaring effect to racers.

The submersible light fittings shall be made of cast bronze or equivalent and complete with 12 V DC/ 24 V DC LED lamp bulbs (with two-core submersible cables). It shall be of IP 68, BS EN 60529:1992+A2:2013 and suitable for operation at the water depth as indicated on the Drawings. Light fittings shall be installed tilting upward at an angle about 10^{o} to the vertical. The whole light fitting shall be easily demountable in water for bringing up the fitting to deck surface for lamp replacement without draining off pool water. A flexible water tight conduit shall be provided connecting the light fitting with power supply system

The colour lens or fittings shall be made of cast tampered glass, convex and heat resistance. The lens shall be mounted on neoprene gaskets. The whole frame of the light fitting shall be smooth with no sharp corner. It shall be installed in recessed position.

Nominal output voltage of the SELV power source shall be 12 V / 24 V ripple-free DC to suit the LED lamp bulbs. The safety isolating transformer of the SELV power source shall be double-insulated, single phase, rated at appropriate kVA, housed in a metal enclosure. The primary winding and the secondary winding shall be so constructed that there is no possibility of any connection between the windings. The safety isolating transformers shall comply with IEC-61558-2-6 and tested by a recognised independent body. Each underwater light shall be connected by a single two-core submersible cable and supplied by a single SELV power source. The source for SELV (i.e. safety isolating transformer) is installed outside Zones 0, 1 and 2 in compliance with Code 26M(4)(a) of Code of Practice for the Electricity (Wiring) Regulations.

Exposed-conductive-parts of the SELV circuits shall not be connected to Earth, or to protective conductor or exposed-conductive-parts of another circuit. Circuit protective conductor connected to metallic enclosure(s) enclosing the safety isolating transformer is connected to earth. The primary winding of safety isolating transformer and the circuit connected to it shall be protected by RCBO having a rated residual operating current not exceeding 30mA. In case of any short circuit fault, the RCBO shall operate to trip the supply. No earth connection between the primary and secondary sides of the safety isolating transformer shall be made made. The earthing conductor of each underwater lighting, if any, shall not be connected to the primary side of the safety isolating transformer. The lowest insulation resistance measured between the primary and secondary sides of the safety isolating transformer shall not be less than 1 Mohm.

A 24-hour programmed timer switch shall be provided and serve to control the "ON" and "OFF" operation of the underwater lighting system. Also, an overriding facility shall be provided.

15.1.8.2 WATER TESTING EQUIPMENT

Water testing equipment shall be able to determine the chlorine residual and pH value of the pool water. The equipment shall be of portable type and suitable for field testing.

For residual free chlorine testing, plain Diethyl-p-phenylenediamine tablets and colour disc shall be provided. For pH value testing, phenol red solution and colour disc covering range of 6.8 - 8.4 shall be provided. The equipment shall be contained in a robust portable case suitable for carrying out field tests. At least 2 sets of testing equipment shall be provided.

15.1.8.3 PORTABLE POOL CLEANING EQUIPMENT

The cleaner shall be completely self-contained, with chassis & casing, removable filter, self-contained removable bag, pump & motor, mechanical drive system, control system, vacuum head, power cord, hand-held control box, etc. and operate without the need for piping connection.

The cleaner shall be of submersible type that can clean the bottom of pool without draining of any pool water, and perform cleaning by sucking up dirt and debris while roving both the bottoms and walls. It shall be fully automatic with driving wheels, and able to run in straight and parallel paths and in free-form-shape pool. It shall have the ability to avoid being caught when meeting obstacles, through the provisions and profiles of its wings, flaps & shoes, and operate quietly with constant and balanced water flow. The cleaner shall be complete with a cart for free moving between storage and pool. All materials of the cleaner shall be resistant to swimming pool water.

The removable filter shall be of cartridge type with porosity not greater than 20 microns, which could be cleaned with an ordinary hose. The pump motor shall operate on 220 V AC, 50 Hz, and the length of power supply cord shall be 31 m minimum. The type of power socket for connection shall be submitted to Supervising Officer before ordering. The cleaner shall be complete with a wireless remote control system such that it can move around in the pool by operating a hand-held control box.

15.1.8.4 ELECTRICAL INSTALLATIONS

15.1.8.4.1 General

(a) Unless otherwise specified, all low voltage electrical equipment necessary for the complete installations under the Contract shall be provided and installed. All necessary wiring from the points of power supply provided by others as indicated on the Drawings shall be carried out.

(b) All electrical work shall be carried out by registered electrical workers. Submit Work Completion Certificate in compliance with the Electricity Ordinance, Laws of Hong Kong.

(c) The accuracy of all installations, shop drawings and wiring diagram and for the correct internal wiring of all pre-wired equipment supplied under the Contract shall be verified.

(d) Unless otherwise specified, all electrical equipment, wiring and installation work shall comply with the relevant parts of this General Specification, Code of Practice for the Electricity (Wiring) Regulations issued by EMSD, BS 7671:2018+A1:2020, the Supply Rules of the electricity supply authority, and the respective recommended installation practices and standards of the equipment manufacturers. The Installations shall be to the satisfaction of the Supervising Officer.

(e) The supply voltage shall be 380 V three phase or 220 V single phase, 50 Hz, unless otherwise specified.

(f) The Clauses in this Sub-section related with control and metering shall be read in conjunction with the relevant parts of this General Specification on control and metering.

15.1.8.4.2 Cable Termination

The final termination of the power cables for main supply to the motor control cubicle and liaison with other relevant parties on sequence of works shall be included under the Works. All electrical Installations for equipment provided under the Works, commencing from the motor control cubicle, shall be supplied and installed, including cabling, switches, wiring, earth bonding, etc.

15.1.8.4.3 Equipment Sizing

All equipment and installations shall be sized with continuous ratings at the designed duties with minimum acceptable temperature rise.

15.1.8.4.4 Wiring in Conduit/Trunking

The electrical wiring shall be installed in trunking and conduit system and all conduits shall be concealed. Whenever possible, all wiring shall be grouped and laced together in a neat and tidy manner. Surface conduits/trunkings are acceptable only in plant rooms. All conduits for dangerous good stores, sodium mixed oxidant generation and storage rooms, ozone generator room and hydrochloric acid shall be concealed and shall be of galvanised steel metal conduits. Power and Control wiring shall be in separate conduits. All electrical Installations in rooms classified as Dangerous Goods Store shall comply with FSD requirements, whether shown on the Drawings or not.

15.1.8.4.5 Conduit

Both surface and concealed conduit system shall be galvanised steel conduits as specified in the relevant parts of this General Specification. Submit conduit run drawings for the electrical and control work to the Supervising Officer for approval before installations. All concealed conduit work shall be done in good time prior to concreting work in the corresponding area, and tie up with the overall programme. Check the building programme and ensure that all concealed conduit are installed prior to concreting.

15.1.8.4.6 Circuit Identification

For control and auxiliary circuit wiring in particular, different colours shall be provided to distinguish the various circuits. In any circumstances, all wires shall have at both ends a coded ferrule permanently marked with suitable characters and codes for identification purpose. Each connection shall terminate at an approved type of terminal block, which shall also be suitably labelled.

15.1.8.4.7 Wiring to Moving Parts

Wiring from the fixed part of the circuits within control panels, starter panels, etc. to the movable parts, such as hinged front plates of the panels, shall be grouped together in a proper manner and be enclosed in flexible PVC tubing strong enough for mechanical protection, and yet flexible enough that the hinged plates can be opened and closed with ease. The wiring from the fixed part to the movable part shall also be long enough to allow the hinged front covers to swing through at least 180 degrees from their normally closed positions.

15.1.8.4.8 Earthing

Proper earthing shall be provided for exposed conductive parts of all his equipment and equipotential bonding for all extraneous conductive parts thereof, as described in the relevant parts of this General Specification, the Code of Practice for the Electricity (Wiring) Regulations and so called for by the as BS 7671:2018+A1:2020, to the main earthing system of the electrical system. All metal parts of equipment provided within the swimming pool zone have to be bonded to the pool earthing grid system. All bonding wires shall be supplied and installed for connection to earth termination points near the equipment or within the zone to be bonded. Allow for and co-ordinate on exact location of termination points.

15.1.8.4.9 Conductive Moving Parts

All conductive moving parts such as hinged front doors of panels, battery and charger cabinets, etc. shall be properly and sufficiently earthed by suitably sized flexible insulated cables to the fixed conductive parts of the panels which are in turn electrically earthed as necessary.

15.1.8.4.10 Electrical Motor

(a) Adequate access to the motors and their associated facilities shall be allowed such that the necessary periodical testing, cleaning and maintenance can be carried out. The motors shall not be installed in a position where surrounding plant or building work may obstruct in meeting such requirements.

(b) Each electric motor, electric air heater battery or other electrical device which is controlled from the main control panel and is so situated that the panel is at a distance and/or out of sight from the equipment. shall be provided with a local "stop-lock" control circuit switch (where there is a separate control circuit), plus a local main power supply circuit isolator in all such cases.

(c) Exception for armoured cables, all other cables appearing above floor level shall be enclosed in approved trunking, solid or flexible conduit, with approved provision for movement of the motor. The terminal boxes for cable connection shall be suitably arranged to make a neat joint with the conduits or cables.

(d) The anti-condensation heater shall be controlled such that the heater shall be de-energised when the starter is switched on and vice versa. Heaters shall be wired from the motor control panel.

(e) Pulleys shall be correctly aligned and any holding down bolts or fixings shall be positioned to ensure correct alignment.

(f) Slide rails shall be provided for all motors driving through belts. Purpose-made adjusting devices shall be provided to adjust the belt tension and to secure the motors.

(g) The protective guards shall be rigidly constructed. It shall not be possible to remove any guard without the aid of a tool.

(h) Motor arranged for automatic restart shall have a label of durable material permanently fixed to it and in a prominent position clearly inscribed with the legend: -

DANGER: THIS MOTOR IS AUTOMATICALLY CONTROLLED AND MAY START WITHOUT WARNING. ISOLATE BEFORE INSPECTION.

A Chinese translation of the above shall also be provided on the same label.

15.1.8.4.11 Low Voltage Motor Switchgear, Starter and Control Panel

(a) General

Motor switchgear, starters and controls shall be supplied and installed to perform the operation and control of the swimming

pool circulation, filtration and disinfection equipment to be provided. The starters and controls shall be housed in wall-mounted local motor control panels, or floor-standing motor control switchboard as required. The control panels or switchboard shall incorporate all control devices, timers, accessories and wiring necessary for proper operation.

(b) Local Motor Control Panel

The local motor control panel shall be of wall-mounted type, unless otherwise specified, to house the motor starter and switchgear.

(c) Motor Control Switchboard

(i) The motor control switchboard (hereafter called the "Switchboard") shall be a free-standing floor-mounted low voltage switchboard to group centrally the motor starters, controls and switchgear for the swimming pool circulation, filtration and disinfection equipment, etc.

(ii) The switchboard shall be installed on a raised concrete "housekeeping" base provided by others. Precautions shall be taken to prevent damage or deterioration of panels during transit and to afford physical protection on site prior to final acceptance.

(iii) Unless otherwise specified in this Specification or the Particular Specification, the Switchboard shall comply with the requirements as stipulated in the relevant parts of this General Specification.

(iv) Automatic power factor correction capacitor

The capacitor bank shall be wall or floor mounting cubicle-type, built up from static primary capacitor unit. The capacitor bank together with its associated equipment shall not be installed inside the switchboard, where practicable. However, if it is not practical due to physical constraint or other justified reasons, the equipment shall be installed in a separate compartment segregated from the rest of the switchboard.

15.1.8.4.12 High Voltage Installations

All the high voltage electrical installation work shall be carried out by a Registered Electrical Contractor and Worker for Grade H electrical work as required by the Electricity Ordinance, (Cap. 406). After the completion of the electrical installation works, it shall be inspected, tested and certified by a Registered Electrical Worker to confirm that the requirements of the Electricity (Wiring) Regulations have been met. The Registered Electrical Worker and Registered Electrical Contractor shall

sign the Work Completion Certificate for the individual high voltage electrical installations and submit to the Supervising Officer before the electrical installations is energised.

15.1.8.5 COMPRESSED AIR SUPPLY AND BACKWASHING SYSTEM

The compressors shall be air-cooled rotary air compressor with pressure lubrication system and direct couple motor. The compressor shall provide compressed air for scouring the filter beds of sand filter prior to backwashing. The compressor shall deliver sufficient quantity of oil free compressed air scouring 1 filter bed at a time in each system. Number of compressors shall be as shown on the Drawings or Equipment Schedule. The compressor shall be fitted with delivery air pressure gauge, oil pressure gauge, suction filter and silencer, air-oil separator, oil heater and ancillary control accessories. The compressor motor shall be selected for non-overloading characteristic. The compressor shall be designed for quiet operation and if noise level exceeds the EPD's requirements, an acoustic enclosure shall be provided for housing each compressor.

The air compressor for the sand filter tank shall be sized to give 50 m/h per unit filter area of air flow through filter during backwashing of each filter.

The compressed air supply and backwashing system shall comprise of 2 air compressors, one duty and one standby. All interconnecting pipeworks and fittings, valves including commissioning valves, shut-off valves, flow switches, flexible connections, etc. to all filters, controls and interlocks, required for proper backwashing as specified shall be provided no matter shown on Drawings or not.

Backwashing system with necessary valves and drains to meet the system requirements shall be supplied and installed. The backwash operation of the sand filter shall be designed for both manual and automatic operation. The Installations shall allow for the filter backwashing activity to be carried out while the swimming pool water treatment system is in operation, i.e. one filter shall be put out of operation in the system. The carbon filter shall not be backwashed by ozone-containing water. A by-pass pipe from the sand filter discharge shall be provided for backwashing of carbon filter.

Backwashing water velocity of sand filter shall be in accordance with manufacturer's recommendation according to sand grain size and depth. The water velocity chosen shall be effective in cleaning the filter in duration of 7 minutes for sand filter excluding the air scouring time.

The air pressure safety valve on the air compressor shall be safety checked and sealed by a competent person. Certificate shall be issued by the competent person certifying that the operation of the safety valve are checked and sealed properly.

Motor, coupling and compressor shall be mounted on a common base plate supported on vibration isolation mountings.

A local control panel adjacent to the air compressor shall be provided such that the plant attendant can manually perform the air scouring operation. All control buttons shall be operated on 12 V/24 V DC.

15.1.8.6 LIFTING FACILITIES

All the equipment in the filtration plant rooms shall be checked and ensured to be well arranged and can be easily accessed for maintenance and operation.

If there is any equipment that cannot be easily removed for maintenance, eyebolts, lifting I-beams, chain hoists, access openings and other lifting facilities for use during servicing and maintenance of the installed equipment shall be proposed for approval by the Supervising Officer, as builder's works requirements will be carried out in the Building Part of this Contract. Sufficient maintenance lifting facilities shall be allowed in the builder's works requirements for proper servicing and maintenance of all equipment on Drawings so that they can be incorporated in the Building Part of this Contract at early stage of project. Access openings, maintenance and lifting facilities shall be provided with no additional cost if additional numbers of them are found required during acceptance of the installations by the Supervising Officer.

Electric driven lifting chain hoists for handling of salt bags for the sodium hypochlorite generation system and the mixed oxidant generation system shall be supplied and installed.

Electric driven lifting chain hoists for handling of large pump motors shall be supplied and installed.

Electric driven lifting facilities shall be supplied and installed to lift and transfer the automatic swimming pool cleaner from storage to pool and vice versa should it be over a certain weight beyond a single operator's lifting capability.

The lifting height of the hoists shall suit the site condition, loading limit of I-beams and eyebolts and weight of the equipment/chemicals. They will provide normal operating purpose such as maintenance, delivery and relocation of materials and equipment. I-beams and eyebolts will be provided in the Building Part of this Contract.

Chain hoists shall be selected and ordered so that they can be mounted on the I-beam installed. Details of hoists shall be submitted to Supervising Officer for approval before ordering.

The load chain shall be of malleable quality, electrically welded, pitched and of calibrated steel complying with BS EN 818-1:1996+A1:2008 and BS EN 818-7:2002+A1:2008 and proof tested to twice the safe working load specified for the hoist. Test certificate shall be submitted to the Supervising Officer.

The hooks shall comply fully with BS EN 1677-5:2001+A1:2008. They shall be able to rotate upon ball or roller bearings for ease of swivelling, and provided with a catch to prevent displacement of wire rope from the hook.

All moving parts of the hoist shall be greased or oiled after installations. Ball or roller bearings shall be packed with appropriate grease to the approval of the Supervising Officer.

Construction of the stoppers of the I-beams shall be ensured to be suitable to stop the trolley motion outside the working range.

A qualified surveyor shall be arranged to carry out the formal test under load conditions. The hoist shall be tested to a proof load of at least 125% of safe working load on site in the presence of the Supervising Officer or his Representative.

All the lifting requirements and access openings shall be submitted as builder's work drawings to be approved by the Supervising Officer.

15.1.8.7 SUPPORTING CHEMICAL TREATMENT

Chemical treatment, other than disinfection purpose, of the pool water shall comprise of dosing of aluminium sulphate (alum) to the raw water to form floc and dosing of hydrochloric acid (HCL) solution to correct alkalinity imparted to water by disinfectants and soda ash (NaOH) to correct the acidity. Centralised preparation and storage tanks shall be provided which shall be designed with a capacity to store for 16 to 24 hours of continuous operation for at least 4 days.

Each chemical dosing system shall have 2 tanks, each can be operated independently while the other is in service. Both tanks are connected and would be used together under normal situation.

The chemical tanks of dosing systems shall be used as combined preparation and storage type and shall be made from reinforced fibreglass or high-density polyethylene, or equal and approved. Each tank shall be complete with outlets, valves, overflows to drains and accessories. Level indication such as level glass tube shall also be provided for all tanks. For alum dosing system, stainless steel with rubber lining is also acceptable and each tank shall be complete with stainless steel dissolving tray and electric stirrers.

Pipings from make up tank shall be supplied and installed to provide water supply for the chemical tanks where required for the normal operation of the system.

Individual chemical metering pumps shall be provided to inject the chemical solutions into the filtration plant. The chemical dosing pumps shall be plastic diaphragm variable output type complete with totally enclosed fractional horsepower motor. The pumps shall also have facilities for manually adjusted stroke length from 30% to 100% and stroke rates. Starters for the chemical pumps shall be of the direct on line push button type with no volt release and magnetic overload protection. Each group of pumps for corresponding pool shall have 2 duty pumps and 1 standby pump, both having same characteristics, with selector switch enabling the choosing of any one of the pumps as the lead, lag or standby pump. Electrical supply and control facilities shall be such that all pumps can operate simultaneously under manual mode.

For alum system, 1 of the duty pump shall operate continuously when the carbon filters are in operation. The maximum dosing rate shall be 2.5 ppm of alum in main flow of water with 1 duty pump or as indicated in the Particular Specification. Initially, the stroke length shall be set to give 1 ppm of alum in main flow of water. The second duty pump is used to raise the alum level manually if required.

All level electrodes used for chemical dosing system shall be of corrosion resistant type suitable for submersing in the chemicals being used or measured.

Details of all equipment, pumps, tanks, controls and calculation shall be submitted to the

Supervising Officer for approval before ordering.

It shall be noted the HCL room is classified as Dangerous Goods stores. All equipment and devices installed in this room shall comply with FSD's requirements. All electrical equipment shall be of flammable proof and explosion proof type where required by FSD.

Clear and concise notices and instructions on the operation procedures for the chemical dosing system shall be posted besides the equipment of the systems. Warning notices shall also be posted to warn operators in handling the chemicals. The notices and instructions shall be made from permanent materials with easily reading characters in red, in both English and Chinese.

2 sets of safety gloves, face mask, goggle, footwear and 1 set of protective clothing shall be provided for handling of chemicals in each of the alum room and HCL room.

15.1.8.8 POOL HEATING

15.1.8.8.1 Pool Heating Equipment

Pool heating is provided by a combination of solar water heating system, heat pump, gas-heated boiler or an electric boiler or a heat rejection plant. Refer to the Particular Specification for the type of heating plant to be adopted. Pool heating equipment shall be interlocked with pool circulation system. When pool circulation system is stopped, pool heating system shall be stopped. Temperature of the hot water system shall be monitored.

15.1.8.8.2 Heat Exchanger

(a) In case when indirect heating is adopted, a plate type heat exchanger shall be used. Heat exchangers shall consist of most energy efficient metal plates pressed into a "Herring Bone" pattern and securely clamped between nitrile rubber gaskets by the pressure end plates of the steel framework. Plates shall be stainless steel or titanium for pool water. The plates shall be suspended from the top bar of the framework and located on the bottom guide bar. No part of the steel framework shall be in contact with the heat transfer fluids.

(b) Heat transfer plates shall be clamped by lateral bolts between a stationary frame plate and a movable pressure plate such that opening of the plate heat exchangers can be done without removing any connecting pipes.

(c) Heat exchanger shall be designed to give a high heat transfer efficiency to achieve close approach temperatures as low as 1°C.

(d) Heat exchanger frame shall be of mild steel and shall be suitable for bolting to a horizontal deck. The frames shall be arranged such that when the tie bars are loosened, full access to all plate surfaces is provided for cleaning and maintenance. The entire framework

and all parts of the units shall be factory treated to prevent corrosion such that the heat exchanger shall be capable of corrosive environment. All holding down bolts shall be of high tensile carbon steel with plastic tube protection. Each shall be equipped with bearing boxes and a locking washer enables the bolts to be opened from the fixed cover. No welded parts are allowed.

(e) Inlet and outlet ports shall be rubber lined or metal lined constructed on the fixed frame plate only.

(f) The heat transfer plates shall be corrugated pattern with thickness of 0.6 mm minimum, and pressing depth of about 3.20 mm with pressure rating a minimum of 1000 kPa or other rating to suit system design as specified. Maximum plate pack length shall not exceed 45% of the total framework length. Double gaskets shall be provided around the bypass port on each plate, with a drain hole between the gaskets to facilitate leak detection.

(g) Distribution area shall be "chocolate pattern" and the flow pattern shall be "counter-flow". Gasket shall be on every plate to eliminate inter-leakage between media.

(h) The heat exchanger units shall be pressure tested in the factory prior to delivery. The plate heat exchanger shall have a working pressure range of 1000 to 2500 kPa and shall be tested with a minimum pressure of 1500 to 3500 kPa for 24 hours suitable to the system design application as specified. Full certification of test results and guarantee for 5-year performance free from leakage by the manufacturer shall be provided.

(i) The heat exchanger for hot water application shall be properly insulated with optimum efficiency and robust insulation against heat loss. The insulation panels shall be of the double skin aluminium or stainless steel cladding with handles suitable for easy removal for plates access for inspection and maintenance.

(j) The Installations shall be in accordance with the manufacturer’s recommendations.

15.1.8.8.3 Thermal Insulation

Thermal insulation shall be applied to pool heating pipes and equipment. Thermal insulation types, properties, workmanship of insulation materials and finishes shall be as specified in the Particular Specification and relevant Clauses in Part 6 of this General Specification regarding thermal insulation.

15.1.8.8.4 Control Panel

A grade 316 stainless steel control panel shall be provided. The panel shall provide the monitoring of the operation of the heat provision system

including start & stop, indication of water flow rates and temperatures through both primary side and secondary side of the heat exchanger, and indication whenever an energy meter is specified of accumulative thermal energy being used.

SECTION 15.2

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 15.2.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

15.2.1.1 GENERAL

On top of the requirements stipulated in relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

15.2.1.2 TESTING AND COMMISSIONING SPECIALIST

The entire testing and commissioning procedure shall be undertaken by competent specialist staff of the contractor responsible for the Works or by a competent independent commissioning specialist engaged by the contractor responsible for the Works with the approval of the Supervising Officer.

Where specified in the Particular Specification, the competent independent specialist shall be engaged and for the approval by the Supervising Officer to conduct testing and commissioning work.

15.2.1.3 SAFETY, FUNCTIONAL AND PERFORMANCE TESTS

15.2.1.3.1 Electrical Tests

(a) Electrical Tests on Motor Control Switchboard

(i) The tests shall be carried out before and after connection of power supply. The tests shall follow the requirements as stipulated in the relevant parts of this General Specification for L.V. Cubicle Switchboard.

(ii) The tests to be carried out for the high voltage motor control switchboard shall strictly follow the tests as recommended by the equipment manufacturer.

(b) Electrical Tests on Motors

(i) Required Tests

- check motor nameplate voltage;

- check motor rotation and speed, prior to connection of the driven equipment;

- ascertain maximum kW absorbed by pump at the most demanding point of the pressure/volume characteristic curve at the specified pump speed;

- check the earth continuity loop resistance for every motor starter;

- check the insulation to earth resistance for every motor starter taken with 500 V insulation resistance tester;

- test the full load current taken by all motors on each phase;

- test the tripping time of starter overloads set to 10% above the motor nameplate rating;

- test the function of each control unit in accordance with the specification (e.g. selector switches correctly wired, high or low circuit cut-out operates, level switches correctly operating);

- check motor temperature in accordance with BS EN 60034-1:2014 as applicable; and

- check starting current of each motor.

(ii) Type Tests

Type tests and abbreviated tests shall meet the requirements of IEC 60072-1:1991, IEC 60072-2:1990 and IEC 60072-3:1994. The Supervising Officer has the discretion to agree or accept type-test results for performance in place of individual unit tests but these will not be accepted in place of practical on site, pressure, insulation, resistance tests which shall still be carried out on individual units.

(iii) Contractor's Responsibility

Approval of test certificates shall not absolve the contractor carrying out the Works from providing motors capable of driving the various items of plant under the conditions of loading stated in the contract.

15.2.1.3.2 Filling Water Systems And Venting

(a) Testing of Tanks

All water tanks shall, after erection, be filled with water and shall remain filled for at least 24 hours during which all joints shall be carefully examined. Any defect shall be rectified immediately and the test repeated.

(b) Flushing of Water Systems

Before finally charging, the water systems shall be thoroughly flushed and all strainers, filters, etc. cleaned or replaced.

(c) General Procedure

The water systems shall be properly charged with water (which shall be treated where specified). The filling process shall be from the bottom of the system upwards. Careful examination shall be conducted to the state of valves and air vents before and during filling to avoid air locks and excessive spillage.

When the whole system is filled, the source shall be disconnected, permanent supply shall be opened and the tank levels shall be adjusted.

15.2.1.3.3 Hydraulic Testing For Water Distribution Pipework Systems

(a) General

All water distribution pipework systems shall be hydraulically tested in sections as installation work progresses and before thermal insulation if any is applied.

(b) Test Pressure

The hydraulic test pressure shall be one and a half times the total working pressure.

(c) Precautions

Before hydraulic tests are carried out, all safety valves, gauges, etc. shall be effectively isolated or removed. This safety equipment shall be effectively tested at their design working pressure during commissioning of the installations.

(d) Method of Testing

For a satisfactory and acceptable test, the pressure shall be maintained for a period of 24 hours or as otherwise stated in the Particular Specification, without loss of pressure after all weak joints, defective fittings and pipes disclosed by the initial

application of the test are rectified. During the final testing period the Supervising Officer or his Representative shall be invited to witness the tests. All sections of the work under test shall be accessible for inspection and selected welds shall be hammer tested.

(e) Hydraulic Test Certificates

Certificates of all hydraulic tests made on Site shall be forwarded to the Supervising Officer for approval and such approval shall be obtained before any thermal insulation if any is applied. A separate and duplicated set of installations/shop drawings shall be provided for the purpose of keeping accurate record of site tests. 1 copy will be kept by the Supervising Officer or his Representative on Site.

(f) Details on Test Certificate

A blank test certificate form shall be submitted for Supervising Officer's approval prior to carrying out the actual test on Site.

All test certificates shall be signed by authorised site representative and by the Supervising Officer or his Representative who has witnessed the test. All test certificates shall contain the following particulars: -

(i) date of test;

(ii) apparatus or section under test;

(iii) makers number (if any);

(iv) nature, duration and conditions of test;

(v) result of test;

(vi) name of Contractor's representative (in block letter) in charge of test; and

(vii) name of Supervising Officer or his Representative who witness the test.

15.2.1.3.4 Testing And Commissioning For Ozone Generation System

(a) Ozone Generating Module

(i) check the cleanliness of the dielectric glass tube;

(ii) check the cleanliness of the electrode;

(iii) check the cleanliness of the stainless steel liner tube;

(iv) check the O-ring for spacer, glass tube & liner tube;

(v) check ozone generating module leakage; and

(vi) check any leakage of pipework.

(b) Drying System

(i) check the solenoid valve diaphragm;

(ii) check the function of the air blower;

(iii) check the cleanliness of the air filter; and

(iv) check the proper adjustment of the cam timer and micro-switch.

(c) Air Supply System

(i) check the proper adjustment of the air flow rate; and

(ii) functional test for the air flow switch.

(d) Cooling Water System

(i) check the proper adjustment of the water flow rate;

(ii) check the solenoid valve diaphragm; and

(iii) check the proper adjustment of the water flow temperatures.

(e) Dew Point Monitoring

(i) check the proper adjustment of the dew point monitor p.c. board; and

(ii) check the cleanliness of the dew point sensor.

(f) Pipework & Accessories

(i) check the leakage of any pipework;

(ii) check all the strainers; and

(iii) check all the valves.

(g) Electrical Equipment

(i) check the tightness of the main power switch;

(ii) check the tightness of all wire terminals;

(iii) check the function of all the indication lamps;

(iv) check the tightness of the wiring of motorised variable transformer;

(v) check the tightness of the high tension transformers; and

(vi) check the function of all safety devices.

(h) Testing

check the proper function of the whole system.

(i) Control Panel

(i) general check for the panel;

(ii) check & test the power supply;

(iii) check & test the section control circuits;

(iv) check the tightness of the wiring terminals;

(v) check & test the induction lamps;

(vi) check the function of the cooling fans;

(vii) check the cleanliness of the panel;

(viii) check the control fuse or MCB;

(ix) check the function of the emergency stop;

(x) check the function of the meters; and

(xi) functional test for the panel.

15.2.1.3.5 Testing And Commissioning For Ultra-Violet Disinfection System

(a) General

(i) ensure the chamber is free from damage;

(ii) check that the cabinet is located satisfactory with respect to operation and safety;

(iii) remove all quartz ware and check for damage; and

(iv) earth continuity checks on system components.

(b) UV Chamber

(i) with the system in operation, ensure that water passes through the chamber

(ii) check the water system for leaks;

(iii) check that the water is flowing in the right direction;

(iv) check that bleed valves are fitted correctly; and

(v) record voltage and current when UV lamp is at full power.

(c) Automatic Wiper System

(i) check that the wipe cycle programme is in accordance with the specified requirements;

(ii) check that the limit switches are in the correct linear position;

(iii) check that the limit switches are correctly wired;

(iv) check that the motor is correctly wired;

(v) check that the wiper flap is the correct distance from the monitor probe tip;

(vi) check that all safety guards are in place; and

(vii) when in operation ensure all wiper features respond correctly.

(d) Control & Monitoring

(i) check that all interconnecting wiring is satisfactory;

(ii) check that the temperature thermostat/sensor is correctly wired and positioned;

(iii) check that system settings are correct; and

(iv) carry out functional check on Control Cabinet and ensure it performs satisfactorily.

15.2.1.3.6 Testing And Commissioning For Mixed Oxidant Disinfection System

Commission and test the system shall be done in compliance with the manufacturer's recommendation.

The testing and commissioning procedure are to be submitted to the Supervising Officer prior to the commencement of commissioning and

testing.

Provide all necessary tools, equipment and labour for testing and commissioning of the system.

Measurements such as production rate of mixed oxidant with average concentration shall be taken.

15.2.1.4 PEAK LOAD WATER QUALITY TEST

In addition to the testing of the function and performance of the system, peak load water quality test on a hot sunny day after the system has been put into operation for 3 to 6 months shall be carried out. The exact testing time and period shall be as instructed by the Supervising Officer. During the test, all key parameters of the filtration, disinfection and chemical dosing plant shall be measured.

The peak load water quality test shall include a chemical distribution test in pools and micro-organism test in pools. In the chemical distribution test, water samples at every grid points at a pre-determined depth of pools for a pre-determined grid system (approximately 3 – 4 m grid) which covers the whole surface area of all pools shall be taken as agreed with Supervising Officer. The water samples shall be tested for pH values and residual chlorine concentration. In the micro-organism test, water samples at 3 pre-determined locations for each pool shall be taken as agreed with Supervising Officer and carry out laboratory tests on micro-organism check such as presence of amoebae, E-coli, Psedudomonas, Legionellas, bacteria count and other disease described in all relevant bylaws and regulations made under Swimming Pools Regulation Cap 132CA and water quality requirements posted in Leisure and Cultural Services Department (LCSD)'s official website.

SUB-SECTION 15.2.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

15.2.2.1 GENERAL

On top of the requirements stipulated in relevant Parts of this General Specification, the Installations and Works during Maintenance Period shall also comply with the specific requirements in this Sub-section.

Operation, servicing and maintenance of the Installations, if specified, shall also refer to the equipment manufacturer's recommendations and specifications.

15.2.2.2 TRAINING REQUIREMENT

2 training courses shall be provided for the Employer's staff on the working principles, operation and maintenance of the whole water circulation, filtration and disinfection system and other auxiliary systems. One training course will be aimed for operational staff and/or maintenance staff which covers detailed operational procedures and steps and precautions. Training notes/manuals are required in both English and Chinese. The second training course will be aimed for management staff and/or non-technical staff which covers brief description of the system and precautions e.g. response during alarm. At least 5 seats shall be given to the Employer's staff for each training course. Training Venue shall be on site or provided by the Employer.

All queries raised by the operational staff during initial stage of operation shall be answered. A qualified engineer shall be sent to site to inspect and to answer any query raised by the operational and maintenance staff if they cannot be dealt with or solved over telephone.

15.2.2.3 COMPETENT TECHNICIAN TEAM

During the Maintenance Period, a team of competent technicians shall be provided to station on site for a period of 1 month, who will carry out daily operation of the whole water circulation, filtration and disinfection system, maintenance, testing and commissioning of the installations. At the same time, the team shall give thorough instruction and demonstration to the swimming pool operation staff on the operation and maintenance of the Installations. All activities shall be recorded in the log book.

15.2.2.4 REPLACEMENT OF SPARE PARTS

At the expiry of Maintenance Period, all consumable parts shall be replaced. Parts with operation life longer than the Maintenance Period need not be replaced.

PART 16 – MECHANICAL INSTALLATION

SECTION 16.1

TECHNICAL REQUIREMENTS

SUB-SECTION 16.1.1

GENERAL

16.1.1.1 GENERAL REQUIREMENTS

The equipment shall be new and of up-to-date model (but in general with proven type not less than 2 years) manufactured for a nominal serviceable life of 15 years. In general, the mechanical and electrical equipment shall be so manufactured as not to require frequent maintenance attention.

All the equipment and material supplied shall be proven products which shall have local agents or representatives.

All items of equipment shall be rated for continuous service at the specified duties under the prevailing atmosphere and operational conditions on-site.

16.1.1.2 INTERFACE WITH CCMS

The works shall include providing contacts or wired/wireless network connection or through IoT technology to allow remote monitoring of essential signal or sensor readings which specified in the Contract or in this Section to be monitored by Central Control & Monitoring System (CCMS) or other central montoring system. The remote monitoring signals shall be compatible with BACnet or other suitable communication protocol for connecting to the CCMS or other monitoring system.

SUB-SECTION 16.1.2

STEAM BOILERS

16.1.2.1 DESIGN

16.1.2.1.1 General

The design of steam boiler and associated accessories shall be included under the Works.

The steam boiler shall be constructed to EN12953 or Pressure Equipment Directive (PED) 2014/68/EU for a maximum working pressure of 800 kPa gauge and tested to 1200 kPa gauge at the manufacturer's works unless otherwise specified in the Particular Specification. Manufacturer's test certificate in quadruplicate is required. The boiler shall be of the genuine 3-pass wet back, radiant heat type with a combustion chamber concentric with the horizontal cylindrical shell and complete with a purpose made fully automatic burner. Non 3-pass boilers are not acceptable and reverse flame is counted as one pass only.

Cradles or footings shall be arranged so that no distortion of the boiler shell and footings will take place due to thermal expansion or any static or dynamic loads.

The boiler shall have front tube removal facilities and shall not be supplied with swinging back door. Inspection door shall, however, be fitted at the back of each boiler. Boilers that required a space in the boiler room for fire tube removal larger than available shall not be accepted. Connections shall be flanged to BS EN 1515-1:2000, BS EN 1092-1:2018, BS EN 1092-2:1997, BS EN 1092-3:2003 or equivalent national/international standards as appropriate.

16.1.2.1.2 Boiler Rating

The boiler rating shall be as given in the Particular Specification. The overall thermal efficiency to BS 845-1:1987 & 845-2:1987 or EN 12953-11 of the boiler shall not be less than 90% fired by the specified fuel over the whole operating range.

16.1.2.1.3 Boiler Controls

Each boiler shall be equipped with a full set of automatic controls in accordance with the requirements of the Boilers and Pressure Vessels Ordinance and the following protection controls: -

(a) Extra Low Water Level Cut-out Protection

It, a second and indepedent low water level cut-out, shall be set to cut off the burner fuel supply when the boiler water level drops below the heating surfaces of the fire tubes and shall activate an

audible and visual alarm. Control shall be of the lockout type with manual reset. Each boiler shall have its own alarm display. The operating principle shall be different from the High & Low Water Level Control so as to enhance the degree of safety.

(b) Overpressure Cut-out Protection

It shall be set to cut off the burner fuel supply when the steam pressure rises to 10% below the safety valves operating pressure (i.e. 90% of safety valve pressure setting) and shall activate an audible and visual alarm. Control shall be of the lockout type with manual reset. Each boiler shall have its own alarm display.

(c) Automatic Firing Controls

The burner firing shall be controlled by steam pressure transducers with capability of 30% adjustment above the nominal working pressure. The firing of the burner shall be fully automatic and of either the high/low/off type or the modulating type depending on the rating of the boiler. The automatic firing controls shall comprise auto sequence controller, pre-purge and post-purge timer units, flame establishment unit, ignition transformer, burner motor starter with adjustable overload protection, photo-electric flame-failure device, burner run indicator, audible and visual lockout alarm with manual reset, high/low fire indicator (for high/low/off type burner only), automatic draught regulator, and ON/OFF switch gear with indication lamp.

(d) High and Low Water Level Control

A high and low water level control with alarm shall be fitted with sequencing blow down valves and lockable steam isolating valves. Alternative direct mounted internal controls incorporating a testing device may be fitted on boilers up to 2250 kg/hr steam output if this is the boiler manufacturer's standard arrangement. The foregoing boiler controls shall be housed in a local control panel on each boiler, together with steam/pressure gauge and thermometer, mounted as an integral part of the boiler package. The control panel shall be mounted on the boiler in such a manner as to be completely free of vibration, heat and moisture, and to preclude damage to contactors and electronic devices. All controls shall be configured to fail-safe.

(e) Total Dissolved Solid (TDS) control

It shall be set to blowdown the steam boiler automatically when the TDS is at a high level. This control shall be interlinked with the blowdown valve so as to achieve an automatic blowdown at a regular interval. The burner should be shut down if the TDS value exceeds the maximum limit as suggested by boiler manufacturer.

16.1.2.1.4 Boiler Insulation

The cylindrical boiler shell shall be efficiently insulated with mineral wool mattresses of minimum 100 mm thick wound closely to the shell and enclosed in a galvanised sheet steel casing of sufficient rigidity with suitable top coating. Thermal bridging should be avoided in the design. The touch temperature of the boiler anywhere shall not be higher than 60°C.

16.1.2.1.5 Boiler Accessories

Each boiler shall be provided with the following accessories suitable for the working pressures and temperatures stated: -

(a) Auto Blow-down valve – the hydraulic gradient of pipeline is continuously decreasing and trapping of water is avoided;

(b) Boiler main stop check valve;

(c) Double safety valves shall be of the enclosed spring type with padlock and discharge pipe;

(d) Steam pressure gauge of industrial and bourdon type, with 200 mm diameter dial, level gauge cock and fixed red pointer indicating the normal working pressure of the boiler;

(e) Boiler feed pump, check valve, controls and necessary piping;

(f) Two water level gauge glass with length not less than 200mm (independent of any water level control);

(g) A high and low water level control (refer to the clause on Boiler Controls for details);

(h) Fully automatic burner and controls (refer to the clause on Boiler Controls for details);

(i) Local control panel and protection (refer to clause on Boiler Control for details);

(j) A drip tray with sand for each oil burner (if applicable);

(k) Combustion chamber, tubes, flue cleaning tools;

(l) Boiler water sampling valve & fittings and chemical dosing equipment as specified in the relevant part of this General Specification;

(m) Air vent with Globe or shut-off device shall be fitted at the highest point of the boiler to release air trapped inside the steam portion of boiler during flash-up and to prevent creation of vacuum during shut-down; and

(n) Manual operated parallel slide blowdown valve.

All mountings for controls and instrument shall be so fitted as to permit ready replacement without emptying the boiler. All controls and instrument shall be so chosen that the operating range lies between 40-70% of the full scale range, calibrated in S.I. Units and accurate to within 5% of the controlling or measuring point.

16.1.2.1.6 Boiler Instrumentation

The following instruments shall be mounted on a self-contained central boiler control panel common to all boilers with all necessary connecting pipes, cables and sensing elements associated with the instruments for monitoring boiler performance. Instruments provided shall be suitable for continuous use at their respective operating temperatures and pressures. All scale shall be so chosen that the operating range lies between 40-75% of the full scale range and accurate to within 5% of the readings.

The instruments/sensors shall be able to communicate with the boiler control and CCMS through IoT (Internet-of-Things) and/or wire/wireless Ethernet and internet technology for remote monitoring. The function for remote data access and remote monitoring shall be provided under the works.

(a) Smoke Density Meter

When specified in the Particular Specification or requested under the latest requirements of the Air Pollution Control Ordinance (Cap.311), in each boiler flue, between the boiler and the first expansion joint as indicated in the Drawings, a double-path type smoke density detector of the approved manufacture shall be fitted to monitor the smoke density leaving each boiler. Appropriate tubes shall be installed diametrically opposed for mounting a light source monitoring unit. Both tubes should be readily accessible for cleaning. The detector shall be wired in conduit to the smoke density meter on the boiler control panel. A smoke density meter shall be provided for each boiler together with indication lights and audible alarm.

Each meter shall be calibrated to energise a green light when operating at normal smoke density and a red light and audible alarm when smoke density exceeds Ringelmann(s) number 1 to BS 2742:2009 "Notes on the Use of the Ringelmann and Miniature Smoke Charts". In addition, the smoke density meter shall be installed with self-cleaning facilities by means of blowing of air.

(b) Draught Gauge

Each boiler shall be provided with a draught gauge to be mounted at a suitable location on boiler flue for measuring draught at boiler flue outlet.

(c) Flue Gas Temperature Indicator

One for each boiler and of the thermal-electric type for indicating the flue gas temperature at each boiler exit shall be provided.

(d) Steam Supply Pressure Indicator

One set for each boiler shall be provided. Each with its pressure tapping installed at the steam flow riser of each individual boiler.

(e) Steam Mass Flow Integrating Meter

One set for each boiler shall be provided. Each shall consist of an orifice plate or equivalent sensor installed at the steam flow riser of each boiler and a signalled to an integrating device (with compensation for steam density variations) at the central boiler control panel to give steam delivered in kilograms with at least 6 digits display.

(f) One Ambient Temperature Indicator

(g) One Digital Timer

(h) Flowmeter

(i) Multiple Flue Gas Analysing Meter

Access panel shall be allowed at boiler exhaust and provide at least one set of combustible multi-gas detection instrument with at least carbon monoxide, carbon dioxide and oxygen as the selected gases to analyse and adjust the combustion efficiency, particularly air/fuel ratio, for enhancement of combutsion efficiency and facilitating continuous-commissioning. When specified in the Particular Specification, the adjustment shall be implemented by an oxygen and carbon monoxide combustion trim system to EN 12064, EN 60730, EN 1634, EN 298 to measure the oxygen level of combustion and continuously adjust the air to fuel ratio to a minimum oxygen value to ensure stoichiometric combustion at highest possible efficiency at the boundary of arising carbon monoxide.

(j) One temperature alarm sensor at discharge outlet of blowdown tank

16.1.2.1.7 Burner

Burner shall be diesel oil fired, gas fired or dual fuel as specified in the Particular Specification.

Rating shall match with the maximum output of the boiler and with efficiency compatible to the stated boiler overall thermal efficiency over

the whole range of firing.

Level of smoke, dust and grit emission shall meet with the latest requirements of the Air Pollution Control Ordinance (Cap.311).

16.1.2.1.8 Diesel Oil Burner

The burner shall be constructed to BS 5410-2:2013 or BS EN 267 for boilers firing with light diesel oil to BS EN 590:2013 class A2. It shall be force draught, of the pressure jet type with suitable automatic air/fuel ratio control to achieve maximum fuel economy throughout the entire operating range of the equipment served. Firing sequence controls shall be fully automatic with appropriate safety timers and controls for pre-purge, post-purge, ignition, flame establishment to BS EN 303-1:1999 and 303-4:1999. Flame detector shall be of the photo-electric type. Failure of the safety timers or malfunction of the burner shall cause fuel shut-off and lock-out. Lock-out shall be manual reset and shall have audible-visual alarm. A burner 'normal' indicator shall also be incorporated. The diesel oil pump shall be of the positive displacement type, have built-in pressure relief, oil pressure adjustment, inlet strainer, oil meter in litres, necessary valves and fittings.

Burner motor shall be rated at 380 V/3-ph./50 ±2% Hz, of insulation class F to BS 4999-141:2004 + A1:2010, type of protection IP54 to IEC 60947-1:2014 or equivalent, with motor starter having low volt release, adjustable thermal overload protection and manual re-setting facilities.

16.1.2.1.9 Towngas Burner

The towngas pipe distribution system will be provided by others up to the plugged point left for the burner as shown on the Drawings. A registered gas contractor shall be engaged to make connection of the burner to the plugged point including all necessary isolating valve, gas booster, gas pressure regulating & safety devices, gas pipe, valve train, fittings, supports, etc. for a complete installation.

The towngas installation including testing and commissioning shall be carried out by an approved competent personnel employed by the registered gas contractor selected from the list of Registered Gas Contractors of relevant class under the Gas Safety Ordinance, Cap. 51.

The connection work shall be carried out in accordance with the Code of Practice for Installation of Pipe and Meters for Towngas (Hong Kong). Upon completion the registered gas contractor shall be responsible for testing his section of gas pipework for leakage and setting to work of the burner in conjunction with and in the presence of the Gas Supply Company or its authorised representative.

The followings are typical properties and composition of towngas produced in Tai Po Gas Production Plant for reference: -

Typical Chemical Composition of Gas

- Carbon Dioxide (CO_2) : 16.3 – 19.9%
- Carbon Monoxide (CO) : 1.0 – 3.1%
- Methane (CH_4) : 28.2 – 30.7%
- Hydrogen (H_2) : 46.3 – 51.8%
- Air ($N_2 + O_2$) : 0 – 3.3%

Wobbe Index

- (MSC dry) MJ/m^3 - 24

Figures for pressure mentioned are gauge values unless otherwise specified.

16.1.2.1.10 Supply Pressure

The supply pressure of the town gas shall be 7.5 kPa (30" W.G.) unless otherwise specified in the Particular Specification.

The burner and equipment installed shall be suitable to work on the above towngas supply. Close coordination shall be maintained with the Gas Supply Company and the registered gas contractor so as to ensure that the meter, the associated controls and installation pipes will provide a complete gas fuel service for his supplied equipment.

16.1.2.1.11 Gas Burner System

The burner shall be manufactured to BS EN 676:2003 or BS 5885-1:1988 "Specification for industrial gas burners of input rating 60 kW and above" or Gas Appliances Regulation (EU/2016/426). The burner shall be fully automatic with modulating air/fuel control, fail safe and fool proof.

Each gas burner system shall be provided with a quick acting manual isolating valve upstream followed by a gas booster or compressor with its protection devices, governor, safety shut-off valves system, gas modulating butterfly valve, combustion air blower & modulating air damper for multi-stage burner and all accessories & control suitable for use with towngas and complying also with the regulations and requirements of the Gas Supply Company.

The main gas and start-gas supplies shall be under the control of constant pressure governor(s) to BS EN 88-1:2011 or BS EN 16129:2013 or Gas Appliances Regulation (EU/2016/426) as appropriate. All flow setting restrictors shall be downstream of the governor.

The safety shut-off system shall comply with BS EN 676:2003 or BS 5885-1:1988: Clause 4.6 or Gas Appliances Regulation (EU/2016/426). The main gas safety shut-off valve system shall be of the double block type including suitable system check or proving systems to the requirements in BS ISO 10770-1:2009 or Gas Appliances Regulation (EU/2016/426).

To facilitate commissioning and testing of the safety system, a manual valve downstream of the main gas safety shut-off valves to isolate the main gas flow other than the start-gas flow shall be provided.

A sequence controller and all necessary timers, relays, contactors, wirings, flame detectors, sensors and switches for temperatures, pressures, positions and flow shall be provided to effect all the pre-start system checks or proving for safety shut-off valves, combustion air and air/fuel ratio; the safety timers for pre-purge, post-purge, start-gas flame and main flame establishment; and the safety shut-down and lock-out for supply gas over pressure, gas booster/compressor inlet low pressure, air flow failure, loss of pilot flame or main flame, electric power failure, failures of the system checks or proving or safety timers, and other system faults all in accordance with BS EN 676:2003 or BS 5885-1:1988 or Gas Appliances Regulation (EU/2016/426).

Control, wring and electrical components shall comply with BS EN 676:2003 and Clause 6 and 8 of BS 5885-1:1988 or Gas Appliances Regulation (EU/2016/426). Audible and visual indications shall be provided for individual fault conditions and lock-out to enable easy fault diagnosis. The combustion air blower motor shall be suitable for operation on 380 V, 3 phase, 4 wire, 50 ±2% Hz, of insulation Class F to BS 4999-141:2004 + A1:2010, and with type of protection IP54 to BS EN 60947-1:2004, or equivalent. Motor starter shall have low volt release, adjustable thermal overload protection, phase failure protection and having manual re-setting facilities. There shall be earthing continuity throughout the gas pipework.

The air/ fuel ratio control for two or multi-stage burner shall be fully modulating with the air damper and the butterfly gas flow valve linked pneumatically, electrically or mechanically. The air/ fuel ratio system shall be set to minimise the risk of off-ratio firing and maximise the combustion efficiency with concentration of CO from the multi-gas detector at boiler exhaust. Suitable pressure or temperature transducers shall be provided with the firing modulating control to give maximum efficiency of the equipment served throughout its entire operating range.

16.1.2.1.12 Gas Boosters and Compressors

Gas boosters or compressors are required for the equipment serviced when the specified gas supply pressure is insufficient for the burners supplied.

The pressure delivered shall be stable without any surging throughout the whole operating range of gas flow rates. Provision shall be made in the pipework for any oil carry-over that may occur.

Booster & compressor motors shall be suitable for operation on 380 V, 3 phase, 4 wire, 50 ±2% Hz, of insulation class F to BS 4999-141:2004 + A1:2010, and with type of protection IP44 to BS EN 60947-1:2004. Star-delta starters shall be used for boosters and compressor motors and shall

comply with BS EN 1906:2012 and shall have low volt release, adjustable thermal overload protection, phase failure protection and having manual re-setting facilities.

Boosters and compressors shall run continuously as long as the equipment served is on demand and sufficient cooling shall be provided. They should not start and stop in conjunction with thermostatic burner control as this increases wear and tear on motors and drives and can cause frequent pressure fluctuations in the gas supply. Overheat thermistor protection or equivalent shall be incorporated in the motors.

Suitable control and protective devices shall be fitted with each gas booster or compressor to prevent pressure fluctuations in the supply mains and any other inconvenience or danger to other users. The control & protective devices shall include those specified in the following clauses where appropriate.

A low pressure cut-off switch shall be impulsed from the booster or compressors gas supply inlet and suitably wired to prevent the booster or compressor causing a reduced or negative pressure at the meter and in the gas supply system. The wiring of this switch shall cause safety shut-down and lock-out of the burner system in the event of reduced gas supply pressure.

The relief valve shall be set to operate at not more than the maximum allowable working pressure and not less than 110% of the rated discharge pressure.

Provision shall be incorporated for a positive displacement compressor to prevent depression in the gas supply during the compressor starts up.

16.1.2.1.13 Purge and Leakage Test

The gas pipework on the complete burner assembly shall be subjected to a leakage test under an air or inert gas pressure of at least 1.5 times the maximum stated working pressure, or 4 kPa, whichever is the greater. The leakage rates shall not exceed 25 mm^3/s of air equivalent under metric standard reference conditions for a burner of up to 300 kW. An additional leakage rate of 1 mm^3/s is permitted for each 20 kW above 300 kW.

Metal armoured flexible pipes shall be certified to withstand at least 3 times the working pressure with a minimum of 350 kPa at both maximum and minimum service temperature.

Means such as a valved and plugged small bore off-take shall be provided to purge and commission the burner pipework and controls. During any purging operation, gas shall not be allowed to accumulate in a confined space. Electric switches shall not be operated and no smoking or naked lights shall be permitted in the vicinity.

16.1.2.1.14 Requirements on Dual Fuel Burners

In addition to the requirements for gas flow pipework and controls in BS EN 676:2003 and BS 5885-1:1988, the dual fuel burners when operating on light diesel oil (BS EN 590:2013 Class A2) shall comply with BS EN 298:2012, BS 799-3:1981, 4:1991 and BS 5410-2:2013 and BS 5410-3:1976, and the British Gas Publication No. 1M/7 "Code of Practice for large gas and dual fuel burners" or BS EN 267 and or Gas Appliances Regulation (EU/2016/426).

The dual fuel burner shall be fully automatic with modulating control of air/fuel ratios on either towngas or light diesel oil. The burner shall be capable of switch-over to either fuel without burner shut-down. It is essential that the fuel not being fired to be proven isolated prior to the commencement of the ignition sequence. The burner system shall also ensure that failure of this proof of isolation at any time causes safety shut-down followed by lock-out. The dual fuel burner shall have separate safety shut-off systems and indications for each fuel. When a fault condition occurs on one of the two fuels, start-up on that fuel shall be prevented and the fault condition would be indicated.

It is acceptable to have a common air system for both fuels provided that the modulating air/fuel control can be automatically adjusted to maintain a good combustion to the specified efficiency and performance throughout the whole operating range of the burner.

16.1.2.1.15 Water Softening/Demineralisation and Deaeration for Condensate/Feed Tank and Make-up Water

(a) Water Softener/Demineraliser

Make-up water from a water break cistern shall be softened and demineralised through an ion exchange resin filtering equipment before passing into the condensate/feed tank. The ion exchange resin filtering equipment shall be of a packaged type with twin resin columns, automatic regeneration associated controls, water T.D.S. meter, valves, piping, pumps and chemicals for regeneration.

(b) Deaerator

A deaerator shall be provided to remove dissolved gases such as oxygen and carbon dioxide from the make-up water before its flowing to the condensate/feed tank.

The water break cistern shall be galvanised, constructed to BS 417-2:1987 or equivalent with cover and of capacity not less than 50 litres. The cistern shall be installed with necessary supports at high level so that the make-up water can flow by gravity through the water softener/demineraliser and deaerator to the condensate/feed tank. A make-up water integrating flow meter shall be installed in the treated water outlet pipe at an accessible position.

16.1.2.1.16 Chemical Dosing and Boiler Water Sampling Equipment

Chemical for initial start up shall include dosage for prevention of water scaling and corrosion. A nitrite-borate-organic non-toxic corrosion inhibitor or as recommended by boiler manufacturer shall be used for this application.

Individual chemical dosing and water sampling equipment shall be provided for each steam boiler.

The chemical dosing equipment shall comprise a chemical injection pump, a mixing tank, necessary controls and pipework. The chemical injection pump shall be of either the reciprocating or diaphragm type, capable of metering adjustments up to 100 litre/hr. and controlled by an adjustable timer up to 24 hours. The pump shall be manufactured from stainless steel or other non-corrodible materials. Chemicals shall be injected direct to each boiler through stainless steel tubings, check valve & diffuser. The mixing tank shall not be less than 100 litre capacity fitted with a gauge glass, drain, supports, and mechanical agitation.

Boiler water sampling device, complying with ISO 5667-7:1993 and BS 6068-6.7:1994 shall be provided for each boiler. The device shall consist of a small closed cylinder fed with cold mains water in which is immersed a stainless-steel coil. The coil shall be connected to the water space of each boiler by means of a valved connection not less than 10 mm size. The jacket of the sampling device shall have a 15 mm size valved cold-water inlet and a 15 mm size drain line carried to waste.

Field-test kit shall be provided in the chemical dosing package including portable pH meter, TDS meter, corrosion inhibitors ppm test kit, etc.

The boiler system water shall be treated to comply with the following requirements or to BS EN 12953-10:2003 and as recommended by boiler maufacturer: -

(a) pH value : 10 – 12

(b) Total alkalinity (as $CaCO_3$) : 300 - 700 ppm

(c) Total hardness (as $CaCO_3$) : below 10 ppm

(d) Total dissolved solids : below 2000 ppm or equivalent
Conductivity : below 3000 µS/cm

(e) Iron, increment : below 1.0 ppm

(f) Copper, increment : below 0.2 ppm

(g) Chlorides (Cl) : below 300 ppm

(h) Sulfite (Na_2SO_3) : 40 – 100 ppm

(i) Phosphate (PO_4): 30 – 70 ppm

Suitable quantities of chemical shall be provided for the purpose of testing and commissioning.

16.1.2.1.17 Pressure Reducing Valves

Each pressure reducing valve set shall be duplicated for standby purpose and shall comprise the following: -

(a) Steam Separator

(b) Parallel Slide Valve

(c) Strainer

(d) Pressure Reducing Valve

(e) Pressure Gauge and Cock

(f) Relief Valve

(g) 25 mm Plugged Branch

Each set shall be preceded by a steam separator installed in the common high pressure steam main, upstream of the reducing valve set.

16.1.2.1.18 Steam Trap Assemblies

All condensate connections from steam equipment shall be provided with steam trap. Steam traps shall be capable of handling the full volume of condensate discharged from the equipment, when starting from cold.

Each trap set shall be preceded by a dirt pocket and shall comprise: -

(a) Globe Valve

(b) Strainer

(c) Spira-tec or functionally equivalent Trap Failure Sensor Chamber complete with Blanking Plug

(d) Float Operated Steam Trap

(e) Sight Glass

(f) Check Valve

(g) Gate Valve

(h) All Unions

All steam trap assemblies which are not readily accessible, e.g. ceiling voids shall be provided with a remote test point complete with cable and sensor wired to the trap.

16.1.2.1.19 Blowdown tank

Blowdown tank shall be provided to collect and cool down the blowdown water from the boiler. The size of blowdown tank shall be selected in accordance to the boiler pressure, number of boilers, duration of blowdown and blowdown regime etc. Piping connecting the boiler and blowdown tank shall not be epoxy coated to avoid any blockage of pipework by coating peel off.

Blowdown tank shall be connected by a cooling water system which shall be equipped with an automatic thermostatically controlled device to inject cooling water into the blowdown tank in case if the water temperature inside exceeds the system set point.

The discharge temperature of blowdown tank shall not exceed 43ºC in any cause. A temperature sensor shall be installed at the discharge outlet of blowdown tank to trigger the alarm when the discharge temperature exceeds the requirement.

16.1.2.1.20 Economiser

Boilers powered by gas shall be equipped with an integrated economiser or a separate condensing economising unit, to recover sensible heat and/or latent heat present in the flue gas. The overall efficiency of the boiler with an economiser shall be at least 90%.

Any condensate generated from the economiser shall have lower pH and shall undergo suitable treatment before discharge. The flue gas after the economiser will have property of generate further low pH condensate while passing though chimney. A high corrosion resisted material shall be selected for the chimney.

16.1.2.2 EQUIPMENT AND MATERIAL

16.1.2.2.1 Pipework Materials

All pipework fittings, accessories, joints and joining media used shall be suitable for the substance conveying in the pipes and shall not deteriorate due to chemical or atmospheric action.

All pipework, fittings and valves must be suitable for the system test pressure.

Valves and fittings joints for steam pipes shall be with pressure rating of PN25 or above.

Gaskets used at steam main, steam header and major steam pipe shall be spiral wound gaskets.

Pipework materials for the various services shall comply with the following: -

(a) Steam

Steam supply pipe up to and including 50 mm dia.	Seamless steel pipe to BS EN 10216-2:2013 with carbon content less than 0.3% fittings to BS EN 10242:1995 and BS 143 & BS 1256:2000.
Steam supply pipe above 50 mm and up to 150 mm dia.	Seamless steel pipe to BS EN 10216-2:2013 with carbon content less than 0.3% with flanged joint to BS EN 1092-1:2018 and BS EN 1092-2:1997.
Condensate return pipe	Steel pipe to BS EN 10255:2004 heavy grade with malleable iron fittings to BS EN 10242:1995 and BS 143 & BS 1256:2000.

(b) Hot and Cold Water

Hot water supply pipe up to and including 65 mm dia.	Copper pipes to BS EN 1057:2006 + A1:2010 Table X and non-dezincificable compression type fittings to BS EN 1254-2:2021.
Hot water supply pipe above 65 mm and up to 150 mm dia.	Copper pipes to BS EN 1057:2006 + A1:2010 Table X and flanged fittings.
Cold water supply pipe	Copper pipes to BS EN 1057:2006 + A1:2010 Table X and fittings to BS EN 1254-2:2021 (up to 65 mm dia.) and BS EN 1254-1,2,4,5:2021 Flanged compression type fittings for sizes above 65 mm dia.

(c) Compressed Air System

Compressed air pipe up to and including 150 mm dia.	Galvanised steel pipe to BS EN 10255:2004 heavy grade with malleable iron pipe fittings to BS 143 & 1256:2000, BS EN 10242:1995 (up to 50 mm dia.). Galvanised flanged fittings for 65 mm dia. and above.

16.1.2.2.2 Valves Materials

(a) Steam – General Isolating

50 NB & below	Bronze Globe Valve	BS 5154:1991
65 NB & above	Cast Steel Parallel Slide	BS EN 1984: 2010

(b) Steam – for Connection to Equipment

50 NB & below	Bronze Globe Valve	BS 5154:1991
65 NB & above	Cast Steel Parallel Slide	BS EN 1984: 2010

(c) Condensate – General Isolation

50 NB & below	Bronze Globe Valve	BS 5154:1991

(d) Condensate – HWS Check Valves

50 NB & below	Bronze Globe	BS 5154:1991
65 NB & above	Cast Iron Check	BS EN 12334: 2001

(e) Drain Valves

50 NB & below	Bronze drain valve	with hose union ends and loose key

Safety and relief valves shall be suitable for the operating conditions of the systems and as required by ISO 4126-1:2013 and the relevant International Standards for pressure vessels to which they are connected unless otherwise indicated. They shall be of the totally enclosed spring-loaded type with padlocks. Safety valves and relief valves shall have a full-bore discharge connection and where any low point occurs in the discharge run it shall be fitted with a 15 mm size waste pipe carried clear of the insulation for drainage. The discharge and waste pipes shall be run to visible safe position.

16.1.2.2.3 Pressure Reducing Valves

Pressure reducing (P.R.) valves up to 50 mm size shall have bronze or malleable iron bodies and may have taper screwed ends. Valves 65 mm size and over shall have cast-iron bodies with end flanged. Flanges for bronze and iron valves shall comply with BS EN 1092-2:1997; bronze valves table 16/21, cast iron valve tables 6/11, 10/11, and 16/11 and malleable iron valves tables 6/12 and 16/12, each according to the maximum working pressure.

Valves for reducing the steam-pressure shall be of an approved spring-loaded relay operated type. The valve seats and discs shall be of nickel-

alloy or stainless steel and shall be renewable. Each valve shall be capable of maintaining a reduced outlet gauge pressure within ±34 mbar of the set pressure and shall be installed with an excess pressure isolating protection valve on the low pressure side.

16.1.2.2.4 Steam Trap Assemblies

Ball float type steam traps, shall be suitable for operation at the line pressure on which it is installed, to facilitate drainage of condensate from the steam equipment.

Thermodynamic steam traps will NOT be accepted.

16.1.2.2.5 Strainer

Strainer shall be Y type with stainless steel screen to BS EN 10048:1997 and cast iron body. It shall be suitable for operating temperature up to 250ºC on the steam and condensate pipeline.

16.1.2.2.6 Sight Glasses

Sight glasses shall be of the double window type toughened glass with SG iron body suitable for operating temperature up to 200ºC on the condensate pipeline.

16.1.2.2.7 Pressure and Temperature Gauges

Pressure gauges fitted to equipment and pipework shall comply with BS EN 837-1:1998 but shall have dials calibrated both in kPa from zero to not less than 1.3 times and not more than twice the operating pressure.

Where fitted on pressure vessels, the gauges shall be as required by ISO 4126-1:2013 with dials not less than 150 mm diameter and with cases of polished brass or chromium-plated mild steel.

Where fitted elsewhere, the dials of gauges shall not be less than 100 mm diameter and the cases shall be of polished brass or chromium-plated mild steel.

Gauges used solely to indicate the altitude or head and pressure of water shall have dials not less than 100mm diameter, calibrated both in kPa and meters head. In addition, they shall be provided with an adjustable red pointer set to indicate the normal working pressure or head of the system. The cases shall be as for the 100 mm diameter pressure gauges as specified above. Gauges shall be fitted with lever handle cocks.

Temperature gauges shall be suitable for 1.5 times the working pressure of the system.

Temperature gauges shall be insertion type complete with a stainless steel pocket/immersion type for pipe entry. Sensor pocket shall be filled with suitable liquid.

Temperature gauges shall have scales properly selected for the system with adjustable red pointer.

16.1.2.2.8 Insulating Material

Insulation for pipes shall be rigid glass or mineral fibre preformed sections finished with 0.8 mm thick hammered aluminium sheeting and all joints overlapped and secured with pop rivets.

Insulation for flanges and valves shall be hammered aluminium removable boxes lined with insulation to same specification as for pipework and fixed with quick release clips.

The maximum moisture absorption shall not be greater than 0.2% by volume.

All insulating, finishing and painting materials shall be selected from types suitable for the surfaces to which they are applied and for the environmental conditions in each area.

No asbestos based insulation shall be used.

All equipment and materials used shall be fire resistant and comply with the requirements of the National Fire Protection Association (NFPA) and the FSD.

The minimum thickness of insulation and 'K' value shall be applied to services as follows: -

(a) Steam

Service	Thickness (mm)	"K" Value (W/mK)
15 mm - 40 mm bore	32	0.035
50 mm - 65 mm bore	38	0.035
80 mm bore	44	0.035
100 mm - 150 mm bore	63	0.035
200 mm - 300 mm bore	75	0.035

(b) Condensate, LPHW Heating Hot Water Service (HWS)

Service	Thickness (mm)	"K" Value (W/mK)
15 mm - 20 mm bore	25	0.035
25 mm - 80 mm bore	32	0.035
100 mm bore	38	0.035
125 mm - 200 mm bore	44	0.035
250 mm and above	63	0.035

16.1.2.2.9 Condensate Return Pump and Receiver

The condensate return pump shall be of ogden automatic pump or vertical centrifugal pump or product having equivalent functions or performance with compatible capacity to cope with the complete steam system. The condensate return pump shall be capable of transferring the condensate collected from the steam traps to the steam boiler room condensate/feed tank through various piping for which gravity return of condensate is impossible.

The body and cover of the pump shall be made of cast iron with gunmetal check valves, mild steel float and non-ferrous working parts. The mild steel receiver of suitable capacity shall be incorporated with suitable overflow and vent pipe. The pump operating pressure shall not be less than the steam mains supply pressure. A pump counter which counts the strokes of the pump is also required for calculating the quantity of condensate handled.

16.1.2.2.10 Condensate/Feed Tank and Make-up Water Demineralising

The condensate/feed tank shall be made of stainless steel.

The mixing tank of the chemical dosing system shall be constructed of heavy-duty polyethylene.

Materials used for towngas service riser and pipes at pressure exceeding 7.5 kPa but not exceeding 200 kPa shall comply with the following requirements where appropriate: -

- BS EN 10255:2004: Steel tubes and tubular (heavy) suitable for screwing to BS 21:1985 pipe threads.

- BS EN 1092-2:1997: Flanges and bolting for pipes, valves and fittings.

- BS 21:1985: Pipe threads for tubes and fittings where pressure tight joints are made on the threads. (metric dimensions)

- BS EN 10242:1995, BS 143 & 1256:2000: Malleable cast iron and cast copper alloy screwed pipe fittings for steam, air, water, gas and oil.

- ISO 4145:1986, BS EN 10241:2000: Wrought steel pipe fitting. (screwed BSP thread).

- BS 1552:1995: Open Bottomed Taper Plug Valves for 1st, 2nd and 3rd Family Gases up to 200 mbar.

- BS 6956:1988: Jointing materials and compounds for water, low pressure steam installations, 1st, 2nd and 3rd family gases.

- BS 3063:1965: Specification for Dimensions of gaskets for pipe flanges.

- BS EN 1514:1997: Dimensions of Gaskets for pipe flanges-Dimensions of non-metallic gaskets for pressure up to 64 bar to BS EN 1092-1:2018 and BS EN 1092-2:1997.

All materials used for gas installation pipes and fittings at pressure not exceeding 7.5 kPa should comply with the requirements of the Standards listed below and any relevant International Standards, in addition to those stated above where appropriate. Where no such standard exists, materials used should be as specified by the Gas Supply Company.

- BS EN 1057:2006 + A1:2010: Copper and copper alloys tubes.

- BS EN 12449:2012: Copper and copper alloys. Seamless, round tubes for general purposes.

- BS EN ISO 9453:2014: Soft solders.

- BS EN 1254-2:2021: Capillary and compression tube fittings of copper and copper alloy.

- BS EN 1254-1:2021 & BS EN 1254-2:2021 Part 2 Metric units.

- BS EN 10312:2002: Light gauge stainless steel tubes.

- BS 61:1969: Threads for light gauge copper tubes and fittings.

- BS 7786:2006: Unsintered PTFE tape for thread sealing applications.

16.1.2.2.11 Pressure Gauge for Use with Towngas

Pressure gauges of the approved type shall be installed across the gas booster or compressor and governor to read the gas static pressure. Accessories such as valves, cocks, tubing, fittings, protective casings, and supports shall be provided for a complete installation. Pressure gauges provided shall be suitable for continuous use at their respective operating temperatures and pressures. All reading scale shall be so chosen that the operation range lies between 40-75% of full-scale range and shall be calibrated in S.I. units with accuracy to within 5% of the readings. All mountings shall be so fitted as to permit ready replacement without venting the gas line.

16.1.2.2.12 Towngas Meter

A Towngas meter of the approved type shall be installed for each burner to measure the Towngas consumption of the burner. The meter shall be suitable for use with the local Towngas supply and conform to the Gas Supply Company's standard. Units of the totaliser shall be in Mega Joules. The meter shall be accurate to the nearest Mega Joule or better.

The meter shall be installed at an easily accessible position.

16.1.2.2.13 Fusible Plug

For boiler provided with fusible plug as an optional safety device to protect the steam boiler against overheating, the alloy shall be designed to melt between 227ºC to 232ºC.

16.1.2.3 ERECTION AND INSTALLATION

16.1.2.3.1 General

The maximum room length available, allowing for fire tube withdrawal from front of boiler, shall be as indicated in the Drawings.

The boiler shall be properly levelled and installed on its concrete plinth to ensure it is in a horizontal position.

Thermal expansion slot for bolts joining the boiler and concrete plinth shall be provided.

16.1.2.3.2 Gas Boosters and Compressor for Towngas Burner

Boosters and compressors shall be installed in well-ventilated locations. The location should be clean, dry, and accessible for maintenance and sited near to the equipment being served thus minimising the length of pipework operating at the higher pressures.

16.1.2.3.3 Towngas Pipe Connection

Suitable anti-vibration mounting shall be used to reduce noise and vibration. Both the inlet and outlet connections shall incorporate a suitable length of flexible metallic tube to eliminate strain on the booster or compressor and to minimise the transmission of vibrations. Connecting pipework shall be adequately supported independently of the booster or compressor. Where the pipework diameter differs from the connections to the booster or compressor properly provided taper pieces or concentric reducers shall be inserted as close to the unit as is practicable to prevent turbulence.

All the control and protective devices specified that are fitted on the inlet of the booster or compressor shall be fitted between the inlet gas isolating valve and the booster or compressor. No other shut-off valve shall be fitted in the pipework between the machine and its inlet isolating valve. The pressure delivered shall be stable without any surging at all operating gas flow rates.

16.1.2.3.4 Control for Towngas Connection

A non-return valve of the approved type shall be installed between a compressor inlet and the low pressure cut-off switch and capable of

withstanding a back pressure equal to the maximum compressor discharge pressure.

A suitable relief valve capable of by-passing the full rated output shall be fitted immediately around a positive displacement compressor to relieve excess gas pressure from the outlet to the inlet to maintain a constant outlet pressure.

A resonator shall be installed on the inlet of a reciprocating compressor to damp down pressure fluctuations.

Where gas is supplied to a gas compressor or compressor type mixer, notices similar to the following should be affixed with suitable Chinese translation to be approved by the Supervising Officer: -

(a) Near the meter inlet valve

氣體警告

啟動任何氣體壓縮機或燃氣發動機之前，燃氣表進氣閥必須完全打開，並且在任何此類設備運行時不得關閉或部分關閉，否則會損壞儀表和設備。

WARNING
GAS

The gas meter inlet valves must be fully opened before starting any gas compressor or gas engine and must not be shut or partially closed while any such plant is in operation, otherwise meter and plant will be damaged.

(b) Near the gas compressor and compressor type mixer

氣體警告

啟動此氣體壓縮機之前，請務必查看儀表進氣閥是否打開，否則會損壞儀表。

WARNING
GAS

Before starting this gas compressor always see that the meter inlet valves are open, otherwise the meter will be damaged.

(c) On the installation

Notices shall be displayed to indicate the presence of gas at high pressure.

16.1.2.3.5 Pipework

All pipeworks including the pipe material, fixing, fittings, welding, supports, valves, drain, vent and overflow pipe unless otherwise specified

above in this section shall be installed in accordance with the Part on Plumbling Installation of this General Specification.

16.1.2.3.6 Pressure and Temperature Gauges

Pressure gauges shall be fitted with lever handle cocks and, where appropriate, siphon pipes or snubber.

16.1.2.3.7 Valves and Cocks

All valves shall be installed with the valve stems truly vertical or horizontal.

Where flanged valves, etc. are specified, details of flanges shall correspond to the appropriate specification. Valve flanges and counter flanges shall be to the same standard.

16.1.2.3.8 Labelling of Valves

Every valve shall be supplied with a plastic sandwich (traffolyte) disc engraved or stamped with the valve reference number and secured to the valve with stainless steel chain.

Valve labels shall be a minimum of 50 mm diameter.

Valve reference numbering system shall be agreed with the Supervising Officer before construction.

A schematic diagram of the system shall be provided and fixed at suitable locations to indicate the reference numbers, type and purpose of the valves. The diagram shall be fade-proof and mounted in a polished hardwood frame with glazed front. Position shall be agreed with the Supervising Officer. Dye line prints will not be accepted.

16.1.2.3.9 Insulation

Pipework insulation shall be deemed to include all open vents, cold feeds, valves, flanges, fittings, heat exchangers, equipment items whether specifically mentioned or not.

The installation and material of the thermal insulation for pipe/duct unless otherwise specified in this Section shall comply with the Part of Air-conditioning, Refrigeration and Mechanical Ventilation Installation of this General Specification.

SUB-SECTION 16.1.3

MILD STEEL CHIMNEY

16.1.3.1 DESIGN

16.1.3.1.1 General

The design of mild steel chimney and associated accessories shall be included under the Works.

The chimney shall be suitable for the rated capacity of flue gases discharging from the firing equipment mentioned in the Particular Specification. The chimney stack shall be connected to the firing equipment e.g. boiler or incinerator.

The chimney shall be capable to cater for part-load operation without cold-air inversion.

Flue gas sampling connections to 'USEPA Reference Method 5' shall be provided in accordance with the Air Pollution Control Ordinance (Cap. 311). "Cone" shape exit nozzle shall be provided to the chimney, where applicable, so that the flue gas efflux velocity can meet with the requirements of the EPD at all loading conditions. Flue gas ejector shall be included if necessary. Flue gas temperature shall be higher than the acid dew point even at part-load.

Explosion doors, soot removal door, expansion joints, dampers and other accessories shall be provided to the flue gas system according to design conditions.

As the chimney effect (pressure difference) will likely affect the performance of the chimney, the calculation of the chimney effect, in mm of water gauge, taking the average temperature of the flue gas and air temperature outside the chimney shall be submitted for the approval of the Supervising Officer. The overall construction of the chimney shall be favourable for all atmospheric conditions. Attention shall be drawn in determining the size and location of the explosion doors and soot removal doors so that the difference between the local static pressure inside the chimney and the atmospheric pressure shall not cause a suction force to blow the outside air back into the plant room through these doors.

The calculations, shop drawings and other relevant information shall be submitted to the Director of Environmental Protection for approval in accordance with the Air Pollution control (Furnaces, Ovens and Chimneys) (Installation and Alteration) Regulations. This shall be done immediately after the Acceptance of Tender in view of the time required by the Director of Environmental Protection in processing the application prior to commencing the site installation work.

The design life of the chimney stack and supporting structures shall be 20 years.

Suitable expansion bellows or compensators shall be installed to diffuse the stresses caused by thermal expansion. The chimney shall be supported by suitable sliding or roller supports to allow for longitudinal and vertical movement due to thermal expansion. Supports for exposed portions of chimney shall be secure enough to withstand the strongest wind loadings in Hong Kong.

The stability of the chimney in respect of its dead weight and wind loading shall be considered in accordance with BS EN 1993-3-2:2006 and the Code of Practice on Wind Effects in Hong Kong 2019.

Appropriate maintenance platform and access to top of the chimney shall be provided for inspection and servicing works.

Provisions shall be made to prevent ingress of rainwater into the combustion chamber through the chimney. Rain caps or cowls shall not be used at the chimney top.

For multiple-firing equipment sharing a common chimney system, a flue gas exit damper with a heat resistant limit switch shall be provided at each flue connection so that the burner will not be energised unless the damper is fully open.

BS EN 1993-3-2:2006 shall be followed, wherever applicable, for requirement of corrosion protections of chimney stacks.

16.1.3.1.2 Exterior Insulation

The chimney shall be properly insulated to maintain the flue gas temperature above 150ºC throughout the entire length of the stack during normal operation at all loading levels to prevent acid condensation and smutting.

16.1.3.2 EQUIPMENT AND MATERIAL

The chimney connections and supports shall be of mild steel grade 43 to BS EN 10029:2010 and to BS 4-1:2005 and BS 7668:2016 for dimensions.

The minimum thickness of steelwork fabricating the brackets and supports shall be as tabulated below: -

Type of Steelwork	Minimum Thickness	Working Environment
Hot rolled sections	8 mm	exposed to weather
	6 mm	not exposed to weather

Hollow sections sealed at end	4 mm	exposed to weather
	3 mm	not exposed to weather
Angle flanges	6 mm	--

The interior and the exterior surfaces of the steel chimney shall be protected with one coat of primer, which shall be of pure silicone resin to provide protection to surfaces subject to temperature between 260°C to 600°C, and provided on chimney stacks. The dry film thickness (DFT) per coat shall not be less than 2.0 mm. The recommended heat resistant coating shall be a self-priming and a two-coat application system good for both interior and exterior of any chimney stacks. Heat resistant aluminium coatings shall be used. The finish coating may be of the same paint as the primer as said above.

16.1.3.2.1 Interior Lining

The interior lining of the chimney stack, where applicable, shall be castable refractory or firebrick in accordance with BS EN 1993-3-2:2006.

16.1.3.2.2 Exterior Insulation

All thermal insulation, including fixings shall comply with BS 5970:2012, BS 5422:2009 and ISO 12241:2008. All surface finishes shall comply with BS 476-7:1997 Class 0 surface spread of flame.

Insulation shall be mineral wool of approved quality, suitable for use up to 300ºC and having a thermal conductivity of not greater than 0.06 W/mºC. The thickness of insulation shall be properly selected for personal protection.

All materials of the same type shall be supplied by a single manufacturer to ensure uniformity of standards and appearance.

Before ordering any painting materials, the type and manufacture of all materials shall be submitted to the Supervising Officer for approval.

All insulating, finishing and painting materials shall be suitable for the surfaces to which they are applied and for the environmental conditions in each area.

No asbestos based insulation shall be used.

All equipment and materials used shall be fire resistant and shall comply with the requirements of the National Fire Protection Association (NFPA) and the FSD.

16.1.3.3 ERECTION AND INSTALLATION

The work shall inlcude supply and install anchor bolts, nuts and lock nuts for the chimney. Grouting shall be carried out by Building Contractor.

The chimney shall be fabricated and installed with all supports, brackets, anchors and ancillary components in accordance with BS EN 1993-3-2-2006: Eurocode 3. Design of steel structures. Towers, masts and chimneys-Chimneys, and as specified in the design. Connection shall suit the firing equipment offered.

The vertical riser shall be installed in sections of about three meters to allow the removal of a section at any time without the necessity for extensive dismantling of the flue system. All joints shall be flanged with high-temperature gaskets. Horizontal sections shall be installed with a rising slope towards the vertical riser and shall be connected to the vertical section in an angled bend of 30 deg. to 60 deg. normal to the riser to allow for proper flue gas flow.

Immediately before applying any protective treatment to all the exterior or the interior surface of the steel chimney, the surface shall be cleaned by chipping, scraping and wire brushing to removal all dirt, loose scale, grease or rust and shall be abrasively blasted to a minimum near White Grade.

16.1.3.3.1 Application of Interior Lining

Immediately before applying refractory lining, the interior surface of the steel chimney shell shall be cleaned and freed from loose rust and scale by wire brushing and painted as per Part 1 of this General Specification.

16.1.3.3.2 Exterior Insulation

The mineral wool shall be covered with 1.6 mm thick hammered aluminium cladding. The cladding sheets shall overlap each other to prevent water ingress into the insulation.

The erection and installation of the thermal insulation for chimney unless otherwise specified in this Section shall comply with the Part of Air-conditioning, Refrigeration and Mechanical Ventilation Installation of this General Specification.

16.1.3.3.3 Lightning Protection

Suitable protection against lightning, in accordance with the recommendations of the relevant clause of BS EN/IEC 62305:2011 shall be provided for the chimney.

16.1.3.3.4 Welding

All welding shall be carried out only by experienced welders with recognised certificate of proficiency, and to the satisfaction of the Supervising Officer or his Representative. The welding electrodes equipment and process shall also be subject to the Supervising Officer's approval and in accordance with the relevant International Standards.

Upon the Supervising Officer's request, the quality of the welder's work shall be demonstrated in accordance with BS 4872-1:1982, BS EN 287 or BS EN 288.

When visual tests on completed work indicate that the quality of welding could be below specification, the Supervising Officer or his Representative shall be entitled to have the welds examined by means of non-destructive tests (NDT) for acceptability at no additional cost to the Employer.

Welding shall not be carried out under unfavourable weather conditions.

16.1.3.3.5 Verticality of the Chimney

The verticality of the chimney shall be checked by optical tooling method. The recommended instruments used for surveying shall include the alignment telescope or jig alignment telescope, jig transit and precise level. These three instruments shall be self-checking and can be tested quickly and adjusted exactly.

16.1.3.4 PARTICULAR REQUIREMENTS ON INSPECTION AND TESTING

The Supervising Officer or his Representative shall be notified and site inspections be arranged for the Supervising Officer or his Representative during the following four stages of works: -

(a) Complete fabrication of the chimney stack in manufacturer's works (prior to delivery to site);

(b) Complete erection, painting but prior to application of thermal insulation materials;

(c) Complete insulation but prior to fitting protective cladding; and

(d) Complete protective cladding but prior to removal of scaffolding.

When the firing equipment is at steady full-load conditions, measurement of the gas temperatures and velocities at the entry and the exit of the chimney stack shall be arranged to verify the performance criteria are fulfilled.

SUB-SECTION 16.1.4

CRANE AND HOIST

16.1.4.1 DESIGN

16.1.4.1.1 Crane

(a) General

The design of crane, hoist and associated accessories shall be included under the Works.

The crane shall be manufactured in accordance with BS EN 13001-1:2015 and BS EN 13001-2:2014 and the electrically operated cranes shall also be in accordance with ISO 4301-1:1986. For the crane and mechanism as a whole, the class of Utilisation, Stage of Loading and Group Classification shall be in accordance with BS EN 13001-1:2015 and BS EN 13001-2:2014 and ISO 4301-1: 1986.

The crane shall either be of a double-girder construction with the crab travelling on the girder rails, or a single-girder construction with the hoist hanging onto the girder. The girder(s) complete with end plates shall withstand maximum lateral and vertical stresses and be within the permissible deflection ratio in accordance with ISO 4301-1:1986.

The crane bridge shall be carried on end carriages of ample size to carry the rated load when lifted at one end of the crane bridge. The end carriages shall be fabricated, welded and stiffened internally throughout their length to produce a box section of high torsional resistance and shall be of approved type.

The track wheel, reduction gear and motor shall be combined to form one assembly. The end carriages shall enable the track wheels to be withdrawn or mounted readily. The wheelbase of an end carriage shall be not less than 1/7 of the crane span.

The electric overhead travelling cranes shall be carried on four roller-bearing double-flanged wheels mounted on steel axles driven by two geared motors simultaneously. The end carriage front plates shall be fitted with resilient buffers to absorb the shock in case of collision with the end stops of the gantry rails. The end carriages of the cranes shall give at least 100 mm clearance from the nearest structure during operation.

The universal beams complete with gantry rails shall be manufactured in accordance with ISO 4301-1:1986. The beams shall be secured onto the steel brackets or reinforced concrete corbel provided by the Building Contractor with spans as shown

on the design. The gantry rails shall be complete with end stoppers and limit switches at the extreme ends of travel. Access to the crane shall be by ladder with necessary safety hoop to be installed at a corner of the building.

The capacity of the drum shall be sufficient for the height of lift designed. The hoist drum shall be accurately machined to contain the hoist rope in a single layer. The drum shall have flanges at both ends and the flanges shall not project less than two rope diameters above the rope. No fewer than two and a half dead turns shall remain on the drum at each anchored end at the lower limit of hoisting. The drum shall accommodate one further turn of rope at the upper limit of hoisting. Rope guides and hardened pressure ring/rollers shall be provided to ensure correct rope reeving during operation.

The crane structures, motor frames and metal cases of all electrical equipment shall be effectively bonded to earth.

(b) Gearbox

The gearbox shall be of rigid construction and comprise of an oil-immersed multi-reduction gear train totally enclosed in a cast housing. High-speed gears shall be of helical teeth configuration. Each geared shaft assembly shall be supported on ball or roller bearings.

The gearbox shall be manufactured so that the gears which they enclose will be automatically lubricated at all operating speeds. The box shall prevent escape or contamination of the lubricant and breathing shall be provided.

Where oil replacement is necessary, facilities for filling, drainage and means of indicating clearly the correct level shall be provided. Gearing shall comply with BS 436-5:1997, BS 545:1982 and BS 721-2:1983 as applicable. Lifting lug(s) shall be provided for the gearbox where deemed necessary.

(c) Brakes

(i) Automatic spring held brakes shall be provided for all drives. Release of brakes shall be by electromagnetic means and of fail-safe operation. The brakes shall be applied smoothly and automatically without snatching when the power supply to the driving motor is cut off and the braking torque shall be at least 200% of the full load torque of the motor;

(ii) Where more than one motor is used to control motion in any direction each motor shall have an individual brake with its release coil energised from the supply to that motor. Brakes with more than one shoe shall be self-

centering such that wear of the brake linings is evenly distributed between shoes. Means shall be provided for adjusting the brakes to compensate for wear on the linings. Long travel (downshop) and cross travel brakes may either be integral with each driving motor or be separated drum brakes;

(iii) Hoist brake shall incorporate mechanical or hydraulic manual release facilities. Hoist motor with integral brakes shall incorporate manual release devices for use during maintenance; and

(iv) Electromagnetic release coils shall be continuous rating and shall be suitable for a 380 V 50 Hz supply unless otherwise stated in the design. It shall be possible to replace a defective coil without dismantling the brake mechanism.

(d) Manual Release

The hoist shall be equipped with a brake release by hand wheels or levers to allow manual lowering of the load in the event of power failure. This brake release shall not affect the clearance adjustment during normal operation.

Facilities for converting down-shop and cross-shop travel from electrically operated to manually operated on power failure shall also be provided. Conversion to manual operation is by hand wheel or lever.

Where hydraulic manual release mechanism is specified, it shall be operated by a foot pedal, depressing of which will release the brake to enable the lowering of the hook by gravity or by hand-winding, in an emergency. When the pedal is released the brake shall be re-applied automatically.

(e) Hooks and Ropes

Top hooks if required to swivel shall be fitted with plain bearings; bottom swivel hook shall be free to rotate under load. The hook shall be tested to 200% full load before assembly and complete with safety latch.

Rope and rope sheaves shall conform to BS EN 12385. The wire rope must be replaced if a wire is broken or if it is found to suffer from swelling, fraying bruises, kinks, permanent bends, damage or corrosion.

The steel rope sheaves shall revolve on anti-friction bearings and shall be guarded for protection against rope displacement and completely protected by steel casings. Where two or more ropes are used in a system, means shall be provided to ensure that the

tensile forces in the ropes are distributed in the designed proportions.

The factor of safety of the wire rope, which is determined by dividing the product of the minimum breaking strength of the rope and the number of falls by the safe working load for the crane, shall be not less than 5.

(f) Safety Facilities

(i) An overload protection device of the mechanical load measuring type with processing electronics shall be provided to prevent damage to the crane and its lifting mechanism. The device shall cut the lifting movement off if the Safe Work Load (SWL) is exceeded. However, the lowering movement shall remain operative. This device shall be of the fail-safe type and shall not reduce the maximum height of lift. Normal setting of the device shall be within 90% to 110% of SWL;

(ii) All cranes shall comprise an automatic safe load indicator, which shall automatically give an audible and visible warning at the control panel or pendent control of an approach to the safe working load and a further warning when an overload occur;

(iii) The testing requirements for this automatic safe load indicator shall conform to the requirements in the Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations and BS 7262:1990;

(iv) Where specified, a working platform of steel chequer plate shall be provided to enable access to the front and to both sides of the electrical control cubicle, motors, brakes and other areas where maintenance or inspection will be required; and

(v) Steel plating shall be provided between the access point and the equipment over the whole of the exposed area. The platform shall be securely fenced with tubular steel guard rails 1000 mm high and toe boards provided along the outer edges of the platform.

(g) Power Collector

Power shall be supplied to the crane through a system of copper bar conductors enclosed in an earthed galvanised steel track or a PVC insulating shroud. Alternatively, a trailing cable fixed to a system of cable trolleys, run on a fixed rail may be used.

The current collectors shall be of the sliding contact type with replaceable contact shoes. The contact head shall be shrouded to prevent accidental contact and mounted on self-adjusting spring-loaded arms to maintain constant contact with the conductor bars. The capacity of the contact head shall be compatible with the conductor. The supply conductor/collector system shall have five conductors - three for the phase supply, one for the earth and one for the neutral connection. Electrical connections between crane platform and the cross travel hoist assembly shall be with insulated flexible cables on rail-runners.

(h) Controls

(i) Each movement of the crane shall be operated by a separate motor. All movements shall start smoothly and inching in either direction shall be possible. If more than one driving motor is used for motion in any direction, the motors shall be synchronised. Limit switches shall be provided for limiting long (downshop) travel, cross travel, and for vertical hook travel in both directions. Limit switches shall reset automatically on reversal of motion. Control of travel shall be by means of push buttons in the pendant control unit.

(ii) Latching contacts shall not be provided in the motor starter circuits to bridge the control push buttons; i.e. constant pressure on the corresponding push button shall be required for the entire duration of travel in any direction. A self-latch type emergency push button to interrupt the control supply to all motor circuits shall be provided. After the emergency stop button is pressed, the pendant unit shall only be operated after it is reset manually.

(iii) The pendant control unit shall have a die-cast metal or glass fibre reinforced polyester enclosure rated IP54 to IEC 60529:2013/Corr 2:2015. The enclosure shall be resistant to mechanical shock. Push buttons shall be provided for the following functions: -

Main Hoist	:	Fast Raise, Slow Raise, Fast Lower, Slow Lower
Cross Travel	:	Left, Right
Long Travel	:	Forward, Reverse
Control	:	Stop, Reset

(iv) The push button, of hold-on control type, shall be electrically interlocked to prevent inadvertent operation of opposite motions. Control voltage at the pendent unit shall not exceed 50 V in accordance with IEC 61439-

1:2020 class 3 or equivalent. Labels in English and Chinese shall be approved by the Supervising Officer.

(i) Electrical Installations

(i) The control cubicle for a crane shall be to a degree of protection of IP54 to IEC 60529:2013/Corr 2:2015. The control cubicle and the components shall be of bulk manufacture with endurance and reliability test records. The panels shall be suitably braced to form rigid structures, taking due account of the vibrations that may be encountered during the operation of the crane;

(ii) The arrangement of the equipment within the cubicle shall be such that all normal maintenance work can be carried out through a hinged and lockable front access door. Components shall be of robust construction, to withstand the effects of intense vibration;

(iii) The control voltage shall not exceed 50 V nominal and shall be supplied either by a rectifier unit fed from a double-wound transformer having the mid-point of its secondary winding earthed, or directly from double wound transformer. The transformer (and where applicable, the rectifier) shall be mounted inside the control panel. Rectifiers shall be of adequate capacity to supply the full d.c. load continuously. The insulation level of the cubicle shall be 660 V;

(iv) The control cubicle shall be fitted with anti-condensation heater and a thermostat. A control push button, lockable with a key, shall be provided on the cover of the electrical control cubicle to de-activate the pendant control unit while retaining the main power supply to the control cubicle for circuit checking;

(v) A lockable isolator shall be provided for the isolation of the main power supply. Labels in both English and Chinese shall be approved by the Supervising Officer. To enable quick and easy maintenance and servicing, the components shall be grouped to form sub-assembly units;

(vi) Electric motors shall comply with IEC 60034-1:2010 and BS 5000-11:1973 as appropriate. Motor enclosures shall comply with IEC 60034-5:2006 and shall have a degree of protection of IP54 to IEC 60529:2013/Corr 2:2015. Motor bearings shall be with minimum working life of 40,000 hours. Bearings shall be arranged so that thermal expansion of the motor shaft does not impose thrust loading unless they are manufactured to accept thrust. Motor winding shall be of Class F insulation in operation at rated operating conditions;

(vii) Motors shall be rated for intermittent duty type S3 to IEC 60034-1:2010, with a cyclic duration factor of not less than 40% at rated output. Motors fed from 380 V 3 phase mains supply (unless otherwise stated in the design) shall operate within ±6% of the nominal supply voltage at motor terminals prior to the starting of motor, and ±2% of the supply frequency;

(viii) The starting kVA shall not exceed the figures specified in IEC 60034-1:2010. D.C. motors supplied from rectifier equipment connected to a.c. mains power supply shall meet the service conditions of voltage and frequency specified for a.c. motors and shall also be capable of continuous operation without causing excessive temperature rise. The rectifier equipment shall be provided with any necessary current limiting devices;

(ix) Brushgear, commutators and slip-rings shall be capable to operate without excessive sparking and to run for long periods without the need for adjustment or replacement of brushes. Adequate protection shall be provided for the windings against deposits of carbon dust. Removable covers shall provide access to the brushgear, commutator or slip-rings;

(x) Starters shall be of air-break contactor type rated for Class B operation. Reversing contactors shall have mechanical and electrical interlocks. Contactors shall comply with IEC 60947-4-1:2012 with assemblies to IEC 61439-1:2020. Direct-on-line starters shall comply with IEC 60947-4-1:2012;

(xi) The utilisation category for contactors shall be AC4 for induction motor starters, DC3 for shunt motor starters and DC5 for series motor starters. The duty rating shall be not lower than intermittent class 30 i.e. 30 operating cycles per hour and 30% on-load. Thermal overload and unbalanced protection shall be provided for each motor, and their settings shall be compensated for ambient temperature of 40ºC;

(xii) Cables shall be sized as required for each particular circumstances. Cables for intermittent duty shall have a minimum one-hour rating to ISO 4301-1:1986;

(xiii) Miniature circuit-breakers shall comply with IEC 60947-2:2013. Triple pole MCBs shall be integral units and shall not be comprised of three single phase units mechanically strapped together; and

(xiv) Fuse switchgear and isolators shall comply with IEC 60947-3:2015. Fuses and fuse holders for short circuit protection shall be high breaking capacity (HBC) fuses to IEC 60269-1:2014. Indicating lamp units shall have a degree of protection of IP54 to IEC 60529:2013/Corr 2:2015. Push button units and limit switches shall have a degree of protection of IP65 to IEC 60529:2013/Corr 2:2015.

16.1.4.1.2 Hoist

(a) General

(i) The hoist shall be to BS EN 13157:2004+A1:2009 or equivalent. The frame of the hoist shall maintain alignment under all expected conditions of service. The reduction gear shall be incorporated inside the hoist unit. The casing shall be strong and rigid. It shall be sealed for protection against dust and dirt.

(ii) All gears sprockets and shafts shall be of strength commensurate with the working load and shall be mounted on anti-friction bearings and sealed against ingress of dirt/moisture or leakage of oil. Adequate facilities for lubrication shall be provided, unless equipment with lifelong lubrication is used. All suspension fittings shall be detachable without damage for inspection.

(iii) The load chain shall pass through close-tolerance guide to minimise wear. Slack chain collecting bag to hold all the length of slack chain shall be provided for all hoists. The hook shall comply with BS EN 1677-5:2001+A1:2008 complete with safety latch. Top hooks if required to swivel shall be fitted with plain bearings, bottom swivel hook shall be free to rotate under load. The hook shall be tested to 200% full load before assembly.

(b) Safety Facilities

For hoist fitted to crane, the automatic safe load indicator shall be as indicated in this Section for crane.

Manual chain hoist shall be equipped with automatic cam-operated brake to arrest and sustain any load up to and including the test load at any position of lift when the hand chain effort is released and to permit smooth controlled lowering of all working loads without serious overheating. It shall be fabricated to the length required in this application with no unauthorised alterations.

For electrically operated hoist, the motor, other electrical components, brake and pendant control shall comply with Section for crane where applicable. Limit switches shall also be provided for limiting the travel of trolley when it approaches to stoppers at both ends of I beam.

(c) Trolley

The travelling trolley shall be of normal headroom type unless otherwise specified in the Particular Specification. The 2-speed electric travel shall be achieved by gear chain system. The manually operated travelling trolley shall either be hand-geared on hand-pushed type as specified in the Particular Specification or Drawings. The trolley shall be maintenance free and run on steel runner wheels. The wheels shall be fitted with precision anti-friction ball bearings, pre-lubricated for life, to absorb both radial and thrust loads. Trolley shall be suitable for mounting onto the Rolled Steel Joist (RSJ) provided by others.

16.1.4.2 EQUIPMENT AND MATERIAL

16.1.4.2.1 Crane

The end carriages shall be fabricated from rolled steel plate.

High tensile bolts and tapered washers etc. shall be used to secure the beams onto the steel brackets or re-enforced concrete corbel provided by the Building Contractor.

The hoist drum shall be manufactured from heavy duty, seamless steel tube supported on high quality anti-friction journals fitted into the main frame side plates.

All gears shall be heat treated for maximum wear and fracture resistance. All gears shall be machine cut and of hardened steel.

All brake linings shall be asbestos free.

Coils shall be vacuum impregnated with a non-hygroscopic insulating varnish or shall be epoxy resin encapsulated.

The hook shall be made of forged steel to BS EN 1677-5:2001+A1:2008.

The steel plating of the working platform shall not be less than 6.5 mm thick and not less than 600 mm wide.

The labels of the pendant controls shall either be engraved and filled with white paint, or be of sandwich type plastic laminate, such as traffrolyte with black lettering on a white background.

The control cubicle for a crane shall be fabricated of sheet steel of minimum thickness 2 mm. Cubicle doors shall be fixed with chromium plated or stainless steel knurled nuts of minimum dia. 16 mm.

Motor bearings shall be of ball or roller type.

Cables shall be sized as required for each particular circumstances. Minimum cross-sectional areas of conductors shall be 2.5 mm2 for power cables and 1.5 mm2 for control cables.

16.1.4.2.2 Hoist

The casing shall be of high tensile lightweight metallic material. The hook shall be made of forged steel to BS EN 1677-5:2001+A1:2008.

For manual operated chain hoist, the hand chain shall be of mild steel to BS 6405:1984.

16.1.4.2.3 Trolley

The trolley shall have a minimum of four ball bearings, single flange runner wheels. Couplings and shafts shall be of high quality steel and suitably heat-treated. The trolley structure shall be of folded steel plate construction and welded throughout.

16.1.4.3 ERECTION AND INSTALLATION

16.1.4.3.1 Crane

The crane shall be erected and installed in accordance with BS EN 13001-1:2015 and BS EN 13001-2:2014 and the electrically operated cranes shall also be in accordance with ISO 4301-1:1986.

The high tensile bolts and tapered washers etc. shall be supplied to the Building Contractor for installation of the bolts into the reinforced concrete corbel. The gantry rails shall be supplied, installed and secured onto the steel brackets or reinforced concrete corbel provided by the Building Contractor with spans as shown in the Drawings.

Wire rope and its tensioner shall be cleaned before the grease is applied.

The constructional and testing requirements for this automatic safe load indicator shall conform to the requirements in the Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations and BS 7262:1990.

Electrical connections between crane platform and the cross travel hoist assembly shall be with insulated flexible cables on rail-runners. The crane structures, motor frames and metal cases of all electrical equipment shall be effectively bonded to earth.

The control pendent shall be suspended from a stainless steel wire to prevent any strain on the supply/control cable at a height suitable for operation from the ground level. If this straining wire is integral with the cable, the wire must be terminated in a crimped-on ring terminal rigidly fixed at both ends such that the weight of the pendent is not carried by the conductors of cable at any time. Where remote control pendent is specified, it shall be free to move along the crane girder by the operator but independent of the movement of the hoist unit.

Epoxy resin based paint shall be used for the finish. Doors shall be fitted with gaskets. Each component within the control cubicle shall be identified with an engraved label which shall be fixed directly to or adjacent to the component.

16.1.4.3.2 Hoist/Trolley

Prior to installation of the lifting appliance, the associated structural lifting facilities such I-beam /eyebolt shall be checked to ensure the suitability of lifting assembly in terms of safe working load (SWL) in accordance with Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations.

The constructional requirements for the automatic safe load indicator shall conform to the requirements in the Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations and BS 7262:1990.

SUB-SECTION 16.1.5

FUEL SUPPLY SYSTEM

16.1.5.1 DESIGN

16.1.5.1.1 General

The design of fuel supply system and associated accessories shall be included under the Works.

The fuel supply system to plants and appliances shall consist of underground horizontal diesel fuel storage tanks, filling hut/ inlet, fuel transfer pumps, daily fuel tanks, the associated pipeworks, electrical power, controls and accessories. Bulk storage tanks, filling hut/ inlet and transfer pumps may not be required for smaller Installations.

The fuel supply system for vehicle refueling shall consist of underground horizontal storage tanks for diesel fuel, jet fuel and/or petrol, fuel transfer pumps, fuel dispensers, the associated pipeworks, electrical power, controls and accessories. Vapour recovery system(s) shall be provided for all petrol storage tanks and dispensers.

The fuel storage and transfer facilities, including layout, etc. shall be submitted and approved by the Director of Fire Services. All works shall be carried out according to the approved drawings.

16.1.5.1.2 Underground Horizontal Fuel Storage Tank

The construction of the underground fuel storage tank shall comply with BS EN 12285-1:2003 or other technically equivalent national or international standards.

All joints in the tank shell and dished ends shall comply with BS EN 1011-1:2009 and ISO 2560:2009.

Tank shells shall be made of rings and each ring shall be formed from a single plate or from not more than two plates welded together, rolled into a true circle. No longitudinal weld in any ring shall lie within the bottom half of the tank circumference to BS EN 12285-1:2003. Cross seams are not allowed. Longitudinal seam welds in adjoining rings of plate shall be staggered from one another by a minimum of 5 times tank wall thickness but not less than 25mm. Joints or seams shall not be placed in the positions of the cradles. All openings in the tank shall be located clear of the welding seams.

An end plate shall be made up from two smaller plates and the welded joint between which shall be horizontal and above the centre of the tank.

The internal surfaces of the tank shall be smooth and free from any obstruction apart from essential pipe connections. No internal bracing or

gusset plate shall be permitted inside the tank.

Tank-hole covers and all flanges and pads associated with each manhole cover shall be provided and completed with bolts, washers and joint rings.

16.1.5.1.3 Daily Service Fuel Tank

The daily service fuel tank shall be fitted with the following standard accessories: -

(a) A tapped filling socket connection on the top of the tank completed with all the necessary fittings and union coupling for connection to the filling pipe;

(b) A tapped overflow socket connection close to the top and on the side of the tank completed with all the necessary fittings and union coupling for connection to the overflow pipe or plugged with a brass screw cap if it is not used;

(c) A tapped outlet socket connection close to the bottom and on the side of strainers, and union coupling for connection to the delivery pipe strainer must be submitted for approval before installation;

(d) A tapped drain socket connection at the bottom of the tank completed with all necessary fittings and connected a 20 mm gate valve with plugs;

(e) A tapped return socket connection on the top of the tank completed with all the necessary fittings and union coupling for the connection to the return pipe; or plugged with a brass screw cap if it is not used;

(f) A tapped vent socket connection on the top of the tank completed with all the necessary fittings and union coupling for the connection to the vent pipe;

(g) One quick closing valve installed on the delivery pipe completed with all necessary linkage for operation from outside of the building. If steel wire and pulleys are used, the wire must be properly adjusted in length and protected; and the pulleys must be securely anchored; and

(h) The tank shall be fitted with an approved content gauge unit. An accurate measuring device shall be provided as may be deemed necessary for the calibration of the content gauge together with a supporting stand which shall be fabricated from angle iron complete with strut and tie members. They shall be designed in such a way that it will be possible to remove the tank without first lifting it. A mild steel oil drip tray welded to the angle bracket or stand shall also be included. Exact height of the frame shall be determined to suit site requirement.

16.1.5.1.4 Fuel Transfer Pumping System

The fuel transfer pumping system shall have rotary fuel transfer pumps completed with all necessary accessories including strainers, check valves, gate valves etc.

Each fuel transfer pump shall deliver the maximum design capacity of the fuel transfer system. For each pair of pumps a manual switch shall be provided to select the pump running mode as 'duty' or 'standby' respectively.

A composite pump control cubicle in the pump room incorporating the starters, safety and protection devices, all necessary wiring work, relays, fuel level control and alarm, push button and indication lights shall be provided.

The pump shall have an auto-off-manual switch with connections for remote start/stop operation by the level switch at the daily service tank. The duty pump shall be actuated when the fuel level in the daily service tank fall below 30% of the tank capacity, cut off automatically when the tank is 90% full. The pumps shall also be inoperative when the fuel level in the underground storage tank falls below a pre-set level.

(a) Audible alarm shall be given off under the following conditions: -

(i) underground storage tank fuel level low; and

(ii) pump fail to start.

(b) The following controls and indicator lights shall be incorporated on the control cubicle: -

(i) A suitably rated main supply door-interlocked isolator with 'Supply On' indicator light;

(ii) An 'Automatic/Off/Manual' selector switch;

(iii) Push button manual 'start/stop' of each of the pump set, and the corresponding indicator lights;

(iv) Indicator lights showing 'pump running';

(v) Selector switch to select duty pump;

(vi) Clean contacts for connection to CCMS for the status monitoring of the pumps; and

(vii) Engraved labels in both English and Chinese for all control operations shall be incorporated on the composite control cubicle.

16.1.5.1.5 Vapour Recovery System

(a) A vapour recovery system shall be provided for the petrol storage, transfer and dispensing system in accordance with the Drawings. The vapour recovery system shall be in full compliance with the Air Pollution Control (Petrol Filling Stations) (Vapour Recovery) Regulation and other relevant regulations.

16.1.5.2 EQUIPMENT AND MATERIAL

16.1.5.2.1 Daily Service Fuel Tank

The daily service fuel tank shall be fabricated from mild steel plate welded onto a mild steel frame. To stiffen the tank, mild steel flat bars are to be intermittently welded on the inside of the tank. The mild steel plates shall be to Schedule 42 while the mild steel frame and flat bars shall be to ISO 657:2000.

16.1.5.2.2 Fuel Transfer Pumps

The fuel transfer pumps shall be of the positive displacement type, with high quality cast iron body, high tensile steel shafts and built in internal relief valve.

The coupling motor shall be flame proof with no volt release and with overload protection.

16.1.5.2.3 Control Equipment

The cubicle shall be of the wall-mounted type, type of protection EEx d flameproof enclosures for operation in Zone 1 hazardous area as classified in EIMCSP and IP65 enclosure to IEC 60529:2013/Corr 2:2015. The drawings and the official certificate issued by BASEEFA or equivalent certification body of the cubicle shall be submitted.

16.1.5.2.4 Level Switches

(a) The level switches shall be manufactured to

(i) IEC 60079-0:2017 Explosive Atmospheres; and

(ii) The Energy Institute Model Code of Safe Practice (Electrical) (EIMCSP).

(b) The level switch shall be of Group IIA and Temperature Class T1 in accordance with IEC 60079-0:2017.

(c) The electrical components of the level switch installed in the vapour space above fuel and inside the fuel tank shall be of the type of protection of EEx ia which is suitable for installation in Zone 0 Hazardous Area as classified in EIMCSP.

(d) The electrical components of the level switch installed outside of the fuel tank shall be at least of the following type of protection suitable for installation in Zone 1 Hazardous Area as Classified in EIMCSP: -

(i) EEx ib

(ii) EEx d

(iii) EEx p

(e) The level switch shall consist of two major components - a level sensor and a switch unit.

(f) Unless otherwise stated, the level switch (where applicable to be accompanied with a controller) shall be capable to control on/off operation of a remote system when a preset level of the fuel in the storage tank is reached. Details of the operation and the exact control level settings shall be as stated in the Particular Specification. The level switch shall be suitable for on-site calibration of the level settings.

(g) The level sensing element shall be installed in a stainless steel tube and placed inside the fuel storage tank. It shall be mounted horizontally or vertically depending on the principle of operation.

(h) The switch unit shall be mounted on the tank and with the level sensor to form an integral set. The unit shall be housed inside a casing made of cast iron or aluminium alloy. It shall be capable of detecting the signal from the sensor and transmitting it (in general through a controller) to control the on/off operation of a remote system.

(i) A copy of certificate to prove the apparatus rating shall be submitted. Certificate issued by authorities other than BASEEFA shall be furnished with details of relevant standard.

16.1.5.2.5 Fuel Dispensing Unit

The dispensing unit shall be of a type approved by FSD. The dispensing pumps shall be integral units, non-computing, suitable for dispensing petrol and diesel oil and complete with: -

(a) 0.4 kW 220 V single phase 2-hour rated flame proof motor, tropicalised winding, suitable for ambient conditions;

(b) Rotary vane type pump unit delivering an output of not less than 50 litres per minute;

(c) Positive displacement type piston meter complete with air release valve and drain line eliminator;

(d) Housing - completely of stainless steel with exception of lower front and rear panels, which shall be of a glossy high-baked enamel;

(e) 10-micron filter with extra large surfaces;

(f) Motor switch shall be a mechanical operating switch that turns on the pump motor and control the flow of fuel oil, shall be built in the handle of the nozzle;

(g) Emergency hand drive;

(h) 4 metres gasoline resistant, rubber anti-static hose and complete with rigid tube control nozzle;

(i) Flexible connector;

(j) A filter in the inlet of the dispensing unit;

(k) Air separator, air release valve and all necessary control;

(l) Finishing colour to be in Brunswick Green to colour reference number 227 specified in BS 381C:1996 unless otherwise specified;

(m) Sight glass, complete with full and uniform dial illumination, light switch shall be inside housing;

(n) An emergency shut-off valve installed in the fuel supply line at the base of each dispensing unit to automatically close the supply in the event of severe impact or fire exposure;

(o) A breakaway connector at the dispensing hose nozzle to stop flow of fuel in the event of the vehicle moving while the nozzle remains in the filling pipe;

(p) The display of the fuel dispenser shall be of the LCD crystal type. All characters on the display shall be clearly and readily readable during day and night times. The height of character shall not be less than 19 mm;

(q) The display shall contain 6-digit of volume (in litres), 5-digit for amount, 4-digit for unit price, 8-digit for totaliser and a 8-digit mechanical totaliser for volume for backup;

(r) The dispenser shall contain an electronic computer unit with self-diagnostics feature. The dispenser shall be able to upgrade with communication between fuel management system in future;

(s) The dispenser shall have a numeric keypad to preset the amount of fuel oil to be dispensed in terms of volume or money;

(t) The pump unit shall be connected to a piston meter in litre measure with accuracy of ±0.25%;

(u) The whole dispenser including the electronic part shall be of the weather-proof type and suitable for use under outdoor conditions;

(v) All necessary conduits, electrical wirings, controls and switches between the electricity supply switch and the dispensing unit including earthing electrodes and protection, if any; and

(w) Petrol dispensing unit used for vehicle refueling has to install vapour recovery system, which shall be of vacuum assisted type with coaxial dispenser hose to comply with the Air Pollution Control (Petrol Filling Stations) (Vapour Recovery) Regulation.

16.1.5.2.6 Hand Pump

A semi-rotary double acting hand pump shall be provided for each daily service tank and consist of 25 mm diameter inlet and outlet and a 25 mm diameter flexible oil resistant inlet pipe of adequate length to suit site conditions.

16.1.5.2.7 Pipeworks and Fittings

All pipes up to 80 mm diameter shall conform to ISO 65:1981 heavy quality and pipes 80 mm diameter and above with BS 1600:1991 or other technically equivalent national or international standards.

Flanges shall be of the slip-on-welding type in accordance with ISO 7005-1:2011 Class 150. Screwed fittings shall be made of malleable iron and threads shall comply with ISO 7-1:1994/Corr 1:2007.

All screwed joints shall be cleaned, threaded and pulled up tightly. All jointing materials shall be resistant to the type of fuel to be conveyed. Gaskets made of rubber or compressed asbestos fibre shall not be used.

Square elbows shall not be used. Where practicable, long sweep bends shall be used in preference to round elbows.

Valves shall be of the 'full way' type to allow free flow of fuel. A sample valve shall be submitted to the Supervising Officer for approval before installation. Valves shall be made of bronze or cast steel.

16.1.5.3 ERECTION AND INSTALLATION

16.1.5.3.1 Underground Horizontal Fuel Storage Tank/ Daily Service Fuel Tank

(a) After the construction of the underground fuel storage tank/ the daily service fuel tank has been completed, it shall then be thoroughly cleaned and all loose debris removed. It shall than be

tested hydraulically at a pressure of 70 kPa, measured at the top of the tank. The pressure shall be maintained for a period of 2 hours to ensure that the tank is sound and shows no leaks or undue distortion. The test shall be carried out by a competent person in the presence of and to the satisfaction of the Supervising Officer or his Representative;

(b) The pressure gauge employed for the test shall be tested and calibrated by organisations accredited by the Hong Kong Laboratory Accredition Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS before use. Pressure gauge with full-scale deflection readings more than 3 times the test pressure shall not be used;

(c) Immediately after hydraulic test of the tank, the tank shall be drained and dried out and a thick coat of linseed oil shall be applied on the interior surfaces of the tank to prevent rusting;

(d) All parts of the exterior surfaces of the tank shall be thoroughly cleaned by mechanical means to remove all rust, mill scale, grease and other foreign matters to achieve a bright, rust free and dry surface. The painting procedures shall comply with ISO 12944:1998+Part5:2007. The condition of the painting and the coating shall be checked after installation by suitable test such as "Holiday Test" and repaired as required;

(e) For the underground fuel storage tank, it shall be calibrated after it has been installed in the tank chamber, by dipstick. The measuring device shall be calibrated;

(f) The dipstick shall be made from 20 mm diameter brass pipe. When the tank has been calibrated, the dipstick shall be marked on all faces by clearly scribed lines of 100 litres intervals for the tanks up to 10000 litres in capacity and of 250 litres interval for those above 10000 litres, and have the volume in figures stamped on two opposite faces at interval of 1000 litres;

(g) After calibration, the tank shall be thoroughly dried and applied with a thick coat of linseed oil on the interior surface to prevent rusting;

(h) The results of calibration shall be tabulated and submitted for record purpose;

(i) If alternative method for tank calibration is proposed, detailed calibration procedures shall be submitted for consideration and approval; and

(j) The following information shall be permanently and clearly marked on a nameplate to be provided to the tanks in an agreed position: -

- Company name of installer;

- Gross capacity in litres; and

- Date of hydraulic test

16.1.5.3.2 Pipeworks and Fittings

(a) Particular care shall be taken to ensure that all pipes and fittings are carefully reamed to ensure that the full bore of the pipe is maintained and where necessary cleaned out before erection;

(b) Round piping supports and anchors as necessary shall be suitably placed to the instruction of the Supervising Officer, in order to provide rigidity to reduce stresses due to unstable ground;

(c) The completed pipework, fitting and valves shall be tested hydraulically before application of protection and painting to a pressure of 700kPa for a period of time not less than 2 hours without undue leaking or distortion;

(d) All associated pipework, fitting and valves shall be completely drained after hydraulic test and shall be blown with compressed air to remove any trace of water and dirt; and

(e) After being dried, the pipework, fitting and valves shall be flushed with oil to prevent rusting.

16.1.5.3.3 Protection of Buried Pipe

The procedures for protection of the buried pipes shall be as follows: -

(a) Clean outer surface of the pipe to remove all rust, mill scale, grease and other foreign matters to achieve a rust free and dry surface;

(b) Apply one layer of Denso Paste or approved equivalent as primer to give a thin continuous coating over the area to be protected;

(c) Apply Denso Tape or approved equivalent spiral on the pipe with minimum of 55% overlap. Care shall be taken to ensure the tape is in contact with the underlying surface of the pipe and to smooth out any wrinkles or air pockets; and

(d) Apply Densopol 60 Tape or approved equivalent on the pipe with minimum of 55% overlap as an outerwrap.

16.1.5.3.4 Painting of Pipeworks

Pipeworks, other than the buried pipes, shall be painted according to requirements as per Part 1 of this General Specification.

SUB-SECTION 16.1.6

GARAGE EQUIPMENT

16.1.6.1 DESIGN

The design of garage equipment and associated accessories shall be included under the Works.

The design of all garage equipment shall be in accordance with the current international standards.

16.1.6.1.1 High Pressure Grease Pump, Grease Storage Drum with Adjustable Drum Lid and Cabinet Grease Hose Reel with Manometer

(a) High Pressure Grease Pump

The high pressure grease pump shall be pneumatically operated, suitable for a maximum operating air pressure of 1000 kPa. The grease pump shall be equipped with a screen filter at the grease inlet, a 1.5 m steel braided rubber delivery hose with terminating unions, a 1.5 m flexible nylon hose with taper insert and quick fix coupler, a 1 m suction tube, a lifting eye bolt and an adjustable drum lid.

(i) Adjustable Drum Lid

The drum lid shall be adjustable and suitable for a 180 kg grease drum. It shall be completed with a tank mounting plate on which the high pressure grease pump can be mounted.

(b) Cabinet Grease Hose Reel

The cabinet grease hose reel shall be a self-contained unit comprising the followings: -

(i) 6 mm dia. 34 MPa (min.) delivery hose of not less than 9 m in length;

(ii) a control valve completed with a built-in manometer and a nozzle for dispensing grease under high pressure;

(iii) a swivel coupler for universal pivoting between the control valve and its hose; and

(iv) a wall mounting plate.

16.1.6.1.2 Low Pressure Oil Pump and Cabinet Hose Reel with Manometer

(a) Low Pressure Oil Pump

The oil pump shall be of the air operated low pressure type suitable for a maximum operating air pressure of 1000 kPa. It shall be suitable for handling lubricating oils. In particular, it shall be fitted with the followings: -

(i) sufficient length of nylon delivery hose with end fittings;

(ii) sufficient length of flexible nylon air hose with taper insert and quick fix coupler;

(iii) a rise tube suitable for the oil tanks ;

(iv) float valve assembly to prevent entry of air into the system;

(v) a mounting plate and the associated accessories; and

(vi) a lifting eyebolt.

(b) Cabinet Hose Reel

The cabinet hose reel for lubricating oil and water shall be a self-contained unit comprising the followings: -

(i) For lubricating oil, 10 mm dia. 20 MPa (min.) delivery hose of not less than 9 m in length; for water, 6 mm dia. 2000 kPa (min.) delivery hose of not less than 9 m in length;

(ii) a manometer/hose-end meter;

(iii) a trigger controlled inlet valve capable of locking in open position; and

(iv) a wall mounting plate.

16.1.6.1.3 Lubrication Oil Tank

The lubrication oil tank containing 4 separate compartments of capacities 2 x 750 and 2 x 250 litres shall be fabricated from mild steel. Each compartment shall be provided with a suitable handhole for cleaning tank interior, a filling port with a water-tight-cap, a weatherproof air breather and a removable lid with suitable accessories for mounting the L.P. oil pump. Painting of the lubrication oil tank shall be in accordance with Part 1 and relevant clauses in Part 16 of this General Specification.

16.1.6.1.4 Waste Oil System

(a) Waste Oil Tank

The underground waste oil tank shall be in accordance with Sub-section of Fuel Supply System in this General Specification.

(b) Waste Oil Transfer Pump

The rotary oil transfer pump shall be completed with all necessary accessories including a simplex suction strainer, a check valve, a gate valve and a starter.

The pump shall be of the positive displacement type, with high quality cast iron body, high tensile steel shaft and built in internal relief valve. It shall be capable of delivering 250 1/min of lubricating oil at 350 kPa.

The coupling motor shall be of the flameproof type completed with no volt release and with overload protection.

(c) Waste Oil Trolley

A waste oil trolley, funnel and the associated pipework which will carry the waste oil from servicing vehicle to the underground waste oil tank shall be provided.

The trolley shall be of metal structure, with supporting wheels resting on the edge of the inspection pit. It shall be installed such as not to obstruct the free movement of the servicing vehicle above the inspection pit.

16.1.6.1.5 Tyre Shop Equipment

(a) Tyre Inflator with Gauge

The tyre inflator shall be of the wall mounted type suitable for inflating tyre automatically to preset pressure. It shall comprise an internally illuminated easy-to-read display with 0 to 1000 kPa adjustable single scale, a built-in air filter, a built-in hose reel completed with a 15 mm diameter bore x 8 metre air hose, a twin hold-on connector and all wall mounting accessories. The hose reel shall be self-retracting so that when the pull on the hose is released, the hose will rewind automatically.

(b) Safety Cage

A safety cage shall be provided for truck tyre inflation. It shall be made of tubular steel welded to a steel base with dimensions as specified in the Particular Specification and shall withstand great exploding force. Details and relevant drawings for the safety cage shall be submitted and approval from Supervising Officer must be

obtained before fabrication.

(c) Truck Tyre Remover

The tyre remover shall be of the electro-hydraulic type completed with bead lifting lever, ring removing lever and clamp pliers suitable for fast and safe operation on tubeless and ring wheels with a maximum diameter of 9.150 mm.

The mounting, demounting and bead-breaking tools shall be located in a revolving turret. The clamping head shall be of the hydraulically operated self-centering type capable of clamping all kinds of rims from 356 mm to 635 mm both on centre hole and rim inside.

The equipment shall be able to run on 220/380 V. 1-ph./3-ph. 50 Hz supply and completed with pedal control to give operator maximum working freedom.

(d) Water Tank

A suitably sized water tank for detecting air leak from the inflated tyre shall be provided at a location where the tyre remover can be worked on conveniently.

(e) Vulcaniser

The vulcaniser shall be of the bench mounted type capable of repairing any type of tube. It shall be suitable for 220 V single phase 50 Hz AC supply.

Basically, it shall comprise a manual quick clamping device and a suitably rated heating unit completed with an adjustable timer. The clamping device shall exert a constant pressure on the tube during operation. The heating unit shall provide an operating temperature of not less than 140^{o}C.

(f) Wheel Balancer

The wheel balancer shall be capable of detecting the vibration of an unbalance or non-concentric rotating wheel with a maximum weight of up to 200 kg, and a maximum tyre width of 500 mm.

The wheel balancer shall be operated with 380 volts 3-phase, 50 Hz AC supply and equipped with a 350 mm video display unit which shall indicate the magnitude and location of the counter weight required to balance the unbalance wheel.

The balancer shall be incorporated with pneumatic lift, drum brake and other operation accessories such as cone adaptor for various central holes of wheel, lockring etc. for fixing the testing wheel onto the balancer shaft.

16.1.6.1.6 Battery Room Equipment

(a) Battery Charger

The bench mounted type battery charger shall comprise two independent circuits capable of charging two banks of batteries at different rates.

The battery charger shall be induced air cooling and complete with the followings: -

(i) Ammeter for charging current;

(ii) Normal rate / High rate charging selector switch;

(iii) Selector for 6 V, 12 V or 24 V batteries;

(iv) Timer for high rate charging;

(v) Solid-state diode assembly;

(vi) Overload protection with re-set; and

(vii) Polarity protection.

The charger shall operate on 220 V, single phase, 50 Hz AC supply. It shall be capable of charging 6 batteries of 24V connected in series with a maximum charging time of 7 hours.

(b) Busbar System

The busbar system for each battery charging circuit shall include independent base plate, side plates and copper rods.

The base plate shall be made of high insulating 'Bakelite' sheet of 5 mm thick. It shall be fixed to the bench top wall using long galvanised bolts holding the base plates at both sides.

The busbar supports shall be constructed of 40 mm square hardwood coated with insulating varnish supporting the two copper rods as shown in the Drawings. Two pieces of 9 mm diameter copper rod shall be provided for each busbar system. Connection and/or provisions for connections between the battery chargers and the cells and between the chargers and the busbars, where appropriate, shall be provided and made in accordance with the relevant standards.

(c) Water Distiller

The water distiller shall be of the storage type and be fully automatic in operation. It shall comprise electric heating element,

boiling vessel, distillate storage vessel, safety valve and the associated controls.

The heating element shall be cut-out automatically to protect against overheating and low water level condition. The element together with the cooling water supply shall also be cut-out when the distillate storage vessel is full and cut-in automatically when the distillate has been taken.

The distiller shall have an output of not less than 4 litre/hour. Water supply to the distiller shall be from a ball-valve operated header tank of 200 litres capacity fitted with a level gauge, a 'filter' and the associated pipework.

The distiller and tank assembly shall be suitable for wall mounting with ample clearance beneath it for collecting distilled water.

16.1.6.1.7 Hydraulic Trolley Jack

The hydraulic trolley jack shall be as follows: -

(a) The trolley jack shall be capable of lifting a load up to 13,000 kg with a minimum lift of 450 mm;

(b) The jack shall comprise a long handle and a large swivelling crutch for easy and safe positioning. It shall provide easy and stable jacking close to obstruction;

(c) It shall incorporate both overload and stroke limiting facilities to protect the operators and the equipment itself; and

(d) Positive means of lowering device shall be built into the handle to control the lowering action and to prevent accidental lowering.

16.1.6.1.8 Side Slip Tester

The side slip tester shall be as follows: -

(a) The side slip tester shall be used for inspecting the wheel alignment of the vehicle's front steering wheels and shall consist of tread plates and a lateral slip amount detecting device;

(b) The side slip test shall be conducted when the front steering wheels of the testing vehicle pass through the side slip tester. The lateral slip detected shall be transmitted to control panel, data processing and storage system;

(c) The test results shall remain visible in the display instrument of the control panel until the instrument is reset automatically or manually;

(d) Maximum per axle loading of the tester is given in the Particular Specification;

(e) Test range of the tester is from IN 10 metre/km to OUT 10 metre/km with a measuring accuracy within ±0.2 metre/km (i.e. ±2%);

(f) The display meter shall be of the digital or analogue display type with a maximum indication for IN and OUT of 10 metre/km; and

(g) The analogue display meter shall have graduation colour as follows: -

(i) Lower range - green,

(ii) Middle range - yellow, and

(iii) Upper range – red.

16.1.6.1.9 Roller Brake Tester

(a) Capacity

The brake tester shall be able to measure and calculate the following items: -

(i) Front axle weight and braking forces of right and left wheels and percentage of deviation of braking forces;

(ii) Rear axle weight and braking forces of right and left wheels and percentage of deviation of braking forces;

(iii) Sum of all braking forces divided by the sum of both axle weights; and

(iv) The braking efficiency of each wheel.

The technical particulars, such as maximum axle load, wheels width of an axle etc., of the roller brake tester shall be given in the Particular Specification.

The limit of error for the indication of the measured value at any point must be within ±3% of the full scale deflection.

(b) Brake Tester

The brake tester shall be of the roller driven type and shall be suitable for: -

(i) Rear drive - rear parking brake vehicles;

(ii) Front drive - rear parking brake vehicles; and

(iii) Front drive - front parking brake vehicles.

It shall be pit-installed and shall be suitable for testing large passenger carrying and heavy goods vehicles with single and multiple axles of the trailing or tandem driven type without a third differential.

The brake tester shall consist of braking force detecting rollers, a braking force measuring device, an axle weight measuring device and a detecting device which confirms the vehicle entry and departure from the tester.

The brake tester shall include two separate pit units which when bolted together, allow both wheels of an axle to be tested at the same time. Each unit shall consist of a welded steel frame carrying two rollers which shall have a specially roughened surface for maximum tyre adhesion. A slip sensing/shut off system comprising an additional spring-loaded roller between the two testing rollers shall be provided. The spring-loaded roller shall be rotated by the wheel under test and shall automatically stop the testing rollers to avoid damage to tyre should the wheels under test lock or the vehicle wheels not be correctly located on the rollers. Each set of testing rollers shall be driven by a separate electric motor through a reduction unit. The torque arm pressure on the load cell shall be relayed electrically or hydraulically to the control panel where the operator can read the gauge best suited to the vehicle on test.

(c) Power Drives

One electric motor shall be provided per pair of rollers for nearside and offside wheels. Nominal rating of each motor shall be suitable to drive vehicle with a maximum axle weight as given in the Particular Specification and able to react the applied braking force up to 3 times the axle load in tonnes.

Motors shall be to BS 4999-141:2004 + A1:2010 and shall be protected up to a minimum of IP44 of IEC 60034-5:2006. Cooling of motor shall be to IEC 60034-6:1991 Class IC0A1 and motor windings insulation shall be Class F to IEC 60085:2007. The roller drive is to be via a gear box to give an equivalent road speed of 2-3 km/hr.

The roller brake tester shall operate on a 380 V 50 Hz 3-phase AC supply. To avoid heavy starting current, suitably rated star-delta starter with overload protection shall be provided.

The roller brake tester shall be suppressed against electro-magnetic interference to BS EN 55014:2006.

Means shall be provided to enable a vehicle to be driven off the machine with the rollers stationary or with the rollers turning in the opposite direction to that used for a brake test (vehicle driving off forwards) or turning in the same direction to that used for a brake test (vehicle reversing off).

(d) Brake Rollers and Roller Surface

The rollers shall be supported in self-aligning sealed for life bearings and shall be able to withstand axle loads up to the capacity as given in the Particular Specification.

The effective width of the rollers shall accommodate all tyre width of vehicles having track widths up to 2,600 mm plus a vehicle misalignment allowance of 150 mm at the ends of each roller. The roller width shall not be less than 900 mm and the outside diameter of the rollers shall not be less than 150 mm.

The protrusion of the brake tester relative to the surface of the test lane shall be protected by safety guard rails.

The roller surface shall provide a minimum coefficient of friction of 0.6 between the road wheeled tyre and the brake roller under both dry and wet conditions. If the rollers are epoxy coated, the gritted surface shall be capable of being resurfaced without the need for special equipment. The roller surface shall be governed by the need for long periods (not less than 3 years) of service without frequent maintenance and attention.

(e) Control Panel and Instrumentation

The control panel shall be of the totally enclosed, flush-fronted pattern, having concealed hinges and comprising all necessary instruments specified herein in a multi-layer arrangement.

The instruments shall be so arranged that there is at least 300 mm clearance between floor level and any control, indication or hand operated component.

The control panel shall be floor mounted with all cable access at the bottom of the panel. It shall be robustly constructed on a rigid steel frame and sectionalised to facilitate handling.

The enclosures shall be protected to IP44 of IEC 60034-5:2006 and be constructed of sheet steel, minimum thickness of 2 mm.

The control panel shall incorporate a complete set of instrumentation (including indicating lamps, push buttons, L&R On/Off, emergency shut off etc.) so that both brakes on an axle can be tested simultaneously and their performance can be directly compared.

The torque arm pressure on the load cell of the brake tester shall be transmitted electrically or hydraulically to the local control panel. The braking force shall be measured and displayed by means of a separate analogue indicator for each pair of rollers. Each indicator shall have low and high scale readings automatically selected to indicate the braking efforts.

The indicators shall be either analogue or digital with readings in kN and can measure up to a maximum of 3 times the axle load. Analogue indicators shall have scale divisions of at least 1/10th of full scale. Point zero for the indicator shall only be set at no load. The indicators on each side of the tester shall be able to operate separately.

A peak hold facility shall be provided to hold the readings until the operator cancels them. A slip warning light shall be provided at the panel for each side. The brake tester shall have provisions for visual indication of individual wheel braking efficiency and of wheel locking whilst under test.

(f) Calibration

The brake tester shall be mounted such that calibration is simple and easily done over the whole range. The means of calibration as well as all other necessary equipment shall be supplied with the brake tester.

(g) Maintenance

The roller brake tester shall be mounted in its location pit as to enable easy access for regular maintenance of its equipment and the replacement and repair of parts.

(h) Safety Features

The roller brake tester shall incorporate all the necessary safety equipment to ensure that it operates as a safe Installation. Safety guard rails and vehicle sensing device (to ensure that the motors cannot be started unless both third rollers are depressed by vehicle wheels) shall be included.

(i) Load Simulator

The load simulator shall work in conjunction with the roller brake tester to apply a known, variable, downward force to the axles of vehicles being tested in the unladen condition.

The equipment shall be capable of simulating an axle load up to the capacity of the roller brake tester as given in the Particular Specification. Loads shall be simulated by two double acting heavy duty hydraulic cylinders which apply load to each side of the vehicle being tested through the medium of nylon straps.

The equipment shall comprise a hydraulic pump with air or electric motor; two double acting hydraulic cylinders; all the associated accessories including hydraulic valves, pressure gauge, hoses etc; and two pairs of nylon straps.

The oil pressure, which in turn determines the simulated axle load, shall be adjustable through a remote control device.

(j) Accessories

The following accessories shall be provided for the Installations: -

(i) Roller cover plates - to cover rollers when the roller brake tester is not in use.

(ii) Safety guard rails - for keeping people away from rollers.

(iii) Suitable wheel chocks - to ensure the wheels of vehicle rest on the rollers.

(iv) Complete set of calibration equipment (including calibration weights) of the dead weight type - to allow calibration of the brake tester over the whole range.

(v) Simple-to-use calculating disk for the supplied brake tester.

The above are the minimum requirements of the accessories to be provided. Any other items that are considered necessary for the complete, safe and satisfactory operation of the brake tester supplied shall be provided.

16.1.6.1.10 Speedometer Tester/Distance Counter

The speedometer tester/distance counter shall consist of rotation transmitting rollers, a rotation detecting device, a digital display unit and facilities to allow the vehicle to leave the rollers after the test.

The rotation transmitting rollers shall be supported in self-aligning sealed for life bearings and shall be able to withstand axle loads up to the capacity as given in the Particular Specification.

A rotation detecting device shall be installed at the rotation transmitting rollers. It shall generate signal in accordance with the rotating speed detected and the signal shall be transmitted to the digital display unit which shall display the linear speed of the rotating rollers as well as the distance travelled by the rotating rollers for a certain period of time.

The display unit shall be incorporated with the followings: -

(a) A 4-digit illuminated display calibrated to measure speed and

distance up to 120 km per hr and 9999 metres respectively;

(b) Selector switch for speed and distance measurements;

(c) A timer which shall cut-in and cut-out the distance measuring display for a pre-set period of time; and

(d) Other technical particulars such as maximum per axle load on the rollers, the minimum and maximum acceptable wheel diameter as shown in the Particular Specification.

The rotation transmitting rollers shall also be provided with roller locking device to facilitate testing vehicle leaving the rollers, rollers cover plates, safety guard rails, wheel chocks and any other items which are considered necessary for the complete, safe and satisfactory operation of the speedometer tester and distance counter supplied.

16.1.6.1.11 Diesel Smoke Tester

The diesel smoke tester shall measure the black smoke emitted by diesel engines and shall be of the fully automatic type.

The smoke tester shall consist of a smoke sampling probe which is fixed in the adaptor of the smoke collecting funnel and shall be connected to a smoke meter through a sampling tube with minimum length of five metres.

The smoke collecting funnel shall be capable of being clamped onto the exhaust pipe of the engine running vehicle being tested and such that smoke can be sucked through the sampling probe into the analyser.

The analyser shall be of an approved type under the Road Traffic (Construction and Maintenance of Vehicles) Regulations and shall be able to operate from 12 or 24 volts DC and 220 volts AC. The smoke sucked in shall be analysed by comparing with certain type of standard gas and its hydro-carbon level shall be indicated by an analogue meter scaled in Hartridge units.

Measuring range of the tester shall be between 0 to 99% with an indication accuracy of not exceeding ±5%. Analogue voltage output shall also be available for hard copy record purpose.

16.1.6.1.12 Headlight Tester

The headlight tester shall mainly consist of a system of lens to project the light distribution (light/dark limit) from the headlights and a marked screen to check the inclination of the beam.

The lens of the tester shall be capable of projecting on the screen a picture equivalent to the one which would be obtained on a wall at 10 metres distance. The quality of the pictures should be in conformity with the national regulations.

The screen shall be marked with vertical and horizontal centre lines in such a way that the adjustment of the beam patterns for the following types of headlamp can be checked on all vehicles: headlamps with asymmetrical dipped beams, headlamps with symmetrical dipped beams, fog lamps, headlamps with main beams.

The centre of the screen shall be fitted with photo-electric cell to determine the high intensity zone or 'hot spot' position of the headlamp. The cell shall be connected to a light intensity meter mounted on the tester.

The tester shall be capable of moving on rails traversely in front of the vehicle. It shall be vertically adjustable to measure headlamps with centres between 500 mm and 1200 mm above ground level.

The equipment shall be capable of being accurately aligned with the vehicle. It shall allow small vertical and horizontal adjustment of up to 2° each side of the center. The overall accuracy of the equipment shall be not less than ±0.1°.

Calibration of the headlight tester shall be simple and easily done. The calibration kit shall be supplied with the tester.

16.1.6.1.13 Joint Play Detector

The joint play detector shall be flush-mounted on the floor and shall be working in conjunction with the rail-mounted pit jack on inspection pit.

The joint play detector shall apply stress hydraulically or pneumatically to the suspension and steering systems through movable steel plate beneath the vehicle wheels in order to check wear and play in steering linkages, brake plate, spring anchorage points of front and rear axles.

The joint play detector shall be controlled from a low voltage (24 V, 50 Hz) control/hand inspection lamp. The inspection lamp shall incorporate a double-acting centre-biased electrical switch on its handle and controlling power to the double acting hydraulically or pneumatically rams that move the plates beneath the wheels.

The plates on either side of the inspection pit shall move in opposite directions during both transverse and longitudinal motions. Forward pushing on the switch shall operate outward transverse motion of the plates, and backward pushing on the same switch shall trigger movement of the two plates forward and backward respectively, imparting a twisting couple on the axle. The inspection lamp shall also be used to light up various areas susceptible to defects.

The joint play detector shall comprise two surface mounting plate units (one on each side of the pit), double-acting pneumatic or hydraulic rams and controls, 220 V/24 V transformers, low voltage control/hand lamp(s), cable of 5 m long, oil mist lubricators, fuses. The joint play detectors shall

be suitable for 220 V 50 Hz. single phase AC electrical supply and compressed air at 1000 kPa.

16.1.6.1.14 Pit Jack

(a) The pit jack shall have rollers resting on rails on top of the inspection pit.

(b) They shall be safe, easy-to-operate, fast travel and robust with a carrying capacity for axle load as given in the Particular Specification.

(c) The width of the supporting rollers for the proposed pit jack shall be adjustable and shall match the respective pit width.

(d) The pit jack shall be pneumatic operated with a maximum operating pressure of 1000 kPa. In particular, the pit jack shall comprise the following items: -

(i) Compressed air operated hydraulic pumps;

(ii) Two hydraulic cylinders with a minimum lifting height of 300 mm;

(iii) Mechanical locking device on each cylinder to enable the load to be taken off from the hydraulic system for prolonged working periods;

(iv) Built-in relief valve to prevent overloading the cylinders;

(v) Flow control valve to control the descending speed of the cylinders;

(vi) Steel rollers at each end of the frame to support the assembly on the pit edging; and

(vii) Sufficient length of flexible air hose complete with quick fix coupler.

(e) When the hydraulic cylinders are fully retracted, the pit jack shall not obstruct the free movement of the inspection vehicle above the inspection pit.

16.1.6.1.15 Engine Analyser

(a) General Description

The engine analyser shall be of micro-computer based capable of diagnosing engine faults up to a maximum of 8 cylinders. The equipment shall be fitted with printing facility to produce printed record of test results for evaluation.

The analyser shall be able to test all vehicles in a conventional manner and accept different 'plug in' connection compatible with various manufacturer's timing methods. For this purpose, the timing lead shall be automatically converted to monolithic mode.

The equipment shall be compact and mounted on a sturdy, mobile wheeled cabinet for easy handling and shall be operated on the car battery (i.e. on 12 volts d.c.) of the vehicle under test.

The equipment with appropriate software and accessories shall be capable of diagnosing/analysing traditional petrol engines and computer based engines, exhaust gas emission level and diesel engine injection timing.

(b) Features

The equipment shall be constructed to meet the following requirements: -

(i) Test Sequence

The programmed test sequence shall be incorporated to facilitate the following tests: -

- The analyser shall be self tested when switched on and shall prompt the user when self test is completed or prompt the user if fault on the unit is located;

- Fully automatic comprehensive check - the analyser shall sequentially proceed with all the test items. Printouts shall be produced upon completion of test;

- Semi-automatic measurement - the analyser shall conduct different groups of test out of automatic mode which shall be selected by pressing coded push button. The test result can be confirmed with the printer; and

- Individual test measurement - specific item of function check shall be manually selected at the time of any specific adjustment. Test result can be confirmed with printer.

The selected measurement mode shall be displayed in the front panel with high brightness digital read out.

(ii) Range of Test

The engine analyser shall be capable of conducting the following tests: -

- Battery terminal voltage under no load condition
- Battery terminal voltage at starting
- Battery current at starting
- Battery terminal voltage at charging
- Engine cranking R.P.M. at starting
- Ignition primary coil voltage
- Engine idling R.P.M.
- Individual dwell angle
- Contact point voltage
- Charging current
- Diode test
- Ignition spark voltage
- Acceleration performance
- Power balance for individual cylinder
- Ignition timing
- Emission content analysis for CO, CO_2, HC and optional for O_2. Calibrating graduation for CO and CO_2 shall not be greater than 0.1
- Pulse length at cranking, idling & acceleration
- Injection cycle
- Injection voltage

Measurement of exhaust emission content against engine speed shall be made by means of infra-red carbon monoxide analyser. Results shall be displayed in high brightness digital readout.

(c) Calibration

Engine analyser shall incorporate a built-in automatic calibration checking device to facilitate quick and accurate adjustment.

(d) Accessories

The engine analyser shall comprise: -

(i) A remote handset which gives a full readout of test results. The handset shall also be able to give command for automatic test procedure; and

(ii) A full range of timing adaptors for vehicles equipped with diagnostic plug.

16.1.6.1.16 High Pressure Vehicle Washing Equipment

The high pressure vehicle washing system supplied shall consist of a high pressure washing machine, 30 metre high pressure water hose, retractable hose reel, lance, water pipework and all accessories.

The washing machines shall be capable to provide a flow rate of not less than 13 litre/minute in a pressure range adjustable from 0 to 9000 kPa by means of pressure regulator.

The pump shall be directly driven by a three phase, 380 Volt, 50 Hz totally enclosed fan-cooled motor with direct on line starter and built-in overload protection. The starter shall be equipped with on/off push buttons.

The machine shall be incorporated with a built-in water tank of minimum capacity of 65 litres in which a ball valve shall be provided for control of the flow of water from a water supply tank. A low level cut-off shall also be built in the water tank to stop the pump when the water level reaches a preset level.

The washing system shall be suitable for operation with addition of detergent. A detergent tank of minimum capacity of 8 litres shall be provided. Control of the detergent shall be made by means of a control valve in the machine.

The high pressure water pipework shall have a minimum working pressure of 9000 kPa. 30 metres of suitably sized high pressure water hose completed with washing gun and accessories shall be connected to the water pipework with suitable couplings. The water hose shall be housed in a wall mounted or floor mounted self-retracting hose reel.

The washing gun shall be of a straight twin lance type of length not less than 1 metre. A trigger shall be built in the handle of the washing gun to control the water flow. A set of four easily changed nozzles of different spray angles of 0^{o}, 15^{o}, and 45^{o} shall be provided.

Upon completion of the installation work, the high pressure water pipework shall be tested hydraulically to 1.5 times of the working pressure for 30 minutes without undue leaking. The hydraulic test shall be conducted in the presence of the Supervising Officer or his Representative.

16.1.6.1.17 Portable Battery Charger

(a) The battery charger shall be manufactured for vehicle battery charging and engine starting. The required duty of the battery charger shall be as follows: -

(i) output up to 100 A for 6 volts and 12 volts batteries;

(ii) output up to 60 A for 24 volts batteries;

(iii) engine starting current up to 600 A for 6 volts and 12 volts starters; and

(iv) engine starting current up to 300 A for 24 volts starter.

(b) The battery charger shall be of the mobile type with a maximum weight of 40 kg. The charger shall be suitable for operating on power input of 220 volt single phase 50 Hz. The battery charger shall comprise the followings: -

(i) ammeter showing charging current;

(ii) normal rate/high rate charging selector switch;

(iii) selector switch for 6 volt, 12 volt and 24 volt batteries;

(iv) timer for high rate charging;

(v) overload protection with reset;

(vi) polarity protection;

(vii) 10 metre a/c power input cable; and

(viii) 3 metres leads c/w heavy duty battery clamps with insulated grips and steel spring jaws.

16.1.6.1.18 Cabinet Grease Hose Reel and Cabinet Hose Reel

The reel shall be easy to use, self-retracting and can be held at full or intermediate extension. The hose outlet guide shall be fitted with a steel roller cluster to allow hose withdrawal from any angle and preserve correct alignment for 'winding on' during retraction.

16.1.6.2 EQUIPMENT AND MATERIAL

16.1.6.2.1 Pipes and Fittings

All pipes less than 80 mm diameter shall conform to ISO 65:1981/ BS EN 10255:2004 heavy quality and pipes of 80 mm diameter and above shall be to BS EN 10216-1:2013 and BS EN 10217-1:2019 with dimensions to BS 1600:1991.

Flanges shall be of the slip-on-welding type in accordance with ISO 7005-1:2011, BS EN 1759-1:2004 Class 150. Screwed fittings shall be made of malleable iron and threads shall comply with ISO 7-1:1994/Corr 1:2007, BS EN 10226-1:2004.

All jointing materials shall be oil resistant for the respective lubricating oil systems. Gaskets made of rubber or compressed asbestos fibre shall not be used.

Square elbows shall not be used, where practicable, long sweep bends shall be used in preference to round elbows.

Valves shall be of 'full way' type to allow free flow of waste oil. A sample valve shall be submitted to the Supervising Officer for approval before installation.

16.1.6.2.2 Valves for Compressed Air

The requirements stipulated in the Sub-section on Industrial Compressed Air System of this Part of the General Specification shall be followed.

16.1.6.2.3 Valves for Water

The requirements stipulated in Part of Plumbing Installation of this General Specification shall be followed.

16.1.6.2.4 Valves for Lubrication Oil

Valves shall be of ‘full way’ type to allow free flow of lubrication oil and made of bronze.

16.1.6.3 ERECTION AND INSTALLATION

16.1.6.3.1 General

The works scope shall include the interfacing works between the individual equipment and the builder’s works. The particular requirements of each individual equipment shall follow the manufacturers’ recommendations.

16.1.6.3.2 Pipeworks

Fabrication, painting, installation, inspection and testing of all pipeworks shall be in accordance with the Sub-section of Fuel Supply System of this General Specification.

16.1.6.3.3 Roller Brake Tester

The Installations shall include all the equipment associated with the brake tester, including the electrical wiring, control console and other accessories mentioned in the Particular Specification.

SUB-SECTION 16.1.7

GONDOLA

16.1.7.1 DESIGN

16.1.7.1.1 System Requirements

(a) The design of gondola and associated accessories shall be included under the Works.

(b) The gondola system shall be designed to achieve maximum safety and the driving system shall be reliable with minimum risk of tilting the cradle;

(c) Drum-type gondola with single-layer cable wiring type shall be adopted to gondola installation for all building height;

(d) Drum-type gondola with multi-layer cable wiring type may be considered for building height exceeding 60 m; and

(e) Dual traction hoist type gondola may be considered only for building height not exceeding 30 m where the building shape is irregular and drum-type gondola cannot be adopted.

16.1.7.1.2 Hoisting Operation for Gondola Cradle

The gondola cradle shall be capable of being lifted up and lowered down in the following manner to the appropriate levels including the roof for carrying out the required maintenance services on the curtain walls, windows and other working areas on the building facade.

(a) The vertical movement of the gondola cradle shall be smooth and free from lateral and rotational motions;

(b) At any maintenance level, the gondola cradle shall be held securely. It shall also be possible to carry out movement/luffing operation on the jib arms to permit the gondola cradle to be moved back and forth for contact with the building facade and warrant safe boarding of gondola cradle on the roof inside the parapet; and

(c) Gondola cradle shall be designed for a net safe working load of 250 kg excluding power cables and accessories. The safe working load shall be clearly marked on the cradle at a position approved by the Supervising Officer.

16.1.7.1.3 Travelling Operation on Roof

(a) Track type Gondola Installations

The requirements for track type Gondola Installations shall be as

follows: -

(i) The whole carriage of the gondola system shall be able to travel along the rails on the roof. The travelling system shall be effected through powered wheel drives along the rail nearer to the parapet. Free running rear wheel(s) with self-pivoting and self-alignment bearings shall be mounted on the carriage and sit on the other rail to take in slight but unavoidable rail misalignment and to ensure smooth corner movement;

(ii) The roof carriage shall be able to travel on steel rails on the roof so as to bring the gondola cradle to any maintenance position of the building; and

(iii) The travelling wheel shall be powered by either geared motor or hydraulic power pack and secured to the bottom of the carriage. Horizontal side guide wheels shall be installed to ensure the travelling wheels run on the centre of the rail surface and prevent overturning at all times. Each wheel shall be installed with self-lubricated bearings. Each drive shall be complete with a brake which is engaged automatically when power is cut. Drive units shall be detachable from the carriage and easily accessible for maintenance or replacement.

(b) Trackless type Gondola Installations

The requirements for trackless type Gondola Installations shall be as follows: -

(i) Guide rails shall be provided for trackless type Gondola Installations. The roof carriage shall be capable of travelling on the flat roof along the guide rail within the travelling boundary limits;

(ii) The roof carriage shall be powered by wheel drives running within boundary limits set by the horizontal guide rail. Free running rear wheel(s) shall be equipped with self-pivoting and self-alignment bearing mounted on the carriage; and

(iii) The travelling wheels shall be equipped with self-lubricated bearing and with a braking system which shall be activated automatically in case of power failure.

Electrical motor shall meet the requirements similar to those for the hoisting system as specified in Hoisting System for Gondola Installations of this General Specification whenever applicable.

The wheels shall be designed to withstand the total dynamic load from the gondola system when travelling.

16.1.7.1.4 Slewing Operation of Roof Carriage

The roof carriage shall be able to rotate by ±180º unless otherwise approved by the Supervising Officer as to suit site conditions.

The slewing operation shall be power operated by an electric motor. The roof carriage shall be suitably designed so that it will be clear from any obstruction such as parapet during slewing. It shall be possible to slew the roof carriage at any position along the rail.

16.1.7.1.5 Movement/Luffing Operation of Jib Arm

The movement/luffing of the jib arms of the roof carriage shall be power operated.

The outreach of jib arms shall comply with the requirements as specified in the Particular Specification.

The operation of the jib arms shall allow safe boarding of personnel from the roof.

The movements of the jib arms shall be synchronised mechanically.

16.1.7.1.6 Operating Speeds

The traversing speed of the roof carriage shall not exceed 20 m/min.

The hoisting and lowering speed shall not exceed 20 m/min.

In movement/luffing operation, the speed of the jib head shall not exceed 20 m/min.

In slewing operation, the linear speed of the cradle shall not exceed 20 m/min.

16.1.7.1.7 Cradle Restraint System

Cradle restraint system shall be designed, supplied and installed for the Gondola Installations. Otherwise, the cradle restraint system shall be of the wire rope type. Mullion Guide shall be preferred to other cradle restraint system.

(a) Wire Rope Restraint System

The design of the restraint system shall base on a plug-in mechanism. The anchor point forms the male part and the connection socket acts as the female part of the system. The system shall provide suitable locking facilities to prevent the connection socket from coming loose or falling out.

The restraint system shall comprise restraint wires, sliding rings, connection plug/sockets, anchor points and other necessary accessories. The system shall provide suitable locking facilities to prevent the connection socket from coming loose or falling out.

Each set of restraint wire, sliding ring and connection sockets shall form an entity.

The connection sockets of the restraint system shall be supplied and fixed on the building facade. These connection sockets shall be flush-mounted and recessed into the building facade. The restraint sockets shall be installed at external RC structure or curtain wall with a horizontal distance ranging from 2.3 m to 3.0 m and a maximum vertical distance of 15 m between restraint levels.

The restraint wire shall be designed for a safety working load of 2.4 kN and shall comply with other requirements applicable to the steel wire rope of the hoisting system. The anchor point and connection socket shall be galvanised for corrosion protection.

The design and installation method (including the precautionary measures) of the restraint system, as well as the related structural calculation of the restraint system, shall be submitted to the Supervising Officer for approval before manufacture and installation.

16.1.7.1.8 Cradle

The cradle shall include the following features: -

(a) All side boards of the cradle shall be fully cladded or of open mesh of aperture of max. 25 mm x 25 mm covering the full height of the cradle;

(b) A solid toeboard of 200 mm height from platform level shall be provided around the cradle;

(c) A trip bar shall be provided under the cradle and across the whole length of the cradle to stop the descent of the cradle when it strikes an obstacle. The trip bar shall be the lowest part of the cradle;

(d) One end of the cradle shall be partitioned off by wire mesh to form a storage space for the power cable where required and a control panel shall be provided inside the cradle;

(e) Suction cup system shall be provided to supplement the cradle restraint system to prevent undue lateral movement of the cradle during operation and to hold the gondola cradle close to the curtain wall. Interlock shall be provided to stop the operation of the gondola cradle during the engagement operation at the suction cup onto the wall. The details of the system shall be submitted for

approval by the Supervising Officer; and

(f) The cradle shall complete with all the necessary accessories for the restraint system.

16.1.7.1.9 Roof Carriage

Where appropriate, ballast weight shall be provided to ensure absolute system stability. The arrangement of drives shall ensure easy maintenance access, and removal without the necessity of dismantling other parts or components as far as possible.

The counterweights shall not be less than 3 times the weight necessary to balance the load on the projecting part of the outrigger when the platform is fully loaded to meet the statutory requirement as stipulated in Factories and Industrial Undertakings (Suspended Working Platforms) Regulations.

16.1.7.1.10 Carriage Enclosure

There shall be enough louvres or openings in the carriage enclosure to allow heat dissipation. A lockable door shall be provided for easy access to the manual brake release mechanism.

16.1.7.1.11 Hoisting System for Gondola Installations

(a) General

The hoisting system shall comprise an electric motor driven drum-type winch system installed in the roof carriage with fail-safe primary and secondary brakes and all the associated wire rope, sheaves and pulleys for hoisting the cradle.

(b) Suspension of Cradle

The cradle shall be suspended by 4 wire ropes. The anchoring position shall be suitably designed such that when one of the wire ropes breaks, the cradle shall remain reasonably stable and the tilting of the cradle shall not cause the material and tools such as water barrel inside the cradle to fall out.

The 4 wire ropes shall pass through the jib arms and wound on the winch drum installed in the roof carriage.

(c) Winch Drum

The winch drum shall be grooved and designed for single-layer spooling except allowed in drum-type gondola with multi-layer cable wiring type. A roller pressing the wire rope on the drum or other equivalent device shall be provided to prevent the rope from leaving the drum inadvertently. The end of the wire rope shall be securely fastened onto the drum. Under all operating conditions,

the rope anchorage shall be protected by not less than two full dead turns remaining on the drum when the cradle is at its lowest position. The diameter of the drum shall be such that the pitch circle diameter of the rope when wound onto the drum is not less than 23 times the nominal diameter of the wire rope used.

A wire rope spooling device synchronised mechanically with the rotation of the winch drum shall be provided to guide the wire rope positively so that the wire rope is accurately wound and channelled in the grooves.

If wire ropes are wound on more than one winch drum, the rotation of the winch drums shall be synchronised mechanically to ensure that the cradle remains level at all operating positions.

(d) Wire Ropes, Shackles and Pulleys

The factor of safety of each suspension rope shall be not less than 8 based on the maximum rope tension when related to the minimum breaking load of the rope.

The nominal diameter of each wire rope shall be not less than 8 mm.

The strength of rope termination shall be not less than 80% of the minimum breaking load of the rope.

Shackles and end fittings for ropes shall comply with the appropriate British Standards or other International Standard.

The wire ropes shall be properly guided throughout the path of travel. Pulleys shall be provided for all bends. All pulleys shall be fitted with self-lubricated bearings. The diameter of each pulley shall be compatible with the wire rope used. Suitable guidance device shall be provided to prevent the wire rope from slipping off the pulley.

(e) Braking System

The hoisting system shall be complete with a primary brake and a secondary brake. The primary brake shall be: -

(i) capable of stopping and sustaining the cradle even when the cradle is overloaded by 25%;

(ii) released when electrically energised; and

(iii) capable of being released manually in the event of a power failure or emergency. The means of releasing the brake shall ensure its immediate reapplication as soon as the control is released.

The secondary brake shall be mechanically operated independently of the primary brake. It shall be capable of arresting and sustaining the platform if the primary braking system fails and the cradle descents at a velocity of 10% above the rated value.

16.1.7.1.12 Control

(a) Control Panel

One control panel shall be provided in the cradle. One control panel and one pendant controller shall be provided on the roof carriage.

The control panel at the cradle shall be fabricated from stainless steel to IP54 enclosure and complete with a lockable door for front access. The control panel at the roof carriage shall be fabricated from sheet steel to IP54 enclosure and complete with a lockable door for front access.

All contactors, switches, fuses, relays and all other items of equipment necessary for the proper control and operation of the gondola system shall be housed in the control panel. The control voltage shall not exceed 50 V.

All control signals between the cradle and roof carriage shall be transmitted via the suspension wire ropes or suitable metal cores incorporated inside the suspension ropes. Separate control cable hanging from the roof carriage will not be accepted.

(b) Control Function in Cradle

It shall be possible to carry out the following control functions using the control panel in the cradle.

(i) Cradle Ascent and Descent -

Dead man type push buttons shall be provided to raise and lower the cradle.

(ii) Movement/Luffing of Jib Arm -

Dead man type push buttons shall be provided to move or luff the jib arm in and out.

(iii) Cradle Parking -

A dead man type push button shall be provided to by-pass the operation of the trip bar during cradle parking. It shall be possible to lower the cradle down fully until all castors rest on the floor by pressing this push button and the cradle descent push button simultaneously.

(iv) Emergency Stop -

A self-latch type emergency stop push button shall be provided to stop all operation of the gondola and activate an audio alarm and visual indication on the roof carriage. The emergency stop push button shall be reset by rotating the push button. The push button shall be in red colour. The emergency stop could be by-passed under maintenance or emergency recovery operations by a key switch housed inside the control panel on the roof carriage. Such key switch should be operated by a separate key normally kept in the Building Management Office.

(v) Intercommunication between Cradle and Roof Carriage -

An alkaline battery operated telephone suitable for outdoor use shall be provided. The telephone shall be detachable and connected to the control panel via a flexible cord.

(c) Control Function on Roof Carriage

Control Panel

The following control switches and indication lamps shall be provided on the control panel on the roof carriage.

(i) Mains ON/OFF Switch -

A key-operated mains ON/OFF switch shall be provided.

(ii) Operation Mode Selection Switch -

A key-operated operation mode selection switch shall be provided for selecting the position of control from the cradle to the roof carriage and vice versa. However, the emergency stop push buttons and the intercommunication telephone in the cradle and on the roof carriage shall be functional at all times independent of the position of the operation mode selection switch.

(iii) Emergency Stop Push Button -

A self-latch type emergency stop push button shall be provided to stop all operation of the gondola and activate an audio alarm and visual indication. The emergency stop push button shall be reset by rotating the push button. The push button shall be in red colour. The emergency stop could be by-passed by a key switch.

(iv) Mains ON Indication Lamp -

A green mains ON indication lamp shall be provided.

(v) Intercommunication between Cradle and Roof -

An alkaline battery operated telephone suitable for outdoor use shall be provided. The telephone shall be detachable and connected to the control panel via a flexible cord.

(vi) Alarm -

Red indication lamps shall be provided for the indication of each of the following faults: -

- Hoist motor trips;
- Emergency stop push button is activated;
- Cradle is overloaded; and
- Overspeed occurs.

An audio alarm shall be activated if one or more of the above faults occurs. The alarm and indication lamps shall be reset automatically when the above fault is cleared.

(d) Pendant Controller

A pendant controller connecting the control panel on the roof carriage via a 2 m long cable shall be provided. The pendant controller shall be suitable for outdoor use. A storage space shall be provided on the roof carriage for the controller.

It shall be possible to carry out the following control functions using the pendant controller: -

(i) Cradle Ascent and Descent

Dead man type push buttons shall be provided to raise and lower the cradle.

(ii) Movement/Luffing of Jib Arm

Dead man type push buttons shall be provided to move or luff the jib arm in and out.

(iii) Cradle Parking

A dead man type push button shall be provided to by-pass the operation of the trip bar during cradle parking. It shall

be possible to lower the cradle down fully until all castors rest on the floor by pressing this push button and the cradle descent push button simultaneously.

(iv) Emergency Stop

A self-latch type emergency stop push button shall be provided to stop all operation of the gondola and activate an audio alarm and visual indication on the roof carriage. The emergency stop push button shall be reset by rotating the push button. The push button shall be in red colour. The emergency stop could be by-passed under maintenance or emergency recovery operations by a key switch housed inside the control panel on the roof carriage. Such key switch should be operated by a separate key normally kept in the Building Management Office.

(v) Dead man type push buttons shall be provided to control the roof carriage to travel in both left and right directions.

(vi) Dead man type push buttons shall be provided to control the roof carriage to rotate in both clockwise and anti-clockwise directions.

16.1.7.1.13 Safety Devices and Interlocks

(a) Safety Devices

The following automatically operated safety devices shall be incorporated: -

(i) Overload Device

A mechanical overload device shall stop and sustain the cradle if the cradle is overloaded by 10%.

(ii) Primary Brake

The brake shall be applied automatically when the city mains fail.

(iii) Secondary Brake

The secondary brake shall be applied when the cradle overspeeds by 10%. The brake shall only be reset manually.

(iv) Uppermost Travel Limit

Limit switch shall be provided to stop the ascent of the cradle when it reaches its uppermost travel limit.

(v) Trip Ba

A trip bar mounted at the bottom of the cradle shall stop the descent of the cradle when it strikes an obstacle. If wire rope restraint system is specified, a trip bar mounted at the top of the cradle shall also be provided to stop the ascent of the cradle if a restraint socket is not detached as required.

(vi) Roof Carriage Travel Limit

Limit switches shall be provided to stop the roof carriage when it reaches its travel limits at the ends of the rail.

(vii) Jib Arm Movement/Luffing Limit

Limit switches shall be provided to stop the movement/luffing of the jib arm at its travel limits.

(viii) Power Supply Cable Limit

Limit switch shall be provided to stop the travel of the roof carriage to prevent the power supply cable connecting the roof carriage and the power socket on the roof from being pulled beyond its limit.

(ix) Slewing Limit

Limit switches shall be provided to stop the slewing of the roof carriage when the slewing limits are reached.

(x) Anemometer

An anemometer shall be provided at high level on upper roof for detection of wind speed. In case the current wind speed is exceeding 14 m/s, an audio and visual alarm shall be activated to alert the nearby operator.

(b) No power Emergency Descent

Facilities shall be provided in the roof carriage to lower the cradle safely without tilting to its lowest landing level at a controlled speed when the power supply fails or in emergency.

The above facilities shall be accessible through a lockable door or access panel at the sides of the roof carriage. The operation instructions of the no power emergency descent shall be clearly indicated on the roof carriage.

(c) Interlocks

The following interlocks shall be provided for the gondola operation: -

(i) Travel of Roof Carriage

The roof carriage can only travel on the rail when the cradle is at its uppermost position.

(ii) Slewing of Roof Carriage

The roof carriage can only be slewed when the cradle is at its uppermost position.

(iii) Direction Control

All push buttons that control gondola movements in two opposite directions shall be electrically interlocked.

16.1.7.1.14 Electrical Installations

(a) Power Supply

The power cable connecting the carriage to the power socket on roof shall be wound on a cable drum with self-rewinding device or equivalent to ease the rewind of the cable when the carriage is travelling on the roof. The minimum cable length shall be 20 to 30 m subject to the site conditions and approval by the Supervising Officer.

The power supply cable connecting the roof carriage and the roof socket outlet and the cable suspended from the roof carriage to the cradle shall be PVC insulated and suitably sheathed and protected wherever possible from damage of breaking, and should have sufficient cable strength to avoid the cables from being damaged by its own weight. It shall comprise with earthing conductor for connecting the roof carriage and the cradle to earth. All control cables shall be properly labelled with ferrules.

The supply voltage is 380 V, 3 phase, 50 Hz. All equipment shall be suitable for use at the supply voltage.

Eye bolt on the wall 500 mm beside the power plug for cable fixing sleeve shall be provided. The power plug for the gondola shall be of 3 phase 5 wire type and of enclosure of IP54 and with independent interlocking switches. The plug to the respective gondola system shall be provided.

(b) Electrical Safety Precaution

Protection shall be provided for all electrical parts, motors, cables

etc. against accidental or environmental damage. All circuit panels shall be lockable by key.

Motors shall be individually protected against overloads, undervoltage and short circuits.

Provision shall be made to ensure that in the event of the power supply being interrupted on one phase, no damages shall occur to the equipment and no uncontrolled movement shall be possible.

All electrical equipment shall have adequate mechanical strength and shall be adequately protected against mechanical damages and water ingress. Adequate mechanical strength refers to the ability to withstand all static and dynamic loads under the design operation conditions. In addition, design calculation taking into account the wind load, building structure and the counterweight etc. should be submitted for our approval. The gondola should be against ingress of water due to inclement weather. In addition, the enclosure of power plugs and sockets shall have the rating of IP54.

For carriage type system, the termination at the power plug shall be safeguarded against the pulling force of the cable rewinding drum on the roof carriage. Hanging loop or equivalent device for relieving the pulling force shall be provided.

(c) Earthing

All exposed metal parts of the roof carriage and the gondola cradle shall be connected together and earthed in accordance with BS 7671:2008 + A3:2015 and BS 7430:2011 + A1:2015.

(d) Lightning Protection

All parts of the gondola system shall be protected from lightning strike with lightning system complying with BS EN/IEC 62305-1:2011 or other relevant international standards.

All sections including movable sections of the rail tracks shall be bonded together using soft annealed copper strip of 25 x 3 mm or flexible copper strand of 475/0.5 mm diameter. The rail tracks shall be connected to the roof lightning protection conductor using soft annealed copper strip of 25 x 3 mm. All connections shall be of negligible resistance, metal to metal and mechanically sound with non-ferrous nuts, bolts and washers using clamps where necessary.

16.1.7.1.15 Special Requirement for Dual Traction Hoist Type Gondola

The dual traction hoist type Gondola Installations shall be equipped with, but not limited to, the following features: -

(a) The dual traction hoist system shall consist of two traction systems connected on the same shaft. Each traction system shall consist of two adhesion pulleys located one above the other and each formed by a pressure disc and a driving disc pressed against one another by pre-adjusted heavy duty springs. The wire rope shall travel around each pulley in form of 'S' shape and shall be seated on the bottom of the groove so as to eliminate differential traction caused by V-shape grooves;

(b) The traction hoist system shall comply with all other features in this section except for winch drum that is grooved and designed for single-layer spooling.

(c) Anti-tilting protection device shall be provided to stop the traction hoists should the inclination of the cradle exceed 5 degrees from the horizontal position. Separate push buttons shall be provided at the control panel such that function of the push button that would cause further tilting of the cradle shall be inactivated;

(d) Final upper limit safety device shall be provided to the cradle to cut all the electrical controls of the machine should the upper limit switch fail; and

(e) A slack rope safety device shall be provided to detect the tension of the wire rope and stops further lowering of the hoist should the tension falls.

16.1.7.1.16 Special Requirement of Gondola Installation Against Adverse Weather

(a) The gondola installation in its operating position should be designed to withstand the sustained wind speed up to 14 meters per second and gust up to 31 meters per second.

(b) The gondola installation in its docked position should be designed to withstand the wind pressure as given in the Code of Practice on Wind Effects in Hong Kong. All loose items of the gondola installation should be securable to fixed structure so that during the typhoon conditions, the items will not be disintegrated or damaged.

(c) A warning label should be fixed at the cradle to remind operator that "Gondola installation should not be used when there is thunder or storm in the vicinity, during rainy periods or when the strong wind signal is hoisted. The cradle should be returned to its docked position and be securely locked.".

(d) All winches, climbers and other lifting appliances or similar devices are required to be protected against the effect of weather, dust or material likely to cause damage to them that could result in a malfunction. Lockable maintenance access covers should be so fixed that they are not readily removable.

16.1.7.2 EQUIPMENT AND MATERIAL

16.1.7.2.1 Cradle

The cradle shall be of an integral construction of aluminium framework. The floor shall be made of non-skid aluminium plate suitably constructed to prevent accumulation of water. All side boards of the cradle shall be fully cladded or of open mesh of aperture of 25 mm x 25 mm covering the full height of the cradle.

Protective rubber cushion strips shall be fixed around the cradle at high and low levels and on all protruding parts of the cradle to minimise possible damage resulted from the bumping of the cradle against the curtain wall, window and building facade.

Non-marking soft rubber rollers shall be provided at each side of the cradle facing the curtain wall so that the cradle can travel vertically in close contact with the curtain wall without scratching or damaging the latter.

16.1.7.2.2 Wire Ropes

The suspension ropes shall be of galvanised steel. The construction details of the wire ropes shall be according to the Section on "Wire Ropes, Shackles and Pulleys" of this General Specification. Each rope shall be in one continuous length and free from joints or repairs.

16.1.7.2.3 Carriage

The travelling wheels shall be made of steel for track type gondola. For trackless type gondola, an outing coating of composite polyamide or equivalent shall be provided. The wheels shall be powered by either geared motor or hydraulic power pack and secured to the bottom of the carriage. Horizontal side guide wheels shall be installed to ensure the travelling wheels run on the centre of the rail surface and prevent overturning at all times.

Each wheel shall be installed with self-lubricated bearings. Each drive shall be complete with a brake which is engaged automatically when power is cut. Drive units shall be detachable from the carriage and easily accessible for maintenance or replacement.

16.1.7.2.4 Carriage Enclosure

The carriage shall be of a welded assembly and hot-dip galvanised with suitable reinforcements to provide a common chassis supporting the cradle hoisting equipment and the carriage drive unit.

The enclosure of the carriage shall be fabricated from 2 mm thick galvanised steel sheet or equivalent with reinforcement as necessary to provide the necessary strength to withstand the wind load. It shall be secured to the carriage with galvanised or stainless steel screws. The

enclosure shall be of suitable dimensions to allow easy access to the internal parts of the gondola for maintenance purpose.

16.1.7.2.5 Accessibility for Maintenance and Method Statement

The safe means of access, egress, working space for all servicing locations of the gondola, especially for building with special building form shall be proposed in the submission.

Method statement for maintenance and periodic statutory certification of gondola installation shall be proposed with consultation from maintenance agent and supported by demonstrations in later stage.

Method statement for replacement of gondola key components after completion of all building construction work shall be proposed.

16.1.7.3 ERECTION AND INSTALLATION

16.1.7.3.1 Installation of Track Rail

The track rail installation for gondola system shall be supported on the concrete plinth and secured by stainless steel foundation bolts. The size of foundation bolt shall not be less than M16.

The track rail fixed onto the supporting concrete plinths shall be on the same level and in parallel within the tolerance as recommended by the gondola manufacturer. The concrete plinths supporting the track rail shall be at intervals between 2 m and 3 m depending on the wheels loading.

Stainless steel foundation bolts, lock nuts and washers shall be installed by the Builder without damaging the waterproof layer on the roof.

Rubber pad shall be provided between the rail clip and the mild steel plate on the track rail for absorbing vibration.

A minimum of 5 mm expansion gap shall be provided along the track rail at a minimum length of 6m to allow thermal expansion. The rail sections shall be joined together using bolted or welded fishplates.

Turning of track rail shall be in easy bending radius in accordance with the gondola manufacturer's recommendation.

16.1.7.3.2 Erection of Gondola

Method statement for delivery and positioning of the gondola onto the roof shall be submitted to the Supervising Officer for approval prior to erection.

16.1.7.3.3 Installation of Restraint Socket System

When carrying out drilling for restraint socket installation and other builder's work at the building facade, precautionary measure shall be taken to prevent debris, hand tools and equipment etc. from falling onto the ground so as to avoid danger to human life.

Prior to installation of the restraint system, at least 5 complete sets of restraint system (together with the curtain wall portion) or 10% of the total complete sets of restraint system, whichever is greater, shall be tested in an approved and recognised laboratory in Hong Kong.

The original (and in triplicate) full laboratory load test report shall be submitted to the Supervising Officer. The laboratory load test shall show that the restraint system is manufactured for a safe working load of 2.4 kN and complies with all other requirements applicable to the restraint system. All costs involved in the laboratory load testing including provision of official laboratory load test report shall be included under the contract.

SUB-SECTION 16.1.8

HOT WATER SYSTEM

16.1.8.1 DESIGN

The design of hot water system and associated accessories shall be included under the Works.

The hot water system shall comprise a combination of the following equipment depending on the design: -

(a) Low pressure hot water boiler;

(b) Semi-storage type water-heated hot water calorifier; and

(c) Non-storage type water-heated hot water calorifier.

The water heater shall comply with the latest Green Specification published by Environment Protection Department. Unless otherwise specified, water heater shall have obtained Grade 1 under the Voluntary Energy Efficiency Labelling Scheme where applicable, or be of recognition type under the Voluntary Energy Efficiency Labelling Scheme from Electrical and Mechanical Services Department if relevant scheme are available for the type and rating of the water heater.

16.1.8.1.1 Low Pressure Hot Water Boiler

The hot water boiler shall be constructed to BS 855:1990 for a maximum working pressure of 1000 kPa and tested to 1500 kPa at the manufacturer's works, unless otherwise specified in the Particular Specification. Manufacturer's test certificate in triplicate is required. The boiler shall be of the genuine 3-pass wet back, radiant heat type with a combustion chamber concentric with the horizontal cylindrical shell and complete with a purpose made fully automatic burner. Non-3-pass boilers are not acceptable and reverse flame is counted as one pass only.

An internal water circulator in the form of a guide vane shall be incorporated to provide positive circulation within the boiler, thus ensuring a more uniform temperature gradient within the shell. The hot water boiler shall have a hydraulic resistance compatible to the Hot Water System. Cradles or footings shall be designed so that no distortion of the boiler shell and footings will take place due to thermal expansion or any static or dynamic loads.

The boiler shall be manufactured for front tube removal unless otherwise specified, and facilities should be provided for this purpose. Inspection door shall be fitted at the back of each boiler. Swing type back door shall not be provided. The maximum room length available, allowing for fire tube withdrawal from front of boiler, shall be as indicated in the Drawings. Boilers that require a space larger than available in the boiler room for fire tube removal will not be accepted. Connections of 50 mm

N.B. or smaller shall be screwed to BS 21:1985 and BS EN 10226-1:2004 and connections of 65 mm N.B. or larger shall be flanged to BS EN 1092-1:2018, BS EN 1092-2:1997 or BS EN 1092-3:2003 as appropriate.

(a) Boiler Rating

The boiler rating shall be as given in the Particular Specification. The boiler water flow temperature shall not be less than 85ºC with the return temperature approximately 15ºC below the flow temperature. The overall thermal efficiency of the boiler to BS 845:1987 shall not be less than 80% fired by the specified fuel as stated in the Particular Specification over the whole operating range.

(b) Boiler Insulation

The cylindrical boiler shell shall be efficiently insulated with mineral wool mattresses of minimum 50 mm thick wound closely to the shell and enclosed in a galvanised sheet steel casing of sufficient rigidity with suitable top coating. The touch temperature of the boiler anywhere shall not be higher than 60ºC.

(c) Boiler Accessories

Each boiler shall be provided with the following accessories suitable for the working pressure and temperatures stated: -

(i) Drain valve;

(ii) Double safety valve shall be of the enclosed spring type with padlock and discharge pipe;

(iii) Altitude/pressure gauge with 100 mm diameter dial level gauge cock and fixed red pointer indicating the normal working head of the boiler;

(iv) Burner thermostat;

(v) Open vent which shall be taken to a point above feed tank sufficient to overcome pump head at that point;

(vi) Fully automatic burner and controls;

(vii) A drip tray with sand for each oil burner;

(viii) Thermometer - with 100 mm diameter dial and fixed red pointer indicating the normal boiler operating temperature;

(ix) Combustion chamber, tubes, flue cleaning tools;

(x) Boiler water sampling valve & fittings;

(xi) Boiler controls; and

(xii) Fuel oil/gas consumption meters.

All mountings for controls and instrument shall be so fitted as to permit ready replacement without emptying the boiler. All controls and instrument shall be so chosen that the operating range lies between 40% to 75% of full scale range, calibrated in S.I. Units and accurate to within 5% of the controlling or measuring point.

(d) Boiler Instrumentation

The following instruments shall be mounted on a self-contained central boiler control panel with all necessary connecting pipes, cables and sensing elements associated with the instruments for monitoring boiler performance. Instruments provided shall be suitable for continuous use at their respective operating temperatures and pressures.

(i) Smoke Density Meter – When specified in the Particular Specification or requested under the latest requirements of the Air Pollution Control Ordinance (Cap.311), in each boiler flue, between the boiler and the first expansion joint as indicated in the Drawings, a double-path type smoke density detector of the approved manufacture shall be fitted to monitor the smoke density leaving each boiler. Appropriate tubes shall be installed diametrically opposed for mounting a light source monitoring unit. Both tubes shall be readily accessible for cleaning. The detector shall be wired in conduit to the smoke density meter on the boiler control panel. A smoke density meter shall be provided for each boiler together with indication lights and audible alarm. Each meter shall be calibrated to energise a green light when operating at normal smoke density and a red light and audible alarm when smoke density exceeds Ringelmann(s) number 1 to BS 2742:2009 "Use of the Ringelmann and miniature smoke charts".

(ii) Draught Gauge - Each boiler shall be provided with a draught gauge mounted at a suitable location on the boiler flue for measuring draught at boiler flue outlet.

(iii) Flue Gas Temperature Indicator - One for each boiler and of the thermal-electric type for indicating the flue gas temperature at each boiler exit shall be provided.

(iv) Boiler Water Flow Temperature Indicator - One for each boiler and of the thermo-electric type for measuring the boiler water flow temperature shall be provided.

(v) Boiler Water Return Temperature Indicator - One for each boiler and of thermo-electric type for measuring the boiler return temperature shall be provided.

(vi) One ambient temperature indicator.

(vii) One digital timer.

(viii) One hot water consumption flow meter.

(ix) Multiple Flue Gas Analysing Meter - Access panel shall be provided at boiler exhaust and be provided with at least one set of combustible multi-gas detection instrument with carbon monoxide, carbon dioxide and oxygen as the selected gases to analyse and adjust the combustion efficiency, particularly air/fuel ratio, for enhancement of combusion efficiency and facilitating continuous-commissioning. When specified in the Particular Specification, the adjustment shall be implemented by an oxygen and carbon monoxide combustion trim system to EN 12064, EN 60730, EN 1634, EN 298 to measure the oxygen level of combustion and continuously adjust the air to fuel ratio to a minimum oxygen value to ensure stoichiometric combustion at highest possible efficiency at the boundary of arising carbon monoxide.

(e) Boiler Controls

Each boiler shall be equipped with a full set of automatic controls in accordance with the requirements of the Boilers and Pressure Vessels Ordinance of Hong Kong and the following protection controls: -

(i) Automatic Low Water Level Cut-out - It shall be set to cut off the burner fuel supply when the boiler water level drops below the heating surfaces of the fire tubes and shall activate an audible and visual alarm. Control shall be of the lockout type with manual reset. Each boiler shall have its own alarm display.

(ii) Over-temperature Protection Thermostat - It shall be set to cut off the burner fuel supply when the boiler temperature rises to 10% above the normal nominal boiler operating temperature and shall activate an audible and visual alarm. Control shall be of the lockout type with manual reset. Each boiler shall have its own alarm display.

(iii) Automatic Firing Controls - The firing of the burner shall be fully automatic and of either the high/low/off type or the modulating type depending on the rating of the boiler.

The automatic firing controls shall comprise auto sequence controller, pre-and post-purge timer units, flame establishment unit, ignition transformer, burner motor starter with adjustable overload protection, photo-electric flame-failure device, burner run indicator, audible and visual lockout alarm with manual reset, high/low fire indicator (for high/low/off type burner only), and ON/OFF switch gear with indication lamp.

(iv) A manual temperature setting device for adjusting the nominal boiler water temperature from 0ºC to 100ºC.

The foregoing boiler controls shall be housed in a local control panel on each boiler, together with altitude/pressure gauge and thermometer, mounted as an integral part of the boiler package. The control panel shall be mounted on the boiler in such a manner as to be completely free of vibration, heat and moisture and to preclude damage to contactors and electronic devices. All controls shall be configured to fail safe.

(f) Burner

Please refer to Sub-section of Steam Boilers in Part 16 of this General Specification for requirements of diesel/towngas burner.

16.1.8.1.2 Semi-Storage Type Water-Heated Hot Water Calorifier

The semi-storage type water-heated hot water calorifier (hereinafter referred to as semi-storage calorifier) shall be manufactured to BS 853-1:1990 + A3:2011 to a Grade as specified in the Particular Specification. The maximum working pressure in the shell and battery shall be as specified in the Particular Specification. The semi-storage calorifier shall be hydraulically tested to 1.5 times the maximum working and design pressure respectively for both shell and heater battery at the manufacturer's works. Manufacturer's test certificate of each semi-storage calorifier shall be submitted, in triplicate, to the Supervising Officer before the equipment depart the factory and prior to shipment.

The shell of the semi-storage calorifier shall be mild steel to BS EN 10028:2009, BS EN 10029:2010, BS EN 10048:1997, BS EN 10051:2010 and BS EN ISO 9445:2010. The mild steel shell shall be lined internally with copper to BS EN 1172:2011, BS EN 1652:1998, BS EN 1653:1998 and BS EN 1654:1998/C106. The copper lining shall have a minimum thickness of 1.2 mm. The copper lining shall be constructed in such a way that no part of the mild steel shell shall come into contact with water. The mild steel shell and the copper lining shall be accurately rolled to shape and the ends shall be formed in presses with generous heel radii.

The heater battery shall be copper to BS EN 1057:2006 + A1:2010 and shall be formed from solid drawn fined copper U-tubes with brass tubeplate to BS EN 1652:1998 and BS EN 1653:1998/CZ123 or CZ112.

The heater battery shall have tube removal arrangement to facilitate cleaning and inspection of the battery. The position of the heater battery shall facilitate proper access for inspection/maintenance.

The semi-storage calorifier shall be configured to horizontal or vertical type as specified in the Particular Specification. Cradles or footings shall be designed so that there shall be no distortion of the calorifier due to thermal expansion or any static or dynamic loads.

A bolted inspection opening of minimum 455 mm in diameter shall be provided. Manhole shall be provided at suitable position to give proper access for inspection/maintenance.

Connections of 50 mm N.B. or smaller shall be screwed to ISO 7-1:1994/Corr 1:2007, BS 21:1985 and BS EN 10226-1:2004 and those above 50 mm N.B. shall be flanged to BS EN 1092-1:2018, BS EN 1092-2:1997 or BS EN 1092-3:2003 as appropriate. Sparge pipe fittings shall be installed for maintaining good thermal stratification of secondary water to ensure effective heat exchange.

The semi-storage calorifier shall be designed to combat the development of Legionnaires Disease. It shall be fitted with a built-in heater battery and an integral circulating pump to circulate water from the storage section through the heater battery and back into the storage section such that no stagnant cold water areas shall exist in the storage section during the operation of the calorifier.

The water shall be heated from cold to the set temperature in a single pass through the heater battery. The set temperature shall be regulated by a direct acting thermostatic control valve fitted on the primary side, which shall have quick response and modulation.

(a) Rating

The rated hourly output of the semi-storage calorifier shall be as specified in the Particular Specification. The heater battery shall be rated to bring the whole calorifier with secondary supply water from 10ºC to 65ºC with primary heating water at 82ºC and with corresponding primary return water not lower that 71ºC. The recovery time period of the semi-storage calorifier is specified in the Particular Specification.

(b) Insulation

The calorifier shall be insulated with mineral wool mattresses of minimum 50 mm thick wound closely to the shell and covered with galvanised sheet steel of sufficient rigidity with suitable top coating.

(c) Semi-storage Calorifier Accessories

(i) The semi-storage calorifier shall be provided with the

following accessories suitable for the working pressure and temperature as specified: -

- An integral pump which circulates water between the storage section and the heater battery section. The integral pump shall operate in such a way that hot water inside the storage section of the semi-storage calorifier shall achieve a temperature of 65°C during the operation of the calorifier;

- The temperature of the calorifier water shall be controlled at 65°C by means of an approved 3-way hot water flow control valve and an immersion thermostat. This control valve shall be in the by-pass position when de-energised. The 3-way hot water flow control valve shall be of fail safe type;

- Drain valve;

- Safety valve which shall be of the enclosed spring type with padlock and discharge pipe;

- Open vent;

- Pressure gauge with 125 mm diameter dial, level gauge cock and fixed red pointer indicating the normal working pressure in S.I. units;

- Thermometer with 125 mm diameter dial and fixed red pointer indicating the normal working temperature in S.I. units;

- Anti-vacuum valve;

- A high limit thermostat connected to an independent hot water isolating valve for protection against overheating of the calorifier; and

- Control panel for integral pump.

(ii) All mounting for controls and instrument shall be so fitted as to permit ready replacement without emptying the calorifier. All controls and instrument shall be so chosen that the operating range lies between 40% to 75% of full scale range, calibrated in S.I. units and accurate to within 5% of the controlling or measuring point.

(iii) The semi-storage calorifier, including heater battery, shell, pressure gauge, integral pump, 3-way hot water flow control valve, immersion thermostat, drain valve, safety valve, open vent, pressure gauge, anti-vacuum valve, high limit thermostat, pump control panel and all

other necessary valves and accessories, shall be of the packaged type manufactured by a single proprietary manufacturer.

(iv) The semi-storage calorifier including all equipment as mentioned in this Section shall be wholly imported and factory-built, assembled, piped and fully tested by a single proprietary manufacturer to form a "complete" set before shipment. The only field connections required on-site shall comprise external control circuitry, electrical power supply, and system external pipework and fittings as appropriate.

(v) Official manufacturer certificate shall be submitted to the Supervising Officer, in triplicate, for each semi-storage calorifier before the equipment depart the factory and prior to shipment.

16.1.8.1.3 Non-Storage Type Water-Heated Hot Water Calorifier

The non-storage type water-heated hot water calorifier (hereinafter to be referred as non-storage calorifier) shall be manufactured to BS 853-1:1990 + A3:2011 to a Grade as specified in the Particular Specification. The maximum working pressure in the shell and the maximum design pressure in the heater battery shall be as specified in the Particular Specification. The non-storage calorifier shall be hydraulically tested to 1.5 times the maximum working and design pressure respectively for both shell and heater battery at the manufacturer's works. Manufacturer's test certificate of each non-storage calorifier shall be submitted, in triplicate, to the Supervising Officer before the equipment depart the factory and prior to shipment.

The shell of the non-storage calorifier shall be mild steel to BS EN 10028:2009, BS EN 10029:2010, BS EN 10048:1997, BS EN 10051:2010 and BS EN ISO 9445:2010. The mild steel shell shall be lined internally with copper toBS EN 1172:2011, BS EN 1652:1998, BS EN 1653:1998 and BS EN 1654:1998/C106. The copper lining shall have a minimum thickness of 1.2 mm. The copper lining shall be constructed in such a way that no part of the mild steel shell shall come into contact with water. The mild steel shell and the copper lining shall be accurately rolled to shape and the ends shall be formed in presses with generous heel radii. Connections of 50 mm N.B. or smaller shall be screwed to ISO 7-1:1994/Corr 1:2007, BS 21:1985 and BS EN 10226-1:2004 and those above 50 mm N.B. shall be flanged to BS EN 1092-1:2018, BS EN 1092-2:1997 or BS EN 1092-3:2003 as appropriate.

The calorifier shall be configured to horizontal or vertical type, unless otherwise specified in the Particular Specification. Cradles of footing shall be designed so that there shall be no distortion of the calorifier due to thermal expansion or any static or dynamic loads.

The heater battery shall be copper to BS EN 1057:2006 + A1:2010 shall

be formed from solid drawn fined copper U-tubes with brass tubeplate to BS EN 1652:1998 and BS EN 1653:1998/CZ123 or CZ122. The heater battery shall have tube removal arrangement to facilitate cleaning and inspection of the battery. Manhole shall be provided at suitable position to give proper access for inspection/maintenance.

(a) Rating

The non-storage calorifier shall provide an output as specified in the Particular Specification when heated by primary heating water from 71ºC to 82ºC and supply hot water at temperature as specified in the Particular Specification.

(b) Insulation

The calorifier shall be insulated with mineral wool mattresses of minimum thickness of 50 mm wound closely to the shell and covered with galvanised sheet steel of sufficient rigidity with suitable top coating.

(c) Non-Storage Calorifier Accessories

(i) The non-storage calorifier shall be provided with the following accessories suitable for the working pressure and temperatures stated:

- The temperature of hot water at secondary flow of the non-storage calorifier shall be controlled at 82°C by means of an approved 3-way hot water flow control valve and an immersion thermostat. This control valve shall be in the closed position when de-energised and shall be of fail safe type;

- Drain valve;

- Safety valve which shall be of the enclosed spring type with padlock and discharge pipe;

- Open vent;

- Pressure gauge with 125 mm diameter dial, level gauge cock and fixed red pointer indicating the normal working pressure in S.I. units;

- Thermometer with 125 mm diameter dial and fixed red pointer indicating the normal working temperature in S.I. units;

- Anti-vacuum valve; and

- A high limit thermostat connected to an independent hot water isolating valve for protection

against overheating of the calorifier.

(ii) All mountings for controls and instrument shall be so fitted as to permit ready replacement without emptying the calorifier. All controls and instrument shall be so chosen that the operating range shall lie between 40% to 75% of full scale range, calibrated in S.I. units and accurate to within 5% of the controlling or measuring point.

(iii) The non-storage calorifier, including heater battery, shell, pressure gauge, integral pump, 3-way hot water flow control valve, immersion thermostat, drain valve, safety valve, open vent, pressure gauge, anti-vacuum valve, high limit thermostat and all other necessary valves and accessories, shall be of the packaged type manufactured by a single proprietary manufacturer.

(iv) The non-storage calorifier including all equipment as mentioned in this Sub-section shall be wholly imported and factory-built, assembled, piped and fully tested by a single proprietary manufacturer to form a "complete" set before shipment. The only field connections required on-site shall comprise external control circuitry, electrical power supply, and system external pipework and fittings as appropriate.

(v) Official manufacturer certificate for each non-storage calorifier shall be submitted to the Supervising Officer before the equipment depart the factory and prior to shipment.

16.1.8.1.4 Hot Water Circulating Pumps and Pipeworks

For each hot water boiler and hot water calorifier, one pair of standby and duty hot water circulating pumps shall be provided as generally indicated in the Drawings for hot water circulation. The capacity of these pumps shall be as specified in the Particular Specification. The piping layouts and hydraulic calculations shall be submitted for approval in selecting the suitable pump heads.

The circulating pump shall be efficiently balanced. Suitable vibration isolation shall be provided to eliminate noise and vibration from transmitting to the pipe system or floor.

Pump control panel shall be provided at locations as indicated in the Drawings for control of the circulating pumps. ON/OFF switch, power-on indication and hour-run meter shall be provided on the panels for each pump. Emergency stop push button shall be provided adjacent to each pump.

Valves shall be provided for the proper completion, working, isolation,

regulation and control of the Installations whether or not they have been specifically named.

Isolating valves shall be provided for all items of plant and equipment to ensure that each item can be removed, replaced or repaired without draining the pipework.

Isolating valves shall also be provided for all risers and droppers for the sectional isolation and draining of the pipework.

Calibration valves shall be provided at suitable locations for effective balance of water flow through the pumps and the calorifiers.

16.1.8.1.5 Pipeworks

Provision shall be made in the piping system for movement due to expansion and contraction by changes in direction of the pipework, by loops or by special expansion joints.

Supports, steadiers and guides shall be arranged to ensure that all movement is taken up by the change in direction of the pipework loop or joint. Where pipework is required to be prestressed for the purpose of reducing expansion stress under working conditions, the extent of the cold pull shall be as recommended by the manufacturer and submitted for approval.

All expansion bellows shall be supplied and carefully installed at suitable positions of the Hot Water System. The expansion joints or changes in direction of the pipework shall be correctly aligned and functional. Support at such joints shall be arranged to ensure that all expansion or contraction is taken up by the expansion joint or change in direction of the pipework. Expansion joints shall be prestressed for the purpose of reducing the expansion stress under working conditions, the extent of the cold draw shall be as recommended by the manufacturer and submitted for approval.

Expansion bellows for angular movements shall be provided with tie rods or hinges to take end thrust.

All expansion bellow joints shall be provided with external protection where exposed to damage. For axial bellows this shall comprise an external sleeve.

16.1.8.1.6 Thermal Insulation

Thermal insulation shall be applied to all pipework and fittings carrying hot fluid.

Pipework insulation shall include all pipework, valves, flanges, fittings, pumps and other plant items whether specifically mentioned or not.

All thermal insulation, including fixings shall comply with ISO

12241:2008, BS 5970:2012 and BS 5422:2009. All surface finishes shall comply with Class O surface spread of flame.

Thermal insulation shall be preformed rigid sections or slabs of glass or mineral fibre, protected and finished by fabricated hammered aluminium casings.

Preformed rigid insulation of glass or mineral fibre for hot fluid pipes shall comply with ISO 12241:2008 and BS 5422:2009.

16.1.8.1.7 Dual Feed and Expansion Tank

Duplicate dual feed and expansion tanks shall be provided. Dimensions and construction details shall comply with BS 417-2:1987, Galvanised Mild Steel Cisterns and Covered tanks and Cylinders, Type SCM 270 with capacity 191 litres each.

The tanks with covers should be positioned above the level of the highest point of the primary Hot Water System. Open vent pipes from boilers shall be returned to the top of the tanks. The cold feed connection to the boilers shall be taken from the side of the tanks. The tank inlet connection shall be fitted with a ball float valve and stop cock. The lever of the copper float shall be adjusted so as to accommodate the expansion volume.

The tanks shall also be provided with the followings: -

(a) A drain valve at the bottom with drain pipes leading to the nearest floor drain;

(b) An overflow which discharges in a visible external position; and

(c) A glass water level sight gauge protected by copper shield complete with cocks.

The tank shall be insulated with mineral wool mattresses of minimum 50 mm thick wound closely and covered with galvanised sheet steel of sufficient rigidity painted with suitable top coat. Shop drawings shall be submitted for approval prior to fabrication of the tanks.

16.1.8.1.8 Water Treatment Equipment

A chemical water treatment equipment kit shall be provided and installed for the Hot Water System and boilers. Dosing shall be applied to the return header of the hot water boilers.

The water treatment facility shall include dosage for prevention of water scaling and hot water corrosion. A nitrite-borate-organic non-toxic corrosion inhibitor or as recommended by boiler manufacturer shall be used for this application.

The chemical dosing equipment shall consist of a suitably sized chemical

pump, housed in a pump box and controlled by a timer and a level controller. Chemicals shall be stored in a polyethylene tank of approximately 200 litres capacity. Chemical feeding pipework shall include a check valve, a gate valve and a diffuser. All pipes for delivery chemicals in the water treatment system shall be of stainless steel Grade 316.

Before commissioning, the whole system pipework shall be chemically pre-cleaned by using high efficiency sequestrant and dispersant. Adequate amount of defoamer shall be applied to control foaming throughout the cleaning process.

Field-test kit shall be provided in the water treatment package including portable pH meter, TDS meter, corrosion inhibitor ppm test kit, etc.

The boiler system water shall be treated to comply with the following requirements: -

pH value	:	9 – 11
Total dissolved solids	:	Below 2000 ppm
Total hardness (as $CaCO_3$)	:	Below 10 ppm
Corrosion inhibitor	:	3000 - 4500 ppm or as recommended by boiler manufacturer

Sufficient quantities of chemical shall be provided for testing and commissioning and the initial half-year operation.

16.1.8.2 EQUIPMENT AND MATERIAL

16.1.8.2.1 Pipework

All pipeworks including the pipe material, thermal insulation, thermal expansion, fixing, fittings, welding, supports, valves, drain, vent and overflow pipe unless otherwise specified above in this section shall be installed in accordance with the Part of Plumbing Installation of this General Specification.

16.1.8.2.2 Valves

All valves shall be of a rating suitable for the design working pressure of the system.

Where flanged valves, etc. are specified, the flanges shall comply with the appropriate specification. Valve flanges and counter flanges shall be to the same International Standards and shall be of the same rating.

Isolating valves for hot water pipework shall be fullway gate type with solid taper wedge.

Combined stop and automatic isolating valves shall be of the dashpot type

with bronze piston and dashpot and nickel alloy valves seat and disc.

The following valve schedule shows the type and the standard to which all valves shall comply: -

(a) Check Valves for Hot Water Pipeworks

Size	Valve Type	Standard
54 NB and below	Bronze Check	BS 5154:1991
67 NB and above	Cast Iron Check	BS EN 12334:2001

(b) Hot Water - General Isolating

Size	Valve Type	Standard
54 NB and below	Bronze Gate valve	BS 5154:1991
67 NB and above	Cast Iron Gate Valve	BS EN 1171:2002

(c) Hot Water - For Water Flow Modulating

Size	Valve Type	Standard
54 NB and below	Bronze Globe Valve	BS 5154:1991
67 NB and above	Cast Iron Globe Valve	BS EN 13789:2010

Holes in covers or in gates for screwed portions or spindles shall have full threads of a length not less than the diameter of the spindle over the threads. Glands shall be machined to provide a running fit between the spindle and the stuffing box. Stuffing boxes shall be properly packed, or fitted with 'O' rings which may be located in plastic bushes.

Gate valves shall have split or solid wedge gates.

Regulating valves on circuits shall have characterised plugs and a lockable indicator on the spindle to show the proportional opening. Pressure gauges shall be provided on the up and down streams of the regulator.

Fullway gate valves shall have metal wheel handles. Wedge gates and all seatings, including the top of the wedge and the associated back seat on the bonnet facing, shall be accurately machined, or alternatively manufactured, to provide a back seating.

The flaps of non-return valves shall be of light construction and shall pivot on a spindle secured by two phosphor bronze hangers. Each valve shall be fitted with a stop to prevent undue movement of the flap and shall be as silent as possible in operation. The valve shall be constructed so that minimum resistance is offered to gravity flow.

Automatic air vent shall be of the mechanical type and works at a maximum operating pressure of 14 bar and maximum operating

temperature of 260ºC. The body and cap of the automatic air vent shall be made of brass to BS EN 12165:2011 with stainless steel capsule.

16.1.8.2.3 Safety and Pressure Relief Valves

Safety and pressure relief valves shall comply with ISO 4126-1:2013 and the relevant International Standards for calorifiers or pressure vessel to which they are connected.

The PR valves shall be sized to match the plant operating pressure and relief capacity so as to give the appropriate degree of protection.

Valves shall be of the totally enclosed spring loaded type with padlock.

Relief pipes from valves to discharge shall be run in full bore tubing of the same quality as the service vessel or pipeline with which the valve is associated. Where any low point occurs in the discharge run, it shall be fitted with a 15 mm size waste pipe carried clear of the insulation for drainage. The discharge and waste pipes shall be run to visible safe positions to be approved by the Supervising Officer.

16.1.8.2.4 Strainers

Unless otherwise specified, strainers shall be of Y-type with stainless steel screen Grade 304-S16 to BS1449:1991 with cast iron body suitable for operating temperature up to 250°C with designed operating pressure not less than 16 bar.

16.1.8.2.5 Hot Water Circulating Pumps

The Circulating Pump shall be of the centrifugal type with direct drive and mounted on a common bed-plate or flange mounted. Circulating Pumps of small flow rate shall be of the vertical in-line type of mounting which shall be either floor mounted or pipe mounted.

The pump shall have cast iron casing, gun metal impeller and stainless steel shaft and shall be suitable for an operating temperature of up to 100ºC. Bearings shall be of the seal-for-life ball or roller type.

Pump motors shall be suitable to operate on 380 V/3-ph./50 ±2% Hz, of totally enclosed fan-cooled type, type of protection IP54 to IEC 60529:2013/Corr 2:2015 "Specification for Degrees of Protection provided by Enclosures", with insulation class F to IEC 60085:2007, and provided with motor starters with adjustable overload protection relay and under-voltage release.

The continuous rating of all motors shall cover the full specified range of duty plus a further 10% margin for the pumps.

16.1.8.3 ERECTION AND INSTALLATION

16.1.8.3.1 Pipework and Fittings

All pipeworks including the pipe material, fixing, fittings, welding, supports, valves, drain, vent and overflow pipe unless otherwise specified above in this section shall be installed in accordance with the Part of Plumbling Installtion of this General Specification.

16.1.8.3.2 Safety and Pressure Relief Valves

Valve shall be mounted with the centre line of the valve spindle in vertical position to ensure that the valve reseals properly after operation.

Relief pipe connections shall be of equal bore to the vessel connection.

SUB-SECTION 16.1.9

INDUSTRIAL COMPRESSED AIR SYSTEM

16.1.9.1 DESIGN

16.1.9.1.1 System Description

The design of industrial compressed air system and associated accessories shall be included under the Works.

The compressor system shall consist of air compressors compressing naturally aspirated air into air receivers. The air receiver outlet shall be connected to a distribution main. Compressed air shall be distributed to consumption points via compressed air pipework for industrial type applications.

All the system components shall be designed to the working pressure as specified in the Particular Specification and the relevant design codes.

The type of compressor shall be specified in the Particular Specification.

The compressor shall be controlled by automatic regulation system which shall be capable of performing one of the following functions as required: -

(a) Constant Running - with the compressor running continuously at constant speed, to load and unload the compressor automatically so as to maintain the pre-selected pressure;

(b) Automatic Stop/Start - when the demand for air is more intermittent, the electric motor shall be automatically stopped and started so as to maintain the pre-selected air pressure;

(c) Manual Dual Control - a combination of constant running and automatic stop/start control. A manually operated changeover switch shall be incorporated so as to permit selection of one or other of the functions; and

(d) Automatic Dual Control - a combination of constant running and automatic stop/start control. The compressor shall be stopped after a pre-determined period of unload running. The stop time delay shall be adjustable up to a period of 20 minutes.

For compressors working in parallel, check valves for preventing rotation reversal shall be installed on the discharge side of compressors which do not have built-in non-return valves.

An air governor shall be provided to regulate the compressor output automatically in accordance with air demand. Demand shall be based on receiver pressure and the governor shall be adjustable both for pressure

and differential range; the pressure differential shall not exceed 15% at its closest setting.

Air line filters, lubricators, pressure regulators and drain traps shall be provided at appropriate location throughout the distribution network to maintain cleanliness of the compressed air and for protection of the pneumatic equipment.

Relief or safety valves shall be fitted to the compressed air system in places where pressure is likely to be accumulated so that such pressure can be released automatically once it exceeds the maximum allowable working pressure by more than 10%.

Venting pipes from relief or safety valves shall be of the full bore tubing and the same quality as the pipework with which the valves are associated. The discharge point of vent pipes shall be terminated at a safe position subject to approval by the Supervising Officer.

Unless otherwise specified, the noise level of the compressor shall not exceed 80 dB(A) measured at a distance of one metre from the compressor during operations.

16.1.9.2 EQUIPMENT AND MATERIAL

16.1.9.2.1 Air Compressors - Screw Compressor

The compressor shall be of single stage, air-cooled, rotary "screw" type with oil injection.

The male and female rotors of the compressor shall be carried on heavy duty double ball/roller bearing of long design life. The rotors shall be precision-ground with no relative sliding movement and the moving elements shall be well balanced to reduce the bearing load. The rotors shall be housed in a high quality cast iron casing.

The compressor unit shall incorporate a replaceable high efficiency paper cartridge filter at the suction end.

An air valve, of air-tight type, shall seal the intake of the compressor at 'no load' or 'stop' condition to prevent the air/oil mixture in the compressor from discharge through the air intake.

An efficient oil separator with easily removable filter shall be fitted at the compressor outlet to limit the coolant carryover to less than 5 ppm. A finned tube type after-cooler with forced draught cooling shall be provided. The cooling fan shall be used to cool the oil cooler as well. A full-flow oil filter with replaceable elements of 10 micron size shall be fitted in the oil return line to the compressor.

A combined check and minimum pressure valve shall be fitted at the oil separator outlet to ensure that the high pressure air cannot back flow from

the system and a rapid rise in air pressure in the oil separator to supply oil for lubrication and cooling.

Oil shall be maintained at an optimum operating temperature of around 55°C to prevent condensation of atmospheric moisture in the system. A thermostatically controlled three-way valve shall be provided for by-passing the oil cooler.

The compressor and motor unit shall be resiliently mounted onto a steel section baseframe through anti-vibration pads.

The complete assembly including the cooling fan etc. shall be housed in a steel enclosure with fully removable steel panels. The panels shall be fabricated from galvanised steel sheets of not less than 1.2 mm thick, infilled with sound absorbent, flame proof glass fibre acoustic lining. Sufficient air intake opening area shall be allowed for in the enclosure. The noise level, measured at 1 m from the enclosure shall not exceed 75 dB(A) while the machinery is in full load operation.

The instrumentation and control panel shall be fabricated from galvanised sheet steel and ergonomically designed to give the operator a clear and comprehensive monitoring of the whole system. Push button or touch-sensitive control switches with indication lamps or L.E.D.'s showing the status of the machine shall be provided. Control voltage shall not exceed 50 V.

(a) The instrumentation and control panel shall incorporate the following items: -

  (i) Start button.

  (ii) Stop button.

  (iii) Reset button.

  (iv) Hours run meter.

  (v) Large clear dial indicating the delivery air pressure.

(b) The plant shall be automatically shut down under the following fault conditions with light indication:

  (i) High compressed air temperature.

  (ii) Motor overloaded.

The contactors, fuses, relays and all other items of equipment necessary for the proper control and operation of the compressor shall be housed in the panel with front access for maintenance. It shall be lockable to prevent unauthorised access and malicious damage to the equipment inside.

The electric or electronic component shall be labelled appropriately to indicate its service either by function or by code, in which case a code index shall be securely attached to the panel for easy and positive identification.

16.1.9.2.2 Air Compressors - Reciprocating Compressor

The compressor shall be of the single acting, two stage air-cooled type.

The air compressor shall be complete with: -

(a) Air receiver of appropriate type and capacity;

(b) Electric motor complete with star-delta starter & support frame;

(c) Automatic start/stop control devices;

(d) Air inlet filters & silencer;

(e) Valves including safety valves;

(f) Intercooler;

(g) Aftercooler;

(h) Air pressure gauge; and

(i) Oil pressure gauge.

and other standard accessories for the complete and satisfactory operation of the air compressor.

The air compressor shall deliver the compressed air into the air receiver through suitable non-return valves. The air receiver shall be equipped with fusible plugs, safety valves, a drain valve, pressure gauge calibrated in kilo-pascals and an air inlet connection.

The air compressor, once started, shall be fully automatic in operation and provision shall be provided for pressure controlled automatic starting or stopping of the compressor depending on the demand for compressed air.

To avoid starting under load, the compressor shall be equipped with automatic unloading devices to bleed off the compressed air from the cylinders whenever the compressor is started or stopped. Bleeding of the trapped air into the crankcase will not be accepted.

Should the trapped compressed air be released every time the compressor is started, manual operation of the unloading device shall be provided for maintenance purpose and sufficient warning sign shall be provided in the Compressor Room and in the O&M manual to draw the attention of the maintenance personnel.

16.1.9.2.3 Compressor Drive

The compressor shall be driven by electrical motor directly or through belt drive.

Belt drive shall be in the form of multi-vee endless belts complying with BS 3790:2006. The belt loading shall be such that should one belt fail, the remaining belts can transmit the full load.

Direct drive for non flange-mounted motors shall be by means of a flexible coupling.

The compressor and motor shall be mounted on a common bedplate. Means shall be provided for adjusting belt tension for belt drive or for aligning the motor and compressor for direct drive.

Flange mounted motors will be acceptable when the motors are attached to and supported and aligned from compressor frames.

16.1.9.2.4 Compressor Lubrication

Lubrication shall be automatic throughout such that frequent start-up and long running of the compressor shall require only minimum attendance and inspection.

For pressure feed systems, lubrication shall be independent of the direction of compressor rotation and an oil pressure gauge shall be fitted.

Effective and accessible means shall be provided for checking the oil level, topping up and draining the sump.

16.1.9.2.5 Compressor Valves

The compressor valves shall be manufactured from stainless steel or other durable material to ensure trouble free service and long life.

The valves shall be of automatic, unequal pressure operation type. Access to valves for maintenance shall be possible without disturbing pipework and ancillary equipment.

Reciprocating compressor valve and valve port type shall be such that no inlet valve can be fitted instead of a discharge valve and that no discharge valve can be wrongly fitted in such a way as to prevent the improper discharge of air.

16.1.9.2.6 Intercoolers and Aftercoolers

All compressors of two or more stages shall be fitted with intercoolers, relief valves and pressure gauges between each stage and shall be provided with drainage arrangement.

All compressors of discharge pressure over 700 kPa shall, unless otherwise indicated, be fitted with aftercoolers, relief valves and pressure gauges and shall be provided with drainage arrangement.

Both the intercooler and aftercooler shall employ the same medium for cooling as used on the cylinders.

16.1.9.2.7 Air Receivers

The receiver shall be an all steel welded fabrication complying with BS 5169:1992 Class III Grade E for a storage capacity up to 500 litres and Class II Grade C for storage capacity above 500 litres.

The receiver shall be either vertically or horizontally mounted to suit the requirements. It shall have welded bosses fitted with properly sized supply, delivery, drain, and safety valves; pressure gauge, handholes or manholes, fusible plug where called for, identification plate and supporting feet.

The receiver shall bear legible and permanent indication of the following: -

(a) Manufacturer's identification mark and serial number;

(b) Hydraulic test pressure;

(c) Date of hydraulic test;

(d) The reference of standard to which it complies;

(e) Class number and grade letter;

(f) Design pressure;

(g) Maximum design temperature; and

(h) Minimum design temperature.

The above indication shall be engraved on an attachment welded to the vessel solely for this purpose. Name plates riveted to such an attachment is also acceptable.

A copy of the manufacturer's certificate of construction and a copy of a certificate issued by a recognised inspection body in the country in which it was constructed, certifying that the receiver complies in all respects with the requirements of this standard shall be submitted. In addition, the certificate shall include particulars of the marking on the receiver.

For those air receivers not constructed to BS 5169:1992 but up to an equivalent or superior international standard, details of such standard in English and the relevant design/construction drawings for the receivers shall be submitted for approval by the Supervising Officer. The drawings

shall be certified by a recognised inspection body in the country in which it was constructed.

16.1.9.2.8 Pipework

Compressed air pipework including vent pipes shall comply with the following current standards: -

(a) BS EN 10255:2004 for steel tube sizes up to 80 mm nominal bore, 'Medium' grade tube for pressure up to and including 1000 kPa, and 'Heavy' grade tube for pressure above 1000 kPa; and

(b) BS EN 13480:2012 and BS EN 10217-2:2019 steel tube for sizes greater than 100 mm nominal bore.

All steel tube used for compressed air pipework shall be galvanised both internally and externally. Screwed fittings shall be of galvanised malleable iron conforming to BS EN 10242:1995.

Screw joints, excluding screwed on flanges, shall be used for steel pipes up to and including 80 mm nominal bore, provided that the maximum permissible pressure does not exceed those specified BS EN 13480:2012. Taper pipe threads shall be used with taper threaded fittings and shall comply with BS 21:1985.

Welded flange joints shall be used for steel pipe with maximum permissible pressure in excess of those specified in BS EN 13480:2012 and for steel pipe above 80 mm nominal bore irrespective of pressure.

Flanges and bolting of flanges shall be in accordance with the recommendations made in BS EN 1515-1:2000: Sections 3.1 & 3.2 and BS EN 1092-2:1997.

Gasket materials for use with flanges complying to BS EN 1092 shall comply with the dimensions given in BS EN 1514-1:1997.

16.1.9.2.9 Valves

Stop and isolating valves up to and including 80 mm nominal diameter shall be of the copper alloy screw down type, and shall comply with, and be used within the limits laid down in BS 5154:1991. For sizes greater than this the valves shall be of the cast steel gate type and shall comply with, and be used within the limits laid down in ISO 10434:2004.

Steel ball valves which comply with, and are used within the limits laid down in ISO 17292:2004 may be used as an alternative to both of the aforementioned types of valves.

Pressure reducing valves for main distribution pipe lines shall be of the fullway type for use with compressed air at the highest working pressure of the system. Valves shall be capable of an adjustment of ±20% of the rated reduced pressure and lockable in any position within the range. A

relief valve shall be fitted on the low pressure side of the valve and a pressure gauge shall be fitted on each side of the reducing valve.

Relief or safety valves shall be made of bronze or gunmetal and shall be of the enclosed adjustable spring loaded type. It shall comply with and be used within the limits laid down in ISO 4126-1:2013. Valves and seats shall be accessible and capable of being reground and reseated. The discharge shall be arranged to avoid injury to personnel.

The relief valves shall be so designed that the moving parts are efficiently guided and have adequate clearance under all conditions of service. In addition, the breakage of any part or failure of any device shall not obstruct free and full discharge through the valve.

Each relief valve shall incorporate permanent markings as follows: -

(a) Manufacturer's identification;

(b) Direction of flow;

(c) Set pressure; and

(d) Flow capacity of valve.

16.1.9.2.10 Air Line Filters

The air line filters shall be designed for the working pressure of the system with aluminium die casting body, bronze filter element and a float type auto drain.

Filters of the 5 micrometer grade shall be used. The bowl assembly shall be of the transparent plastic type with bowl guard. For applications involving thinner solvents or other hydrocarbons which may attack the plastic bowls, metal bowls with level gauge shall be used.

16.1.9.2.11 Air Line Lubricators

Air line lubricators shall be of the oil fog type with adjustable drip.

Lubricators shall be suitable for the working pressure and air flow rate of the system with aluminium die casting body, transparent plastic type bowl and bowl guard. For applications involving thinner solvents or other hydrocarbons which may attack the plastic bowls, metal bowls with level gauge shall be used.

16.1.9.2.12 Pressure Regulators

Pressure regulators shall be of the balanced diaphragm type and incorporate a built-in pressure relief feature.

The regulator shall be designed for the working pressure of the system and fitted with pressure gauge and limit indicator. The adjustment knob

shall be of the locking type.

16.1.9.2.13 Drain Traps

The drain traps shall be float-operated and automatic in operation.

16.1.9.2.14 Pressure Gauges

Pressure gauges shall have their scale marked in kPa and comply with ISO 4126-1:2013 and BS EN 837-1:1998. A gauge cock fitted with anti-syphon pipe shall be provided at the points which require pressure readings.

The operating pressure of the gauge shall be within the middle of the full scale reading and provided with a red field on the scale to indicate the maximum allowable working pressure.

The dial of the pressure gauge at a level above 1.8 metre shall be 150 mm whilst that at a level below 1.8 metre shall be 75 mm.

16.1.9.2.15 Quick Release Couplings

The couplings shall be so designed that they automatically seal the air pressure on the upstream side and vent the air pressure on the downstream side, so as to prevent a hazard when the adaptor is removed. Other connectors for flexible hose shall be of the fullway screwed union type with seating rings.

16.1.9.3 ERECTION AND INSTALLATION

16.1.9.3.1 General

A schematic flow diagram of the compressed air system, properly framed, shall be provided in the Compressor Room.

For emergency shut-down of electric motor, a self-latch red stop button shall be provided at a readily accessible location within one meter from the compressor to interrupt power to the motor.

16.1.9.3.2 Installation of Air Compressors

The air compressor shall be bolted onto the plinth through anti-vibration mounting to prevent vibration generated by the set from being transmitted to the building structure.

Sufficient space shall be allowed around each compressor unit for inspection, necessary attention, and dismantling when required.

Independent isolators shall be provided for each compressor.

The compressor shall be installed with an efficient air intake filter

designed and constructed in such a manner that it shall be easily accessible for inspection & cleaning and shall be as close as possible to the compressor.

The compressor shall also be fitted with a suction silencer to reduce the intake noise to a level in compliance with the Noise Control Ordinance. The silencer shall be located at the downstream of the air filter so that the filter is subjected to minimum pulsation effects.

All piping connected to the compressor shall be arranged with flanged fittings or unions to permit easy removal of the compressor or components at any time, without disturbing the piping.

The discharge pipe from the compressor to the aftercooler or receiver shall be free to expand under heat and shall not be in contact with wood or any flammable material.

In multiple-unit compressor systems, valves shall be provided for isolating each compressor. Check valves alone shall not be relied upon for isolating compressors.

Where an isolating valve or non-return valve is installed between the air compressor and the receiver, the pipe line on the compressor side of the valve shall be protected by a suitable safety valve so adjusted as to permit the air to escape as soon as the design pressure of the piping or compressor is exceeded. The safety valve shall be of sufficient size to relieve the full output of the compressor without the pressure rising 10% above the set blow-off pressure.

For air compressors over 5.5 kW, an ammeter with phase selector shall be provided.

16.1.9.3.3 Guards and Insulation

All moving parts of the machine shall be guarded so as to comply with the requirements of Factories and Industrial Undertakings Ordinance (Cap. 59), Occupational Safety and Health Ordinance (Cap. 509), and other subsidiary legislation made under the Ordinances.

The guards shall be easy to remove and re-install, and shall have sufficient rigidity to withstand deflection and prevent rubbing as a result of bodily contact.

Pipework or other parts with an external surface temperature in excess of 60^{o}C and which may be accidentally contacted by personnel in normal operation shall be guarded or insulated. Other high-temperature pipework shall be clearly marked in accordance with ISO 3864-1:2011 and BS 1710:2014.

16.1.9.3.4 Air Distribution Pipeworks

All compressed air distribution pipeworks shall be adequately supported.

Service connections shall branch from the top of the main using long sweep bends and outlet points shall be provided at a height of approximately 1.5 m from the floor level unless otherwise specified.

Each take off pipe shall be provided with one outlet point with a self-sealing, quick release coupling for connecting pneumatic tools or instruments.

The distribution system shall be self-draining by arranging the pipework sections to slope down in the direction of air flow, to convenient drainage points. Each drainage point shall be fitted with an automatic drain trap and the drainage points shall be installed at intervals not exceeding 30 metres of pipe run.

The main shall fall approximately 1 in 100 in the direction of flow. At suitable intervals, the main shall be brought back to its original height by using two 90^{o} long sweep bends and with the provision of a drain leg at all the low points.

When pipe mains are subject to variations of temperature, e.g. the main runs outside from one building to another, a separator and drain leg shall be fitted at the point where the air flow enters the building so that the moisture condensed is collected and removed.

If a pipeline is laid direct in the ground or embedded in concrete, the pipes shall be either flange jointed or continuously welded and shall be protected by a wrapping of two layers of 'Denso' tape or products having equivalent function and performance. In addition, the line shall be sloped and a drain fitted at the lowest point with an access hand hole and cover. The size and position of the hand hole shall be as indicated in the drawings.

For pipes on straight runs of more than 10 metres, slightly oversized brackets shall be used to allow axial movement and accommodate expansion, but provide lateral restraint. Under no circumstance shall the supporting interval exceed those recommended in the Code of Practice for the Selection and Installation of Compressed Air Services by British Compressed Air Society.

Unless otherwise indicated in the drawings, brackets shall be used to support the pipe runs.

The pipelines through which the discharge air passes to the aftercoolers or air receiver shall always be kept clean internally to avoid combustion of the oily carbon deposits. The piping shall drain toward the aftercooler and receiver so that gravity assists the flow of oil through the hot zone.

SUB-SECTION 16.1.10

SEWAGE PUMPING SYSTEM

16.1.10.1 DESIGN

16.1.10.1.1 System Requirements

The design of sewage pumping system and associated accessories shall be included under the Works.

The pumps shall be designed for handling sewage containing solid particles up to 60 mm diameter. The pumps shall be designed for operation in completely or partially submerged conditions.

The motor shall be capable of tolerating a maximum continuous starting frequency of 10 times per hour without overheating.

The power developed by the motor shall not be less than 110% of the power required by the pump.

16.1.10.1.2 Pump Control

There shall be two modes of operation, the 'Automatic Mode' and the 'Manual Mode'.

Normally the system will be put under automatic mode of operation. In this mode, one of the 2 pumps shall be on duty while the other pump shall be in "standby". The standby/duty operation shall be interchanged after each pumping operation, and the 2 pumps shall alternate in turn to operate as standby/duty. The main purpose of this arrangement is to ensure even tear and wear of the pumps. However, provision shall be made to ensure that if one pump is taken out of service or fails, the other pump shall be able to operate to take over all necessary duties of the former pump.

The operation of the pump shall be completely automatic as set by the appropriate level regulators as indicated in the Drawings. When the sewage level rises to a certain predetermined level, the duty pump shall automatically start under the control of the regulator at that level. The duty pump stops when the sewage level falls to the lowest level regulator. If there is an upsurge of sewage, and the duty pump fails to cope, the standby pump will be started if the level rises to the higher level regulator. Under this circumstance, both pumps shall then be operating until the sewage reaches the lowest level regulator.

There shall be another extra high level regulator to provide high level alarm when both pumps are incapable of discharging the incoming sewage flow.

The level of the level regulators shall be adjustable and determined on-site.

No-flow protection device shall be provided for each pump. The running pump shall be locked out on detection of no-flow condition. An adjustable timer shall also be provided to inhibit the no-flow detection system during starting of pumps.

Manual operation for these pumps shall be provided for individual control of the pump operation for maintenance purpose. However, the pump shall be stopped automatically by the lowest level regulator.

An emergency stop button shall be provided adjacent to the pumpset at a location approved by the Supervising Officer.

16.1.10.1.3 Control Panel

The control panel shall consist of a lockable isolator for each pump, suitably rated HRC fuse for each pump and control circuit.

An alarm system shall be installed within the control panel for indication of high sewage level in the pump chamber, pump running with no-flow condition, motor overload, single phasing and power supply under-volt. A button shall be provided to mute off the above audible alarm but the appropriate indication red light shall remain energised until the fault is cleared.

16.1.10.2 EQUIPMENT AND MATERIAL

16.1.10.2.1 Pump

Pumps shall be manufactured to meet the following requirements: -

Pump casing	Cast Iron to BS EN 1564:2011 Grade 220
Impeller	Austenitic Cast Iron to BS EN 13835:2012 Grade L – Ni Cu Cr 1563
Shaft	High Tensile Stainless Steel to BS EN 10084:2008, BS EN 10087:1999, BS EN 10088-1:2015, BS EN 10095:1999 and BS EN 10250-1:1999 & 4:2000 Grade 431S29
Bearing	Ball/Ball, no regreasing shall be required until after 3 years of continuous operation
Seals	Carbon/Tungsten Carbide
Bolts, nuts, screw, washer and hold-down blots	Stainless Steel to BS EN 10084:2008, BS EN 10087:1999, BS EN 10088-1:2015, BS EN 10095:1999 and BS EN 10250-1:1999 & 4:2000 Grade 316

The sewage pump shall meet the designed capacity on normal operation.

The sewage pump shall be arranged with flanged connection to the discharge pipe. Each pump shall be closely coupled to the totally enclosed built-in submersible electric motor suitably rated for the pump.

Two mechanical seals, made of the material specified in above, shall be provided to seal off the leakage of sewage from the pump to motor.

The hydraulic efficiency of the pump shall be within the highest efficiency range at the specified operating point.

16.1.10.2.2 Pump Motor

The motor shall comply generally with BS 4999-141:2004 + A1:2010 and shall operate on a 3 phase, 380 volt, 50 Hz supply.

The motor shall be of the squirrel cage, totally enclosed type with insulation of Class "F" to IEC60085:2007. Enclosure type of IP68 to IEC 60529:2013/Corr 2:2015 shall be used.

The motor shall be capable of supplying its rated output at rated speed at any voltage in the range 94% to 106% of the nominal voltage and shall satisfactorily operate continuously at its rated duty without excess temperature rise within this range.

The motor shall have its own built-in cooling system which shall enable the motor to operate continuously at its rated current regardless of whether the electric motor is above or below the surface of the liquid.

16.1.10.2.3 Control Panel

The cubicle of the control panel shall be vermin proof and lockable to prevent vandalism. The thickness of sheet steel shall not be less than 2 mm and shall be properly reinforced with angle iron. The cubicle shall be constructed to conform to IP44 to IEC 60529:2013/Corr 2:2015 for indoor use and IP65 for outdoor use.

All indicators, relays, control switches, push-buttons, fuses and other auxiliary apparatus shall be provided with labels clearly stating their function. The labels supplied shall be inscribed in English and Chinese characters.

16.1.10.2.4 Level Regulator

Level regulators of PVC sheathed stainless steel Grade 316 electrodes shall be used.

16.1.10.2.5 Pipework

Pipes and fittings shall be of ductile iron. Ductile iron pipes and fittings

shall be to BS EN 598:2007. Pipes shall be to Class I. Flanges shall be PN16 to BS EN 1092-2:1997 but made of ductile iron. The first and last flanges shall match the Building Contractor's provision.

Flanges shall be machined smooth, drilled to BS EN 1092-2:1997: PN16 and jointed with a 3 mm thick full face rubber gasket to BS EN 1514-1:1997. All fixing and holding down bolts, nuts and anchors etc. shall be of stainless steel to BS EN 10084:2008, BS EN 10087:1999, BS EN 10088-1:2015, BS EN 10095:1999 and BS EN 10250-4:2000 Grade 316.

16.1.10.2.6 Valves

Gate valves shall be made of cast iron of full bore clearway pattern to BS EN 1171:2002 with solid wedge gates and outside screws and shall have a minimum normal pressure rating of PN10. Ductile iron flanges shall be PN16 to BS EN 1092-2:1997.

Reflux/non-return valves shall be to BS EN 12334:2001 and of single door swing check pattern having cast iron housing and gunmetal seat. Door shall have shock absorbent facing of suitable material. Both gate and non-return valves shall have stainless steel stem of Grade 316.

16.1.10.3 ERECTION AND INSTALLATION

Discharge connection and stainless steel Grade 316 guide bar and chain shall be supplied and installed for automatic connection of the pump to the discharge end and for the lifting up of the pump for inspection without entering into the sump. The lifting chain shall have intermediate hooking rings for easy lifting.

The guide bars shall be properly installed and the alignment shall not exceed the tolerance as required by the manufacturer or obstruct lifting up of the pump.

Adequate supporting arrangements for all pipes shall be provided.

Pipes with puddle flanges shall be provided where they pass through the walls of concrete substructures.

SUB-SECTION 16.1.11

PNEUMATIC TUBE TRANSPORTATION SYSTEM

16.1.11.1 DESIGN

16.1.11.1.1 System Requirements

The design of pneumatic tube transportation system and associated accessories shall be included under the Works.

A pneumatic tube transport system, which may be a single zone or a multi-zone system, is a distribution network of tube system, in which carriers of various sizes containing small items are driven by air. The prime mover is a blower that can alter the direction of the air in the tube as required to move the carrier through the system. The destination of the carrier may be controlled by diverters that switch the carrier from one branch to another. A central controller ensures that carriers are transported through the network.

The system shall be comprised of sending and receiving stations, a central control and supervisory unit, a transfer tubing network, transfer switching devices, or transfer units, blower units, carriers, and all other ancillary facilities for the completion of the System.

The system shall allow for future extension up to 25 zones and 500 stations or to the quantity specified in the Particular Specification.

The system shall be able to be extended by adding inter-linkages or connections among the zones. The inter-linkages shall provide routes to inter-zone transference.

16.1.11.1.2 Operation Requirement

Sending / receiving priorities function shall be provided to ensure that urgent items can be handled with a higher priority.

The dispatching, routing, spacing and storage of carriers shall be directed by the control centre to provide automatic, unattended transmission of carriers between all stations.

The system shall provide shortest route travel. Transactions between stations on the same zone shall process to the closest turnaround point to the destination.

The system shall provide a smooth, quiet, safe and efficient transaction.

The system shall be modular type such that it can be easily modified and/or extended. The system shall be suitable for both horizontal and vertical conveyance of the material or specimens specified.

The system shall be configurated such that each zone in the system can be shut down and isolated from the rest of the System for maintenance or repair without affecting the operation in other branch lines.

Facilities shall be provided to ensure that the materials or specimens being transported by System shall not be damaged or spilled out.

Carriers shall be smoothly accelerated and decelerated. No shock, violent agitation, or excessive vibration is permitted.

16.1.11.1.3 Carrier Velocity

The System shall provide at least 2 transport speeds, standard speed and safety speed. The standard speed and the safety speed shall not to cause material/specimen damage or spillage or affecting the specimen characteristics while satisfying the delivery time performance requirements specified in this and the Particular Specification. However the maximum speed should not be more than 6 m/s.

16.1.11.1.4 Carrier Distribution

Transaction shall not be accepted at the source station if the carrier cannot be delivered to the destination station.

Carriers in process shall be delivered to dumping station if a failure occurs in the route while they are in transit.

When a power failure occurs at the control centre, all transactions information remaining in process shall be stored in memory and the carriers in-transfer shall be delivered to their destinations when power is restored.

The system shall allow prioritising the stations on sending or receiving order so that the system can process the urgent carrier on the expressway in the shortest time.

“Automatic Homing” function shall be provided for the system. Each carrier shall be equipped with “transponder” to identify its own “home address”. The system shall be fitted with corresponding devices that enable the carriers to return its individual home station automatically.

16.1.11.1.5 System Control

Closed loop control shall verify that commands to the system equipment have been properly executed before the next segment of each transaction is started.

The destination selection capability of any station shall be controlled from the central control and supervisory unit.

Component diagnostics shall be performed at central control and supervising unit and the results shall be displayed for troubleshooting.

Station software feature enhancements shall be capable of being downloaded to the stations from the central control and supervising unit.

The system shall incorporate automatic recovery procedures to find and deliver carriers that do not reach their destination without maintenance personnel intervention as far as possible.

An emergency shutdown special function shall be provided at any designated station. This special function shall be used to immediately shut the system off if a carrier with a leaking specimen is received at a station. Immediate shutdown of the system shall provide for a safer environment by minimising the spread of contamination throughout the system by other carriers.

When the automatic fire alarm system is triggered, the pneumatic tube system shall be able to complete all transactions being in transfer. The fire alarm signal shall be displayed in all sending/receiving stations and the system is required to shut down to prevent the spread of smoke or flame via the system.

16.1.11.1.6 Sending and Receiving Stations (Stations)

Stations shall be of the recessed front-loading type.

The Stations shall be electronically activated and motor driven. Loading of the carrier shall be safe and easy on operation. The station door shall be automatically closed after the carrier loaded and open after the carrier dispatch.

Stations shall be wall mounted and the mounting height to the top of the Stations shall be 1.55 m above the finished floor level unless otherwise specified to suit the operational need.

Stations shall comprise of independent dispatcher and receiver of carrier. Thus outgoing carrier shall be capable of being inserted even when the station is receiving.

All mechanical and electrical components shall be accessible and removable for repair or replacement.

Electronic control units shall be solid state, plug-in units for fast replacement and shall be interchangeable with units in other stations.

All visible metal surfaces shall be factory painted. Bright metal finish parts shall be stainless, brushed aluminium or chrome plated.

The standard station dispatcher shall be capable of dispatching not less than the specified design payload or 5 kg payload at the designed speed.

Position of station dispatching and receiving mechanisms shall be detected by contactless sensors such as optical or RFID sensors.

A full sensor and audible full indicator shall be provided in each station to detect and indicate that a station cannot receive any more carriers. A message shall also indicate the overload and other status information. The condition shall automatically be reset upon carrier removal from receiver.

Each station shall be provided with a storage rack for not less than 5 empty carriers.

An indication or operation algorithm to guide the user entering the destination of the carrier to be sent.

An audible and visual carrier arrival signals shall be provided at each Station to indicate the arrival of carriers.

On receipt of the carriers arrival signal, the signal shall be activated until silenced by the staff.

For Stations which are remote from the manned locations, remote alarm panels shall be provided at such manned locations and wired up to the corresponding Stations, so that appropriate carrier arrival alarm can be relayed to its designated destination. All the fault indications/alarms of the corresponding Stations shall also be repeated in the remote alarm panels.

16.1.11.1.7 Carrier Arrival Receivers

Carrier arrival receiver shall be provided and installed for each Station. The receiver shall be with sufficient size and capacity so as to accommodate the carriers allocated to the Station.

The receivers shall be fixed under the Stations and positioned to allow the arrival carriers to be stored in them without blocking the exit tubing under the Stations.

The receivers shall be padded with sound-absorbing and soft material so as to provide a soft landing of the carriers.

16.1.11.1.8 Display and Keypad Unit

All Stations shall be provided with an interface for user control. This interface shall include a cleanable keypad and display.

The visual display shall be a liquid crystal display.

All text message used on the display shall be in English.

When performing a shipment, the display shall show, but not be limited to, the following messages to the users: -

(a) An indication to show whether the Station/ System is ready to accept a shipment request;

(b) A display echoing the destination of a carrier to the user for his confirmation before dispatching a carrier;

(c) A message to confirm the completion of a shipment; and

(d) Rejection messages shall be provided.

16.1.11.1.9 Station / System Availability

Whenever the Station or the System is out of service for any reason, the screen shall display “system out of use” or “station out of use” as appropriate. In addition, a warning light shall be given out.

The display shall incorporate with station availability lights. The signals shall indicate “the Station is available for use”, “the system is busy” and “the Station / System is out of service”. The colour of the indication shall be subjected to the approval of Supervising Officer.

(a) Alarm message shall be displayed for the following conditions: -

(i) Incoming carriers at the receiving station;

(ii) To empty a station receiver when it is full; and

(iii) Receiving station is not available.

(b) A cleanable membrane keypad shall be provided for entering instructions / control. The operation of the interface shall be simple and easy to be understood. The keypad shall provide a control to the following functions: -

(i) Send/Enter key - to activate dispatch after destination selection or enter data for special functions;

(ii) Cancel/Clear key - to allow for transaction cancellation or clearing of display during special function activation;

(iii) Special function key - to request special features;

(iv) Directory - listing station addresses;

(v) Instruction compartment - for operating and special function instruction;

(vi) Redirecting carriers to other Stations;

(vii) Giving visual and audible warning when a wrong instruction is input;

(viii) Giving visual and audible warning when faults are detected in the System;

(ix) Selecting the carrier transferring speed; and

(x) Cancelling wrong inputs.

The display and keypad unit shall provide an activatable station directory. Through browsing the station directory in the help menu, user can have a quick reference to the address of the Stations in the System.

16.1.11.1.10 Central Control and Supervisory Unit

Data stored in the central control and supervisory unit shall not be lost even in case of the mains power supply failure. Once the power supply is restored, the unit shall self-start automatically and complete all outstanding carrier transactions.

2 sets of central controllers, one set as duty and one set as hot standby shall be provided to perform the function in planning and controlling the transmission of the carriers in the System.

The central controllers shall be capable of being re-programmed so as to cater for the future extension or modification to the System.

(a) The computer or microprocessor in each controller, the interfacing circuits, etc. shall be modular in configuration and shall be built up from solid-state components throughout. Each circuit module shall be easily removable for maintenance. The system shall perform the following functions: -

(i) control on sending / receiving transaction among the Stations, and control all movement of carriers;

(ii) system self-test;

(iii) provision of System status information;

(iv) automatic purging cycle;

(v) system software re-configuration;

(vi) continuous polling of all Stations;

(vii) control, change sending / receiving priorities;

(viii) assign any station to priority;

(ix) manual control;

(x) PIN or Touch Key Security system;

(xi) independently shut down and start up any station, zone or system for isolated diagnostic interrogation or repair; and

(xii) interrogate any system component through command/execute/ respond diagnostic programme. Allow for ability to manually process any carrier through the system from the keyboard also.

(b) A key board security mode shall be selected to control access to the displays.

Each central controller shall be multi-tasking which means that several programmes can be operated in the controller simultaneously.

Each central controller shall be able to controlling up to 25 zones and 500 Stations or to the quantity specified in the Particular Specification.

Sufficient facilities shall be provided to store and display the following information: -

(i) the addresses of the Stations sending or receiving carriers;

(ii) the paths of the carriers being transmitted;

(iii) the transmission times; and

(iv) the System status.

(c) Each central controller shall have a cleanable keypad and display for instruction input.

Each central controller shall provide an interface provision which shall be connected to the automatic fire alarm system, so that in case of fire, the controller shall able to direct the system to complete the transaction in transfer and display the signal in all sending/receiving stations and then shut down the System so as to prevent the spread of smoke or flame via the System.

Each central controller shall also be provided with sufficient interfacing ports for the connection to modem, printer, and the Building Management System.

The workstation shall be located at Pneumatic Tube Plant room and used to monitor and display in real time the progress of all carriers transporting in the System. The display shall include, but not be limited to, the following information: -

(i) At sending Station
- carrier loaded
- carrier accepted
- carrier dispatched

(ii) At transfer switching devices
- carrier arrival
- carrier departure

(iii) At receiving station
- carrier approaching
- carrier arrived
- carrier ejected to the receiver

(iv) A display header for all displays shall be provided that show the date, time, daily transactions, total transactions, system status, number of alarms and full stations.

(v) Station List - shows addresses available and their selection codes.

(vi) System Traffic Display - shows status, transaction in process and number of pending transactions for each zone.

(vii) Alarm Displays - shows failure details and corrective action for any condition that has interrupted normal system operation.

(viii) Station Status Display - shows operational data and assignments for a specific station.

(ix) Station Maintenance Display - shows accumulated operating cycles for all stations.

(x) Blower Maintenance Display - shows accumulated operating time/cycles for all blowers.

(xi) Transaction Summary Display - shows total transactions by zone and by station.

(xii) Priority Summary Display - shows transaction priority assignments for all stations.

(xiii) Diagnostic Display - allows keyboard operation of stations, carrier transfer units and blowers for recovering undelivered carriers, confirming malfunctions, etc.

(xiv) Configuration Display - allows entry of system layout and operating parameters.

(xv) Purge Display - used to automatically purge selected zones or the system of transient carriers.

(xvi) The workstation shall provide a graphics display to show the System schematics and the working/health status of

the major components in the System, and locations of all carriers in traffic etc.

(xvii) The workstation shall have sufficient memory to store at least the last 1000 carrier transaction records.

(xviii) A printing facility shall also be provided to record the transaction information.

(d) Based on the transaction records, the workstation shall perform transaction analysis on the System.

A printer shall be provided for the following functions: -

(i) Provide hard copy record of individual alarms and transactions.

(ii) Print time and date each alarm is cleared.

(iii) Print time of power loss and power restoration for control centre power failures.

(iv) Any system event such as transactions and alarms can be recorded on a CD for off-line analysis.

16.1.11.1.11 Diverters

The noise level of diverters shall be less than 50 dBA at 1 metre distance.

Diverter shall be simple and require minimum maintenance.

Diverters shall meet all safety and fire resistance requirements.

16.1.11.1.12 Blower Unit

The blowers shall be suitably sized and shall provide sufficient driving force to transport carriers containing the material specified along the transfer tubing network in all tubing, stations, transfer units etc. and any future extension of the system.

The blowers shall provide sufficient vacuum and pressure driving force in the tubing network to transport fully loaded carriers at a speed up to 6 metres/sec or the designed maximum speed specified in the Particular Specification.

All blowers shall be able to operate simultaneously and independently.

Blowers shall be suitable for ceiling, wall, or floor mounting.

Blower packages shall be self-contained units with the blower, motor, shifter, starter and controls factory assembled on a vibration dampened frame.

The vacuum, pressure and atmospheric ports of blower shall have mufflers to minimise noise.

One blower package per zone shall be provided.

The blower assembly shall allow complete and clear access to service mechanical and electrical components.

The blower system shall be provided with automatic shutdown control.

Piping shall be complete with all necessary tees and elbows to suit the system requirements. The locations of the blowers, the transfer units, and the tubing networks etc. shall be properly coordinated and matched to suit the system requirements and component performance/limitations.

A shifter or similar provision shall be used to set the System for vacuum, pressure or idle operational modes.

The shifter shall use dynamic braking instead of physical contact type brakes to eliminate downtime caused by worn or faulty brakes.

Filters shall be provided at the air intake point of the blower units to ensure the cleanliness of air inside the tubing network.

16.1.11.1.13 Drive Motors

Drive motors shall be suitable for operation from an a.c. supply of 380 V 3 phase 4 wire 50 Hz. The motors shall have a rating sufficient to start their connected equipment when fully loaded.

Each motor shall be capable of tolerating the starting frequency up to 85 times per hour without overheating.

In addition to other clauses of this part of Specifications, the motors shall comply with IEC 60034-1:2010, IEC 60072-1:1991, IEC 60072-2:1990 and IEC 60072-3:1994 whichever is appropriate. Some particulars are as follows: -

Type of Enclosure	:	IP54
Rating	:	Maximum Continuous Rating
Speed	:	Not exceeding 3000 rpm

16.1.11.1.14 Flow Control Valve

Flow control valves shall be provided to alter the airflow direction in the transfer tubing network without changing the rotation direction of the blower units.

The valves shall be able to break the airflow in the network when the carrier almost reach its destination.

16.1.11.1.15 Carriers

The body of the carriers shall be made of autoclavable, transparent, clear molded high impact resistant and distortion free plastic.

The carriers shall be fully accessible, equipped with side opening safety swivel self-lock lids on both sides to prevent them from opening during transportation.

Inside both end of the carriers shall be covered with elastic material. A fully loaded carrier shall not be damaged even it is dropped from a height of 1.5 m. New replaceable wear bands and latches shall be provided which shall eliminate gluing process.

Both the interior and exterior of the carriers shall be suitable for steam or chemical sterilisation.

The internal dimension of the carriers shall not be less than 400 mm in length and 110 mm in diameter. It shall be able to carry material up to 5 kg in net weight or the specified design payload.

The number of carriers shall be sufficient to enable an efficient operation of the System. In any case, there shall be at least 5 carriers at each Station available for transportation.

'Protective Insertion' shall be provided for holding the handing material such as blood samples, test tube, drugs, small surgical tools, etc. as specified in the Particular Specification.

16.1.11.1.16 Carrier Detectors

Contactless detectors such as beam or RFID detectors shall be provided to monitor the progress of the carriers throughout the System.

For beam detectors, they shall only operate in the invisible part of the light spectrum and shall not be sensitive to daylight or any form of artificial lighting so as to prevent faults arising from false detection of extraneous light.

The detectors shall be mounted on the transfer tubing securely with precise assembly using injection moulded brackets and shall be removable without damaging the tubing network.

The external of the detectors shall have a LED to indicate its working status.

Whenever a blockage in the System is detected, an automatic purging programme shall be activated to clear the blockage and purge it to the receiving tube. The receiving tube shall be located at the Pneumatic Tube

plant room. If the automatic purge is not successful, an alarm signal shall then be given out and kept energised until reset manually by the responsible staff.

16.1.11.1.17 Safety

Access to the System shall be secured to prevent unauthorised entry.

The transfer area room shall permit safe access to all components in the System which require inspection, service or maintenance.

16.1.11.1.18 Station Braking

In order to ensure quiet and smooth operation, the arrival carriers shall be able to decelerate gradually. Once the carrier comes to a complete stop, it shall then be released to a collection receiver or a carrier storage below the Station.

Acoustic treatment shall be provided in the Stations to reduce the noise generated. The noise level shall be less than 65 dBA at 1 metre distance.

16.1.11.1.19 Station Accessory

A rack for the storage of at least 5 carriers shall be provided at each station.

An encapsulated Stations Directory and Operation Instructions shall be indicated in each station.

16.1.11.1.20 Dumping Station

Dumping station shall be provided in the Pneumatic Tube Plant Room so as to facilitate removal of blockages from the System.

16.1.11.1.21 Empty Carriers Storage Station

In ensuring the availability of empty carriers at each station, empty carriers storage stations or equivalent facilities shall be provided. With these facilities, when there is a demand, users can call empty carriers from the storage stations to their Stations. However, when there is a surplus of empty carrier at the Stations, carriers can be forwarded and deposited in the storage stations.

At least one empty storage station for each zone of the System shall be provided and the storage capacity shall not be less than 4 empty carriers.

Attenuation of the plant noise and/or vibration emanating from equipment shall be provided. The overall pneumatic tube transport system shall be selected which shall not produce a noise level in excess of 65 dBA at all times when the plant and equipment are in full operation. Necessary noise attenuators and anti-vibration mountings for all equipment shall be allowed and for and guaranteed to have the deflection necessary giving a

total transmissibility of not more than 10%. Mounting sizes shall be determined by the respective equipment manufacturers and the mountings shall be installed in accordance with the manufacturer's instructions. The specified duties or capacities of all systems shall not be degraded when fitted with acoustic or anti-vibration treatments.

16.1.11.2 EQUIPMENT AND MATERIAL

All tubing and bends shall be of appropriate outside diameter, AISI Type 321 stainless and acid-proof chromium-nickel steel or equivalent performance material. The wall thickness shall not less than 2 mm. A smooth internal bore must be retained throughout the tubing network specifically produced for the pneumatic tube transport system.

All bends shall have a centre line radius to suit the system requirement, with a uniform cross-section free from wrinkles and distortions. No expanded bends shall be allowed in the System.

All pipework and fittings of the same material shall be supplied by a single manufacturer to ensure uniformity of standards and composition.

All pipework delivered to site shall be new and provide with certificates from the factory to identify different grades, materials and manufacturers.

All pipework and fittings, accessories, joints and joining media used shall be suitable for the substance conveying in the pipes and shall not deteriorate due to atmospheric action.

All pipework shall be free from burrs, rust and scale and shall be thoroughly cleaned before installation.

All pipework shall be fabricated as far as practicable to site dimensions such as building dimensions and the sizes and positions of plants on the site.

16.1.11.3 ERECTION & INSTALLATION

16.1.11.3.1 Pipework

All pipework shall be adequately supported in such a manner as to permit free movement due to expansion and contraction. Pipework supports shall be arranged as near as possible to joints, valves and changes in direction. The spacing of the supports shall not exceed 3 m.

Vertically rising pipes shall be adequately supported at base of riser to withstand its total weight. Branches shall not be used to support the riser.

Pipes shall be arranged so as to provide subsequent access to any pipe for maintenance or removal purposes.

The anchors and supports shall be constructed of galvanised steel sections of appropriate strength and stiffness to an acceptable international / material standards.

Galvanised steel anchors capable of resisting the maximum stresses shall be provided. Cast-iron chairs with at least two wrought-iron stirrup bolts shall be used, the bolts being provided with sufficient thread to ensure an effective grip on the tube.

The configuration of the network shall permit assembly and disassembly so as to accommodate future extension and modification.

Except for the section of tubing immediately connected to the Stations, all horizontal transfer tubing shall be installed above the suspended ceiling level.

Suitable airtight compound shall be applied for seal joints.

For identification purpose, the tubing network shall be clearly marked / labelled.

As tubing network is prone to build up dust due to an electro-static charge created by the transport of the carriers through the tubing network, action shall be taken to earth the network so as to eliminate the electro-static charge in addition to the electrical bonding as required by BS 7671:2008 + A3:2015.

Tubes shall not be built solidly into walls and joints, and must not be positioned within the thickness of walls, floor or in any other inaccessible position.

Joints shall be clean threaded and pulled up tightly. No caulking shall be allowed in any circumstance. Particular care shall be taken that all tubes shall be absolutely free from internal obstructions. To ensure this, all tubes and fittings shall be carefully reamed to ensure that the full bore of the tube is maintained, and where necessary shall be cleaned out before erection. Plugs shall be inserted in all open ends during the progress of the works to prevent the ingress of dirt and moisture.

Any stoppage which is found to impede passage through the pipework shall be removed after the system having been put into commission including making good of all pipework concerned.

All pipework shall have joints in positions which will facilitate erection and dismantling.

All fittings shall be of the same size as the tubes connected to them.

Thermal insulation for the sections of the tubes that are subject to condensation especially those routed outside the air-conditioned area of the building shall be provided.

16.1.11.3.2 Sleeves Through Walls and Floors

Wherever the pipework passing through the movement or expansion/contraction joints of any building structure, flexible connection joints shall be provided.

For holes passing through walls or floors, sleeves necessary to accommodate piping with insulation in position shall be provided to make good the openings in the walls or floors. The positions of such sleeves shall take into account of the structural stability of walls or floors.

The sleeves shall be of sufficient diameter to permit freedom of movement of the tubes but the clearance all round must not exceed 3 mm. For walls, the sleeve shall be of a length so that it is flush with both sides of the finished wall. For floors, the sleeve shall be of a length so that it is flush with the finished ceiling below and shall project 25 mm above the finished floor surface.

Wherever the tubing passing through fire-rated walls, floors, ceilings or other barriers, appropriate and approved fire sleeves or collars with suitable fire rating shall be installed so as to retain the integrity of the Building.

The rating of the fire protection sleeves shall comply with the requirements of the FSD and BD.

The fire sleeves shall allow a free passage for the carriers under normal conditions.

16.1.11.3.3 Provision for Thermal Expansion

Provision for movement due to expansion and contraction shall be made by changes in direction of the pipework or by special expansion joints.

Supports, steadies and guides shall be arranged to ensure that all movement is taken up by the change in direction of the pipework loop or joint.

All expansion joints shall be supplied and correctly aligned at the suitable positions. Support at such joints shall be arranged to ensure that all expansion or contraction is taken up to the expansion joint or change in direction of the pipework. Expansion joints shall be pressurised for the purpose of reducing the expansion stress under working conditions. The extent of the cold draw shall be as recommended by the manufacturer.

Expansion joints for angular movements shall be provided with tie rods or hinges to take end thrust.

All expansion joints shall be provided with external protection where exposed to damage.

Expansion joints shall be installed so that they are not subject to stresses.

They shall be installed so that they are in their free position at a temperature midway between the high and low limits of normal service.

Expansion joints shall be provided with guides to ensure that all movements are taken up in the designed manner. The manufacturer's recommendations shall be closely followed. Guides shall be secured rigidly and shall provide free movement for expansion without undue tolerance. Means for lubrication shall be provided where necessary.

Guides shall be adjustable in both directions in the lateral plane so that the pipework can be accurately aligned with the expansion device.

Guides and anchors shall meet with the written approval of the expansion joint manufacturer.

16.1.11.3.4 Vibration Control

All equipment, tubing, etc. shall be mounted on or suspended from approved foundations and supports in order to prevent the transmission of vibration and mechanically transmitted sound to the building structure.

Vibration isolators shall be selected in accordance with the weight distribution so as to produce the correct deflection.

All rotating machinery shall be accurately balanced, statically and dynamically. All blowers and other rotating equipment shall be suspended or on vibration isolating assembly.

All connections to rotating machinery or assemblies containing rotating machinery shall be rendered flexible, such as stainless steel flexible tubing connections.

Mounting systems exposed to corrosive environments and in plant rooms shall be protected against corrosion.

Vibration hangers shall contain a steel spring and an 8 mm deflection neoprene element arranged in series. The neoprene element shall be moulded with a rod isolation bushing that passes through the hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the hole and neutralising the effect of the spring. Springs shall have a minimum travel to solid, equal to 150% of the rate deflection. Minimum deflection shall be 35 mm.

Where vibration is present in tubing, the tubing shall not contact any part of the building when passing through walls, floors etc. Sleeves containing an approved isolating material shall isolate the tubing and be sealed with heavy non-hardening mastic. Seal shall comply with requirements of Fire Services Department.

SUB-SECTION 16.1.12

VEHICLE TURNTABLE

16.1.12.1 DESIGN

16.1.12.1.1 General Requirements

The design of vehicle turntable and associated accessories shall be included under the Works.

The vehicle turntable shall facilitate better manoeuvring of vehicle of truck or the like in a limited space. The turntable shall be electromechanical driven and capable of handling static, eccentric loads. The maximum handling capacity and turntable diameter shall be as specified in Particular Specification.

The turntable shall consist of a circular structural steel platform supported on maintenance free type centre pivot and castor wheels. The turntable shall be capable of turning 360^{o} continuously in both clockwise and anticlockwise directions and the rotational speed shall be approximately 0.75 revolution per minute unless otherwise specified.

All starting operation shall be by a key-operated on/off switch to prevent unauthorised usage. The operation of the turntable shall be controlled by on/off push buttons of deadman type for forward (clockwise), reverse (anti-clockwise) and reset mode of operation.

A hold-down type emergency stop device shall also be provided to cut off the power to hydraulic power pack in case of emergency.

In the event of power failure, the turntable shall be capable of being disengaged from the drive unit and be capable of manually operated. An easily accessible manual operating device of the approved type shall be provided. An interlocking device shall be installed to prevent the drive unit from being started when the turntable is manually operated, and vice versa. Contactless sensors such as optical or InfraRed scanner/sensor shall be installed to facilitate the vehicle positioned correctly on the vehicle turntable and inside clearance zone.

A float type level sensor shall be provided in the turntable pit for detection of flooding. Grease traps or sump pits should be provided for the drainage.

16.1.12.1.2 Main Frame

The main frame shall be shop fabricated in segments, bolted and welded properly in good workmanship.

The deck surface of the turntable shall be fabricated from non-slip, solid steel chequer plate of 10 mm in thickness. To allow accessibility for servicing and general cleaning of the turntable, adequately sized access

openings with lockable hinged covers shall be provided on the deck surface.

16.1.12.1.3 Drive System

The turntable shall be driven by hydraulic drive unit located in the drive pit of the turntable. The hydraulic fluid shall be supplied by a power pack.

Each drive unit shall consist of a hydraulic motor, speed reduction gear unit, torque limiter, driving sprocket and associated chain drives as necessary. The drive motor shall be of high torque hydraulic motor manufactured for intermittent operation.

The turntable shall be driven continuously 360° in both clockwise and anticlockwise directions by controlling the hydraulic valves unit. The turntable shall be locked in position without slip when it is not in use.

The motor shall be suitably rated to drive the turntable under all normal conditions of service without overloading and shall not automatically restart on restoration of failed mains or fault.

16.1.12.1.4 Supporting Castors

One set of supporting castors shall be provided underneath the turntable to take up the imposed loading. The castors shall be equally spaced and fixed on appropriate pitch circle diameter(s) to suit the stated builder's work.

Structural calculation shall be provided to support the number of castors required and the number of castors shall normally be in the range of 12 to 24 to suit the site condition.

The structural calculation shall allow spare capacity for driving the turntable in case of one castor is failed.

16.1.12.1.5 Centre Pivot

The bearing for centre pivot arrangement shall have dynamic and static capacity to withstand the imposed thrust and moment. The bearing house shall be attached on a mild steel baseplate to be fixed on the turntable pit base by anchor bolts.

Maximum Lateral Force applied should be based on a vehicle of maximum turntable operating capacity coming to a complete stop on the turntable from a speed of 10km/h over a distance of 1m.

` 16.1.12.1.6 Control Panels

Unless otherwise specified, all electrical equipment shall be suitable for use in ambient temperature up to 40ºC and relative humidity up to 100%. All electrical equipment shall be suitable for a rated voltage as specified.

The control panel shall be ergonomically designed to suit the physique of the average Hong Kong operators.

Control cubicles shall be vermin proof and shall also meet the requirements of IP54 enclosures with interior finished to an approved Matt White and exterior opaline green to BS 381C:1996 or other type of finishing material such as stainless steel approved by the Supervising Officer.

All control cubicles shall have labels made from laminated self-coloured materials and engraved with descriptions in both English and Chinese to be approved by the Supervising Officer.

The contactors, switch fuses, relays and all other necessary items shall be housed in the appropriate control panel which shall be arranged with front access for maintenance. It shall also be lockable to prevent unauthorised access and malicious damage to the equipment inside.

Each relay shall be labelled appropriately to its service either by function or by code, in which case a code index shall be securely attached to the panel for easy and positive identification.

A wall-mounted lockable control panel shall be installed to include the operation and protection system for the vehicle turntable.

The panel shall be made of galvanised steel sheet of 2 mm minimum thickness and the enclosure shall be protected to IP54 as per IEC 60529:2013/Corr 2:2015. The panel shall be coated with one coat of metallic zinc-rich primer to BS 4652:1995, type 2 or lead primer to BS 7956:2000, two undercoats and one finish coat. Undercoats and finish coat shall be of properly matching type and the finish coat give a hard gloss finish as required. The external paint finish shall be light grey to colour 631 of BS 381C:1996.

All circuits shall be accommodated in accordance with IEC 61439-1:2020 permanent labels of the approved type shall be provided for the identification of major components.

A Soft start/stop, ramp up/ramp down in motor speed shall be catered in the control sequence as an advanced safe operation procedure.

Each control panel for the vehicle turntable shall include but not limit to the following major items: -

(a) Triple pole motor starters to IEC 60947-4-1:2012 for power pack motor. Each starter shall be equipped with triple pole thermal overload protection device complete with manual reset.

(b) Associated power and control circuits with appropriate HRC fuse protection.

(c) One set of outgoing terminals and auxiliary terminals.

(d) Key-operated on/off main switch.

(e) Heavy duty push-buttons for the following purposes: -

(i) Deadman type push-buttons for the forward and reverse modes of operation;

(ii) lamp test; and

(iii) fault reset.

(f) Heavy-duty, mushroom head, hold-down type emergency stop push button with manual reset.

(g) Indication lamps for the following purposes: -

(i) power on;

(ii) modes of operation (forward and reverse);

(iii) motor overload; and

(iv) high water level alarm in the turntable pit.

16.1.12.1.7 Power Pack Motor

The power pack motor shall be totally enclosed, squirrel cage, high torque induction motor to BS 4999-141:2004+A1:2010 and manufactured for intermittent operation capable to tolerate a maximum starting frequency of 12 times per hour at rated voltage without overheating. The motor shall have a minimum of Class F insulation and Index of Protection to IP55 in accordance with IEC 60529:2013/Corr 2:2015.

16.1.12.1.8 Cabling

Allowance shall be made to protect all cables from ingress of water, especially in the drive pit, using water tight junction box, flexible conduits, etc.

16.1.12.2 EQUIPMENT AND MATERIALS

16.1.12.2.1 General

The main members of the turntable frame shall be fabricated from beams, channels and angle iron of high-grade structural steel to BS 7668:2016, BS EN 10029:2010, Parts 1 to 3 of BS EN 10025, BS EN 10210-1:2006 and shall withstand the laden vehicle load.

All steelwork shall be shot blasted to ISO 8501-1:2007 2nd quality (SA 2.5) or be hot-dip galvanised to BS EN ISO 1461:2009 as specified in the

Particular Specification and painted in accordance with Part 1 and relevant clause in Part 16 of this General Specification.

The centre pivot shall consist of bronze bush with suitable vertical thrust bearing arrangement.

16.1.12.2.2 Speed Reduction Gear Unit

The reduction gearbox shall be totally enclosed and shall be capable of transmitting the maximum rated power of the drive motor continuously.

The reduction gears shall be practically submerged in and lubricated by oil bath which can be drained off conveniently at an accessible position on the bottom of the gearbox. The gearbox casing shall be with access for routine inspection and maintenance.

The minimum grade of material of the gearbox components shall be as follows: -

Components	Material
Casing & Baseplate	Cast iron
Shaft and Gears	Steel to BS EN 10095:1999, BS EN 10250:2000, BS EN 10084:2008 & BS EN 10087:1999
Drive nut & sleeve	Aluminium bronze

16.1.12.2.3 Chain Drive

Roller chain in the drive unit shall be made of high quality non-ageing steel. The chain shall be case hardened for improved wear resistance.

The chainwheel shall be forged and case hardened to provide necessary strength. Roller chains and chainwheels shall conform with ISO 606:2015.

16.1.12.2.4 Motor

The motor shall be suitably rated to drive the hydraulic power pack under all normally conditions of service without overloading.

16.1.12.2.5 Cabling

The power cables shall be steel wire armoured cable to BS 6724:2016 with copper conductor and suitably rated in accordance with BS 7671:2008 + A3:2015.

The cables shall be suitable for installation in the piping provided by others between the control panel and the drive unit.

16.1.12.3 ERECTION AND INSTALLATION

16.1.12.3.1 Main Frame Construction

The clearance between the turntable pit and the turntable circular edge shall not be greater than 10 mm during operation.

All steelwork shall be primed before erection and the under coat and finishing coat shall be coal tar epoxy paint. The priming and painting shall be conducted in accordance with the requirements in Part 1 and relevant clause in Part 16 of this General Specification.

The foundation of turntable pit provided by the Building Contractor shall be checked to ensure that anchor bolts for castors are correctly located and the pit base is reasonable level for supporting the turntable.

16.1.12.3.2 Supporting Castors

Each castor shall consist of a cast steel wheel running on a stainless steel shaft with self-lubricating bearing, the bearing shall be properly sealed to prevent entry of moisture. The wheels shall be supported on stainless steel wheel brackets to be mounted onto the pit base. Provision shall be made to ensure all castor wheels shall have good contact and match with the running rail as stated below.

Running rail(s) of cold rolled steel shall be installed on the underside of the turntable for each set of supporting castors. The dimensions of each rail track shall conform to the dimensions and location of the respective castor wheels underneath the turntable.

SUB-SECTION 16.1.13

FOOD WASTE COMPOSTING SYSTEM

16.1.13.1 DESIGN

16.1.13.1.1 System Description

The design of food waste composting system and associated accessories shall be included under the Works.

The food waste composting equipment shall be installed to turn food/organic waste into liquid/solid fertiliser by bio-technology.

For equipment that produces solid fertiliser, the solid fertiliser produced shall be able to be removed out of the equipment easily and safely. Any equipment and tools needed shall be provided.

For equipment that produces liquid fertiliser, the liquid produced from the equipment shall fulfill the requirements of the Air Pollution Control Ordinance (Cap. 311) and the Water Pollution Control Ordinance (Cap. 358) and other relevant legal requirements.

Volume reduction of the waste shall not be less than 70% within 24 hours. The food/organic waste shall include vegetable, meat, poultry, small fish and chicken bones, seafood, rice, noodles, and etc. Big bones like chicken leg bones and rib bones shall be able to be treated by the equipment but with longer processing time.

The remaining food/organic waste that are not compostable shall be easily and safely removed without affecting the normal operation and performance of the equipment with the tools provided.

The equipment shall be a low maintenance, easy operated, high efficient machine that biologically converts virtually all organic food waste products including small fish and chicken bones into either nutrient rich liquid fertiliser or solid fertiliser.

For equipment that produces liquid fertiliser, an organisation accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisation accreditied by an accreditation scheme mutally recognised by HOKLAS or HKASshall be employed at the cost stipulated in the Contract for testing of the liquid fertiliser produced; the results of the test shall indicate that the liquid fertiliser could be discharged to public sewers without violating the requirements of the Water Pollution Control Ordinance (Cap. 358) and other relevant legal requirements .

The equipment shall have devices to minimise all odour, air particulate and generated noise.

16.1.13.2 EQUIPMENT AND MATERIAL

Each food waste composting system shall be completed with the following items: -

16.1.13.2.1 Chamber

The body of the machine including the base supports and auxilary supports shall be made of stainless steel to BS EN 10088-4:2009, Grade 304 or better and suitable to be operated in both indoor and outdoor environment. The thickness of the stainless steel sheet shall not be less than 1mm.

The chamber of the machine shall be made of stainless steel to BS EN 10088-4:2009, Grade 304 or better. The thickness of the stainless steel sheet shall not be less than 2mm.

Automatic food waste infeed device shall be provided as required for large capacity model.

Inlet with door shall be provided for continuous feeding of organic waste, machine should stop automatically when inlet is opened.

Water supply point when specified in the tender drawing, would be provided by the Building Contractor. The work shall include supply and installation of connection pipework from the equipment to the water supply point.

Water discharge point with grease trap when specified in the tender drawing, would also be provided by the Building Contractor. The work shall include supply and installation of connection pipework from the equipment to the drain point with access points for cleaning at appropriate locations. After decomposition, liquid fertiliser shall be discharged to drainage continuously via the discharge point or stored up for irrigation of landscape areas.

Electrical heater shall be provided with thermostat control to maintain optimum temperature for the best condition for micro-organism to function.

Mixer shall be made of stainless steel to BS EN 10088-4:2009, Grade 304 or above to facilitate the waste and the medium to be mixed correctly and assists micro-organism to work effectively.

Exhaust air pipe made of stainless steel of appropriate thickness to BS EN 10088-4:2009, Grade 304 or better shall be supplied and installed as specified in the tender drawing from the equipment to the ambient to discharge the odour generated during the composting processes.

Control panel shall be stainless steel and provided with the following indicator lamps: -

(a) Equipment in operation;

(b) Content high level;

(c) Motor overloaded;

(d) Chamber high temperature;

(e) Other relevant fault signals.

16.1.13.2.2 Temperature Control

Temperature control device shall be provided to maintain the temperature of the compartment and provide optimum conditions for bacteria to function.

Electrical heater shall shut off automatically if the compartment temperature goes beyond a certain maximum limit of not exceeding 70^0C.

16.1.13.2.3 Input of Food Waste

Inlet with door shall be provided for continuous feeding of organic waste.

Inlet door shall be equipped with rubber gasket to prevent the spread of odour.

All moving mechanical parts of the machine body shall stop operating when the inlet door is open.

Automatic infeed of food waste by a separate gear motor shall be provided for machine with capacity requirement of more than 100kg/day.

16.1.13.2.4 Mixing

Fully automatic mixing device shall be installed for mixing the organic waste, bacteria and media in the compartment. The mixing operation shall be provided by a separate gear motor with constant speed.

The compartment of the machine shall be made of stainless steel to BS EN 10088-4:2009, Grade 304 or better.

The stirring shaft and blade shall be made of stainless steel to BS EN 10088-4:2009, Grade 304 or better.

Continuous mixing shall not be applied in order to minimise electricity consumption. The mixing device shall be activated periodically at controlled interval. (e.g. 1 minute mixing every 60 minutes)

The machine shall have appropriate safety installation to prevent operators from injury arisen from touching the moving mechanical parts inadvertently.

16.1.13.2.5 Bacteria and Medium

The bacteria shall be non-hazardous to human's or animal's health.

The bacteria shall be able to survive for at least 2 weeks if no organic waste is fed, and their activities shall be able to resume once the organic waste is fed again.

The bacteria and medium shall have a service life of more than 6 months.

The application of bacteria and medium shall have at least 2 years of proven track records.

16.1.13.3 ERECTION AND INSTALLATION

The work shall include the interfacing works between the individual equipment and the builder's works. The particular requirements of the equipment shall follow the manufacturers' recommendations.

SECTION 16.2

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 16.2.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

16.2.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

16.2.1.2 STEAM BOILERS

Factory test shall be carried out for the boiler plant, tanks, cylinders and pumps, the test reports shall be submitted to the Supervising Officer.

Installations or sections which will be embedded in the structure or concealed in permanently sealed ducts, trenches, roof spaces, etc., shall in addition to the above specified tests be individually tested as they are laid and before being embedded or concealed.

All pressure tests shall be carried out before the application of thermal insulation, where this would prejudice the completion of the Installations the section concerned shall be individually tested before the application of the insulation.

All associated pipework, fitting and valves shall be completely drained after hydraulic test and shall be blown with compressed air to remove any trace of water and dirt.

Before commissioning, the whole system pipework shall be chemically pre-cleaned. Adequate amount of defoamer shall be applied to control foaming throughout the cleaning process.

After being dried, the pipework, fitting and valves shall be flushed with oil to prevent rusting.

The steam equipment including safety valves and accessories after completion shall be subject to the inspection and approval by the Commissioner for Labour and Director of Water Supplies. The examination of the plant by approved independent Surveyor(s) or Laboratories is required if deemed necessary by the above relevant authorities. The respective Certificates of Approval or Fitness and registration shall be obtained on behalf of the Employer for those equipment or systems which fall within the Boilers and Pressure Vessels Ordinance (Cap. 56), and other relevant statues. Original certificates

should be framed and posted conspicuously near the respective equipment or systems on-site. Four copies of these certificates shall be submitted to the Supervising Officer.

All pipework, vessels and boilers shall be cleaned up thoroughly before subject to inspection, both internally and externally.

16.2.1.3 MILD STEEL CHIMNEY

[RESERVED]

16.2.1.4 CRANE AND HOIST

Valid test certificates from the manufacturers for the hook and rope shall be submitted to the Supervising Officer.

The crane, hoist and the associated structural lifting facilities such as I-beam/eye bolt shall be tested and examined by an approved independent Surveyor. The respective certificates in accordance with the Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations shall be obtained.

The Inspection and Testing of the crane and hoist system shall comply with the Guidance Notes on Inspection, Thorough Examination and Testing of Lifting Appliances and Lifting Gear.

16.2.1.5 FUEL SUPPLY SYSTEM

Competent Examiner specified under this Sub-section shall satify the requirements stipulated under the Air Pollution Control (Petrol Filling Stations) (Vapour Recovery) Regulation.

A Competent Examiner shall be employed to test and examine the storage tanks, pipeworks and the vapour recovery system upon the completion of the Installations and before the system is put into use for the first time. For storage tanks, the tests shall be completed and certified by a competent person.

The vapour recovery system shall be tested by the Competent Examiner in accordance with the test requirements specified in Schedules 1, 2 and 3 of the Air Pollution Control (Petrol Filling Stations) (Vapour Recovery) Regulation.

The medium of test for the vapour recovery system shall be nitrogen as specified in Schedule 2 of the Regulation.

After satisfactory completion of the tests, certificates in a form specified by the Authority duly signed by the Competent Examiner shall be submitted to the Supervising Officer.

A test certificate and a certified true copy of the drawings of the vapour recovery system installed to the petrol filling station shall be delivered to the Authority for registration. The drawings shall clearly indicate, but not be limited to the following: the locations and sizes of the inlets, vents, pressure/vacuum valves, safety valves and petrol storage tanks.

The endorsed certificate of the vapour recovery system shall be issued to the Supervising Officer within 14 days after receipt from the Authority.

The certificate with suitable protection shall be displayed at a conspicuous location in the petrol filling station.

All possible safety measures shall be taken before and during the test with particular attention to be paid, but not limited, to the following: -

(a) The work area shall be blockaded;

(b) All the identifiable sources of ignition, including electrical power to electrical devices associated with vacuum-assisted systems, if installed, shall be eliminated;

(c) The pressure/vacuum valves serving the petrol storage tanks shall be working properly before commencement of the test;

(d) The pressure relief valve to be used in the test shall be checked to be working properly before commencement of the test; and

(e) All the connection and fittings shall be checked and secured properly.

16.2.1.6 GARAGE EQUIPMENT

[RESERVED]

16.2.1.7 GONDOLA

The suspended working platform shall be inspected and tested in accordance with the relevant statutory requirements under the Factories and Industrial Undertakings (Suspended Working Platforms) Regulation where the load tests shall be carried out by a competent examiner after installation.

Functional tests including all safety devices shall subsequently be carried out.

16.2.1.8 HOT WATER SYSTEM

Before Installations are handed over or subjected to inspection and tests, the entire Installations shall be thoroughly cleaned, both internally and externally.

All fluid-related Installations shall be flushed with clean water. This shall be preceded by chemical cleaning where indicated. During the flushing or scavenging process, provision shall be made to exclude filters, pumps, meters and any other items of plant which could be damaged by the cleaning operation. The entire operation shall be carried out to the satisfaction of the Supervising Officer or his Representative.

Factory tests shall be carried out for the boiler plant, calorifiers, tanks, cylinders and pumps.

Installations or sections which will be embedded in the structure or concealed in permanently sealed ducts, trenches, roof spaces, etc. shall in addition to the above specified tests be individually tested as they are laid and before being embedded or concealed.

All pressure tests for pipework and fittings shall be carried out before the application of thermal insulation.

After finishing the installation work, the complete Hot Water System Installations including calorifiers, pressure reducing valve sets, water pipeworks, fittings and associated accessories shall be subject to the inspection and approval by the Commissioner for Labour, Director of Water Supplies and other relevant statutory authorities. The examination of the plant by approved independent Surveyors is required if deemed necessary by the said authorities. It is required to obtain the respective Certificate of Approval or Fitness, at the expense according to the Contract, on behalf of the Employer for those equipment or systems which fall within the Boilers and Pressure Vessels Ordinance (Cap. 56), Fire Services Regulations (Cap. 95), requirements from Water Supplies Department and other relevant statutory regulations. Original (and in triplicate) certificates of approval shall be submitted to the Supervising Officer before the relevant equipment is put into operation.

Each safety valve shall be surveyor tested to its designed pressure on completion. Test Certificates in triplicate, including the original copy, shall be submitted to the Supervising Officer.

16.2.1.9 INDUSTRIAL COMPRESSED AIR SYSTEM

The complete installation shall be subject to a hydraulic pressure test at 1.5 times the maximum working pressure of the system for a minimum period of one hour without any deformation or leakage.

Following the hydraulic pressure test, air leakage tests shall be carried out. Pipework shall be isolated into convenient sections and the air pressure in each section raised to the maximum working pressure of the system. This pressure shall be held, with the supply disconnected, without sign of leakage for a minimum period of one hour.

The air receiver and all relief or safety valves shall be subject to survey in accordance with the Boilers and Pressure Vessels Ordinance by an approved surveyor. Three copies of the survey report including the original copy issued by an authorised surveyor shall be submitted to the Supervising Officer for retention after the survey.

16.2.1.10 SEWAGE PUMPING SYSTEM

[RESERVED]

16.2.1.11 PNEUMATIC TUBE TRANSPORTATION SYSTEM

16.2.1.11.1 General

Tests shall be carried out in accordance with the relevant sections of Health Technical Memorandum 2009, especially the following: -

(a) Air leakage test for pipelines and work stations;

(b) Carriers Flow rate and delivery accuracy test;

(c) Electrical tests;

(d) Test of mechanism for operation and control;

(e) All tubing is identified and to the specification; and

(f) All functions of the system shall be fully tested with the use of Central Control and Supervisory Unit to control the system. A full software check and debug of all software errors shall also be done.

All pressure tests for the pneumatic tube and fittings as specified above shall be carried out before the application of the thermal insulation.

16.2.1.11.2 Testing of Noise Control System

The method of all sound and vibration measurements shall generally be in accordance with BS 4142:2014+A1:2019, HTM 08-01 or other technically equivalent national or international standards. Measurement shall be taken by an industrial grades sound level meter.

Sound level readings shall be taken with a simple sound level meter using the ‘A’ scale weighting network. The spaces in which readings shall be taken in general be the following: -

(a) Plant rooms;

(b) Outside plant room doors;

(c) Occupied rooms adjacent to plant rooms; and

(d) Sending / Receiving Stations.

Sound level readings shall be taken using a sound analyser to give an octave band analysis of the sound spectrum and to pinpoint the frequency values of peak sound levels.

Laboratory test shall be carried out for samples transported through the system if required in the Particular Specification.

16.2.1.12 VEHICLE TURNTABLE

The driving system and supporting castors shall be visually inspected before erection of cover plates.

The system shall be functional tested with the specified loading capacity after completion.

16.2.1.13 FOOD WASTE COMPOSTING SYSTEM

[RESERVED]

SUB-SECTION 16.2.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

16.2.2.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during Maintenance Period shall also comply with the specific requirements in this Sub-section.

Operation, servicing and maintenance of the Installations, if specified, shall also refer to the equipment manufacturer's recommendations and specifications.

16.2.2.2 STATUTORY INSPECTION

Statutory Inspections shall be carried out for the Installations during the Maintenance Period as per the requirements stipulated under relevant ordinances and regulations. Inspection reports shall be submitted to the Supervising Officer and any irregularity identified shall be rectified.

16.2.2.2 STEAM BOILERS

The Steam Equipment including safety valves and accessories during the Maintenance Period may subject to the inspection request by the Commissioner for Labour. The examination of the plant by approved independent Surveyor(s) or Laboratories is required if deemed necessary by the authorities.

16.2.2.3 MILD STEEL CHIMNEY

[RESERVED]

16.2.2.4 CRANE AND HOIST

[RESERVED]

16.2.2.5 FUEL SUPPLY SYSTEM

[RESERVED]

16.2.2.6 GARAGE EQUIPMENT

[RESERVED]

16.2.2.7 GONDOLA

16.2.2.7.1 Competent Examiner specified under this Sub-section shall be a registered professional engineer registered under the Engineers Registration Ordinance (Cap. 409) within a relevant discipline specified by the Commissioner for Labour.

16.2.2.7.2 Routine Maintenance

The work shall include all preventive maintenance work in accordance with Manufacturer's recommendation to ensure that the gondola system operates safely, economically, free of faults, at the designed capacity and duty and in accordance with good trade practices, recommendations of the equipment manufacturers and statutory requirements. In particular, all maintenance work shall comply with the requirements of the Factories and Industrial Undertakings (Suspended Working Platforms) Regulation. The requirements specified in the subsequent clauses are the minimum requirements for the routine maintenance service.

After exposure to weather conditions likely to have affected the stability of the suspended working platform, the following shall be carried out: -

(a) the suspended working platform should be load tested and thoroughly examined by a Competent Examiner as soon as practicable thereafter and before the suspended working platform is used again; and

(b) in the event of the anchorage, ballast, counterbalance or supports being found on examination to be unsafe, steps should be taken to ensure the stability of the suspended working platform.

16.2.2.7.3 Weekly Check

The work shall include visual and physical inspection and test on the state of individual items of the gondola system to find out if there are any items having abnormal wear and tear, malfunction, oil leakage, overheating, corrosion, unusual noise, dislocation, misalignment, visual cracks, overloading, abnormal slackening or elongation, and excessive vibration etc. and to carry out subsequent remedial work such as repair and replacement of defective parts, re-inspection and test to ensure that the gondola system operates effectively and safely. Any defect which has been rectified shall be recorded in the maintenance logbook.

A wire rope shall not be used for raising or lowering, or as a means of suspension of, the suspended working platform or as its safety rope if any one of the following situations stated in (a) to (c) below occurs during inspection of wire ropes: -

(a) in any length of 10 diameters, the total number of visible broken wires shall not exceed 5% of the total number of wires in the rope;

(b) there is any kink or distortion in the rope; or

(c) there is on the rope marked signs of wear or corrosion.

Under Section 19(1) of the Factories and Industrial Undertakings (Suspended Working Platforms) Regulation (Cap. 59AC), a statement to the effect that it is in safe working order shall be entered into an approved form (Form 1 - Certificate of Weekly Inspections of Suspended Working Platform) by the competent person who shall have substantial training, practical experience and competence to perform the duty. The Form 1 shall be completed immediately 7 days preceding the gondola is put into use.

In particular, the following items shall be carried out: -

(a) Inspection of

(i) hoist mechanism, wire ropes and shackles;

(ii) life lines and safety belts;

(iii) power cable and plug;

(iv) braking system;

(v) locking devices;

(vi) guide rail and toe-board of working platform; and

(vii) electrical wiring and earthing component.

(b) Functional test of

(i) all operational control including emergency stop;

(ii) telephone;

(iii) manual descend facility;

(iv) all limit switches;

(v) fall arrest device if installed; and

(vi) braking system.

(c) Lubrication of moving parts

(d) Reconditioning or replacement of rusty parts

(e) General cleaning

16.2.2.7.4 Six-monthly Check

Under Section 20(1) of the Factories and Industrial Undertakings (Suspended Working Platforms) Regulation (Cap. 59AC), a thorough examination on the gondola shall be performed by a Competent Examiner in the immediately preceding 6 months before it is put into use. A certificate in the approved form (Form 2 - Certificate of Thorough Examination of Suspended Working Platform) shall be completed by the Competent Examiner to certify that the gondola system shall be in safe working order.

(a) The following functional test items shall be carried out under maximum safe working load: -

(i) Operational control including emergency stop;

(ii) Manual descend facility;

(iii) Limit switches;

(iv) Automatic safety devices; and

(v) Braking systems.

(b) The following visual inspection items shall be carried out: -

(i) Inspection and adjustment, if necessary, of all brakes;

(ii) Re-tightening of all load bearing bolts;

(iii) Inspection of rollers and guide pulley are free to rotate; and

(iv) Inspection of anchorage system for any corrosion and defect.

16.2.2.7.5 Annual Check

In addition to the items in six monthly check, under Section 20(2) of the Factories and Industrial Undertakings (Suspended Working Platforms) Regulation (Cap. 59AC), a load test and a thorough examination on the gondola system shall be performed by the Competent Examiner in the immediately preceding 12 months before it is put into use. A certificate in an approved form (Form 3 - Certificate of Load Test and Thorough Examination of Suspended Working Platform) containing the statement to the effect that the gondola system is in safe working order made by the Competent Examiner shall be obtained.

The following items shall be carried out: -

(a) Re-tightening of all roof track anchor bolts;

(b) Overhaul or replacement of worn out parts;

(c) Proof load* for testing on suspended working platform in the gondola shall be 150 percent of the safe working load.

(d) Proof load* for testing on the wire rope shall be at least twice of the safe working load;

(e) Overload* device function test shall be carried out in accordance with the manufacturer's instruction. The amount of the overload used shall be in line with manufacturer's recommendation;

(f) Drop test* shall be carried out at the safe working load on the suspended working platform in order to ensure the automatic safety devices shall be capable of stopping and holding the load on the suspended working platform specified by the manufacturer;

(g) Touching up painting; and

(h) Repair of damaged or worn out galvanised coating of the system including tracks.

* The proof load test, overload device function test and drop test shall be conducted at or near ground or landing level. Before conducting the tests, a thorough examination shall be carried out by the Competent Examiner to ensure that no defective parts, malfunction of devices or loose components are present in the suspended working platform.

16.2.2.7.6 Record of Routing Maintenance

After each check, if the gondola is safe for operation, a copy of Form 1 shall be submitted to the management office of the building for record purpose. If it is necessary to put the gondola out of service for repair, the management office shall be informed immediately. The Supervising Officer shall be informed of the fault occurred and the expected date on which the gondola can be put back into service. When the repair work is completed and the gondola is safe for operation, Form 1 shall be submitted to the management office and a report to the Supervising Officer regarding the cause of the fault and the repair work shall be provided.

16.2.2.8 HOT WATER SYSTEM

[RESERVED]

16.2.2.9 INDUSTRIAL COMPRESSED AIR SYSTEM

[RESERVED]

16.2.2.10 SEWAGE PUMPING SYSTEM

[RESERVED]

16.2.2.11 PNEUMATIC TUBE TRANSPORTATION SYSTEM

[RESERVED]

16.2.2.12 VEHICLE TURNTABLE

[RESERVED]

16.2.2.13 FOOD WASTE COMPOSTING SYSTEM

[RESERVED]

PART 17 – LIQUEFIED PETROLEUM GAS INSTALLATION

SECTION 17.1

TECHNICAL REQUIREMENTS

SUB-SECTION 17.1.1

GENERAL

17.1.1.1 DESIGN

Where design is specified for any part of the Installations, the Liquefied Petroleum Gas (LPG) Installation shall be designed to comply with the statutory requirements as well as the requirements in the Specification. Where design is not specified, the design shown in the Drawings or in the Particular Specification, complete the detailed design and installation details of the whole Liquefied Petroleum Gas Installation shall be developed and the most appropriate equipment shall be selected to comply with the statutory requirements and all other requirements of the Specification. All design drawings, calculation and installation details shall be submitted to the Supervising Officer for approval.

The completed design with support of drawings/models of the assembled/prefabricated mechanical, electrical & plumbing systems, and the proposed integration/connections with other services shall be submitted to the Supervising Officer for approval before manufacturing.

For LPG installation classified as a Notifiable Gas Installation (NGI) under the Gas Safety Ordinance (Cap. 51), the works shall include application for construction approval to the Gas Authority. The LPG installation shall comply with the Guidance Notes on Gas Supply Installations issued by the Gas Standards Office.

17.1.1.2 INTERFACE WITH CCMS

The works shall include providing contacts or wired/wireless network connection or through IoT technology to allow remote monitoring of essential signal or sensor readings which specified in the Contract or in this Section to be monitored by the Central Control & Monitoring System (CCMS). The remote monitoring signals shall be compatible with BACnet or other suitable communication protocol for connecting to the CCMS as specified in the Contract.

SUB-SECTION 17.1.2

BULK LPG STORAGE VESSELS

17.1.2.1 GENERAL

This section covers fixed LPG storage vessels of capacity in excess of 450 litres water capacity which are normally refilled on-site.

17.1.2.2 STORAGE VESSELS

Vessels shall be designed and constructed of steel in accordance with a recognised Pressure Vessel Code such as PD 5500:2021+A1:2021, AS1210:2010, or ANSI/ASME Boiler and Pressure Vessel Code Section VIII or equivalent. The approval shall be obtained from the Gas Authority and the manufacturer's test certificates shall be submitted to prove that the vessels are in compliance with the standards. Use of partial standards shall not be allowed.

Vessels shall be post-weld heat treated in accordance with the respective design codes and shall be subject to 100% radiography examination and a satisfactory "charpy" test at minimum design temperature.

Bulk tanks shall be designed to minimum pressure of 1.725 MPa and a minimum design temperature of -10°C.

Each vessel shall be provided with a permanently fixed and clearly visible data plate that shall include as a minimum the following information: -

(a) the Pressure Vessel Code;

(b) the manufacturer's name and serial number;

(c) the water capacity in kilolitres;

(d) the maximum working pressure in kPa;

(e) the date of manufacture;

(f) design temperature range in °C – minimum and maximum;

(g) date of test, pressure applied, inspection authority, and its symbol; and

(h) provision of sufficient space for subsequent re-test marking.

The vessel supports shall be of adequate design with due consideration of the vessel shell stressing and transmission of loading to the ground.

Saddles, bearing or corrosion plates shall be designed in accordance with the Pressure Vessel Code to which the vessel is designed and shall be of steel. Where saddles are not welded to the vessel, bearing and/or corrosion plates shall be used. The latter shall also

be used whenever there is likely to be severe corrosion between the vessel and the supporting structure.

Saddles shall project downward more than any other projection on the lowest part of the vessel. Where saddles are not used, the vessel supports shall be shaped to conform to the vessel shell.

Vessels or mounded tanks shall be secured at both ends against flotation and they shall also be secured against movement at the end to which the connections are made.

Skirts for vertical vessels shall be provided with at least two vents to prevent the accumulation of liquid or vapour.

Horizontal vessels shall be sloped slightly towards the drain connection; alternatively the liquid withdrawal connection shall be at a slightly higher level than the drain connection.

Vessels exceeding 5000 litres water capacity shall have a manhole of minimum diameter of 450 mm. The manhole in the form of extruded nozzles shall be of not less than 550 mm internal diameter.

In addition to inlet and outlet connections, each bulk storage LPG vessel shall be provided with at least one of each of the following fittings: -

(a) pressure relief valve connected directly to the vapour space;

(b) plugged shut-off valve for connection;

(c) a fixed maximum liquid level device and a contents gauge;

(d) a pressure gauge connected to the vapour space; and

(e) a suitable earthing connection.

All fittings on vessel or mounded tank shall be accessible above ground level and shall be either on the manholes or on welded extensions.

17.1.2.3 PRESSURE RELIEF VALVES

Pressure relief valves shall be of tamper-proof, direct spring loaded type, and designed to start to discharge and attain full flow at pressure in accordance with the Pressure Vessel Code of the vessel. Weight loaded relief valves shall not be used. The pressure relief valve shall have the following information stamped on the valve or on a separate metal plate securely fixed to it: -

(a) the manufacturer’s identification including name and catalogue or type number; and

(b) the start to discharge pressure. Space shall be provided on the valve or the metal plate for subsequent stamping of periodic retest dates.

In the case of multiple pressure relief valves, provision made for isolating any one relief valve for testing or servicing shall ensure that the remaining relief valves provide the full capacity. In the case of vessels fitted with single relief valves, provision shall be made for their removal for testing or servicing by the use of an automatic shut-off valve which shall be fully open by the presence of the relief valve and shall close before the relief valve is completely removed.

For underground vessels or mounded tanks, the full flow capacity of the pressure relief valves may be reduced to not less than 30% of the capacity derived from the following formula: -

$$\text{Flow rate, litres/s air} = 177.637 \times (\text{Surface Area, m}^2)^{0.82}$$

Excess flow valves shall not be installed between the vessel and any pressure relief valve.

17.1.2.4 VENT PIPES

For all underground vessels or mounded tanks, the relief valves shall be fitted with vent pipes adequately supported and having outlets at least 2 m above the top of the vessels to which they are fitted and at least 3 m above ground level. Vent pipe outlet shall be located away from fixed sources of ignition at a minimum distance of 4.5 m. Electrical fittings within this area shall be in accordance with this General Specification.

Vent pipes shall be designed for the full flow characteristic of the relief valves, to allow for drainage of water and to ensure that in the case of ignition of discharging products, flame impingement on the vessel or on any adjacent vessels, piping or equipment is avoided.

Vent pipes shall be provided with loose fitting captive rain caps.

In case of vessels fitted with protective covers, the vent shall be provided to direct the discharged LPG through the relief valve away from the vessel shell.

17.1.2.5 SHUT OFF VALVES AND EMERGENCY VALVES

All liquid and vapour connections on vessels other than those for relief valves, plugged openings and those where the connection through the vessel shell is not greater than 1.4 mm, shall have fire resistant shut-off valves conforming to BS EN 12266-1:2012 and BS EN 12266-2:2012 or ANSI/ API Std 607:2016 or equivalent, capable of manual operation located as close as practicable to the vessel. Particularly, liquid and vapour withdrawal connections shall be fitted with shut-off valve completed with integral excess flow valves. Filling connection shall be fitted with shut-off valve and check valve.

Other connections to the vessel greater than 3 mm diameter for liquid and 8 mm diameter for vapour with the exception of those for relief valves and drain connections shall also be protected with an emergency valve.

Remotely controlled emergency valve shall be provided for large size connections of 40 mm or above. The emergency valve manual control shall be operated from a safe area and be of the “fail-safe” type.

17.1.2.6 FILLING CONNECTIONS

All filling connections of a storage vessel shall be installed in accordance with Section 3.1.5 of with Code of Practice for Hong Kong LPG Industry Module 1 and be equipped with: -

(a) an emergency valve, e.g. an excess flow valve, back check valve; and

(b) a shut-off valve preferably capable of manual operation.

Filling connections shall be easily accessible, preferably within the storage fenced area, and as close to the vessel as is practical, but not directly underneath.

Filling connections shall be located so that the safe positioning of the delivery vehicle and its quick removal in an emergency are facilitated.

Offset/Remove filling connections including vapour returns, shall be clearly labelled "liquid" or "vapour" as appropriate and shall terminate about 1 m above ground and shall allow a horizontal connection to be made with the delivery hose(s).

17.1.2.7 DRAIN CONNECTIONS

Drain connections designed shall be installed in accordance with Section 4.7 of Code of Practice for Hong Kong LPG Industry Module 1 to permit drainage to atmosphere shall be provided with a shut-off valve which is preferably not more than 50 mm nominal size. The outlet of the drain valves shall be provided with a length of piping terminating with second shutoff valve, preferably not more than 25 mm nominal size. A sufficient length of piping shall be provided downstream of the second valve to ensure that discharge will not take place beneath the vessel. The drain valve adjacent to the vessel connection shall be quick action type.

No drain or blow-off line shall discharge into or be in the proximity of any public drainage system or any other drainage system where this would be liable to create a hazard.

The outlet of the drain valve system shall be blank-flanged, plugged or otherwise secured against tampering when not in use.

Pipework between the drain system valves and between any valve and a blank-flange or plug etc. shall be protected by hydrostatic pressure relief valve.

17.1.2.8 GAUGES

The content gauges shall clearly indicate whether they read in % water capacity, % rated LPG capacity or actual contents in litres, tonnes, etc. Each bulk tank shall be equipped with at least two gauges for indicating the quantity of content, one of which shall be of a fixed liquid level type.

Any content gauge which relies on bleeding to atmosphere shall be such that: -

(a) The bleed hole maximum opening is not larger than 1.4 mm otherwise it shall be protected by a shut-off valve and a suitable emergency valve;

(b) It shall not be completely withdrawn in normal gauging operation; and

(c) The gland shall be capable of being repacked without withdrawing the vessel from service.

The setting of the maximum level devices shall be suitable for the grade of LPG being stored and shall indicate a maximum product level for the designed usage at a temperature of 52.5°C.

Temperature gauges shall be of the indirect type comprising pockets merged in contact with the vessel contents. Pockets if temperature gauges shall be in the form of blind tubes suitable length, oil filled, permanently welded to the vessel and constructed in accordance with the Pressure Vessel Code of the vessel.

Pressure gauges shall be provided for all fixed storage vessels and connected to the vapour space of the vessel and easily readable from ground level. Pressure gauge mounting connection shall be protected either by a tapping reduced internally to a bleed hole not larger than 1.4 mm or by a suitable excess flow valve and shut off valve.

17.1.2.9 MAXIMUM PERMITTED FILLING VOLUME

The maximum permitted filling volume should be reference to the legal requirements for filling of cylinders as prescribed in the Regulation 10(2) of the Gas Safety (Gas Supply) Regulations, Cap. 51B.

LPG tank or cylinder shall not be filled other than such that, at temperature of: -

(a) 47.5°C, the tank will not be more than 97%, and the cylinder will not be more than 95%, full of LPG in liquid form; and

(b) 52.5°C, the tank or cylinder will not be full of LPG in liquid form.

17.1.2.10 LOCATION AND SAFETY DISTANCE

No underground storage vessels shall be installed in basements or open pits. Storage vessels shall be spaced and located in accordance with Code of Practice for Hong Kong LPG Industry Module 1in which the distances given are the minimum recommended and refer to the horizontal distance in plan between the vessel and the nearest point of a specified feature, e.g. an adjacent storage vessel, building, property line, fixed point of ignition, any point of the LPG installation boundary up to which the general public legitimately have access. For underground vessels, distance from the vessel is measured from the valve assembly on the manhole cover.

The distance from the valve assembly on the manhole cover and the loading/unloading point to the LPG installation boundary up to which the general public legitimately have access must be at least 3 m.

For underground storage vessels, the distance between the vessel and the LPG installation boundary must be at least 1.5 m and the concrete chamber around the underground storage vessel must be wholly within the LPG installation boundary.

17.1.2.11 ARRANGEMENT AND SEPARATION

In the case of multiple vessel installations, and where vessels are interconnected in the liquid phase, precautions must be taken to prevent both overfilling and the unintentional transfer of liquid from one vessel to another.

The arrangement and separation of storage vessels shall comply with the requirements stipulated in Code of Practice for Hong Kong LPG Industry Module 1.

An LPG storage vessel shall not be installed nearer than 7 m to any vessel or bund wall of vessels containing any other inflammable liquid with a flash point below 65 °C.

The number of storage vessels in one group shall not exceed six. Any vessel in one group shall be at least 8 m from any vessel in another group unless a radiation wall is erected between the groups, or adequate fixed water drenching systems are provided.

Separation kerbs for directing spillage away from vessels and other important areas shall not be higher than 380 mm.

Suitable protection shall be provided to prevent possible damage to the above ground vessels and associated equipment valves, etc. by the use of crash barriers, bollards or a non-continuous kerb of not more than 380 mm in height.

Individual underground vessels or mounded tanks of a multi-vessel system shall each be enclosed by a separate concrete chamber.

Underground vessels or mounded tanks shall be protected from above ground loadings due to vehicular traffic or other cause, by fencing off the area under which the vessels are buried or protecting them with reinforced concrete slab or other adequate cover. The perimeter of the area under which the vessels are buried shall be permanently marked.

17.1.2.12 FINISHES AND COATING

The exterior of an underground vessel shall be covered with a coating material which shall be strongly bonded to all external surfaces of the vessel. The coating material shall have the following properties: -

(a) be electrically insulating and possess high dielectric strength;

(b) be inert and impervious to water;

(c) possess adequate mechanical strength to resist damage during handling of the vessel; and

(d) have sufficient flexibility to allow for any damage due to expansion or contraction of bulk tank.

After coating of the vessel is completed, “holiday” test shall be carried out in accordance with this General Specification.

17.1.2.13 CATHODIC PROTECTION

Every mounded or underground vessel shall be provided with a cathodic protection system complete with test point (Regulation 12(1) of the Gas Safety (Gas Supply) Regulations, Cap. 51B). The system shall be designed in accordance with NACE SP0285-2011. The anodes shall be of a design life which is adequate for providing the required protection until the vessel(s) is due for the next test and examination required under the Regulation 8(4) of the Gas Safety (Gas Supply) Regulations, Cap. 51B. Tests on the cathodic protection system shall be made after completion of the installation and at 6 month intervals thereafter. The test results shall include the following data and shall be recorded and retained for the life of the vessel.

(a) quantity, size and location of anodes;

(b) date of installation;

(c) type of backfill material; and

(d) resistivity measurement of electrolyte.

SUB-SECTION 17.1.3

LPG CYLINDERS

17.1.3.1 GENERAL

This section covers LPG installation using transportable, refillable cylinders, each not exceeding 130 litre water capacity. For safety of LPG disposable cylinders, the Guidance Note GU19 on "Safety of Disposable LPG Cylinders" shall be observed.

The LPG installation may not ask for the supply of LPG cylinders. However, LPG shall be supplied in cylinders which comply with the Guidance Notes on Gas Supply Installations or other recognised pressure vessel codes and approved by the appropriate authority of Government of Hong Kong Special Administrative Region.

Refilling the transportable cylinders shall not be carried out locally at the LPG installation.

17.1.3.2 LIQUID-DRAW SYSTEM

Installation using liquid-draw LPG cylinders shall be incorporated with a vaporiser for the production of vapour LPG, which shall subsequently be conveyed to the appliance through pressure regulator(s).

Hydrostatic pressure relief valve shall be installed on each liquid piping that can be isolated by valves.

All liquid-draw cylinders shall be conspicuously marked for clear distinction from vapour-draw cylinders.

17.1.3.3 VAPOUR-DRAW SYSTEM

Installation having vapour-draw LPG cylinder may direct feed the installation through pressure regulator(s).

17.1.3.4 MULTI-CYLINDERS SYSTEM

Multi-cylinders in cylinder banks shall be manifold together by a permanent header, which shall be linked together through changeover device to enable that only one bank cylinder will supply LPG to appliances at any one time.

Manual and automatic changeover device shall be equipped with indication for the particular bank of cylinders being in operation, and may be complete with pressure regulation device should it be used in a vapour-draw system. The operation of the changeover device shall avoid GAS ON-GAS OFF-GAS ON situation.

Connection of the cylinders to a manifold shall be made by flexible hose and of sufficient length for easy manoeuvring of the cylinders. A flexible hose connecting to a manifold shall not be left unconnected after commissioning.

Safety Devices

(a) Provision shall be incorporated into a manifold system to ensure that failure of a flexible hose connecting a cylinder to the manifold will not cause the complete loss of content from other cylinders.

(b) When more than one cylinder supplying LPG to a piped gas system by means of flexible hose to a manifold system, appropriate safety devices shall be incorporated in accordance with Regulation 11(e) of the Gas Safety (Gas Supply) Regulations, Cap. 51B.

(c) The device consisting of a stop valve with check function shall be installed between the flexible hose and the manifold system for all cylinders. In the case of liquid withdrawal cylinders, one particular cylinder of each bank shall be installed with a stop valve with excess flow device to allow liquid LPG to flow back from the vaporiser.

(d) By-pass pipework in addition to changeover device may be provided to ensure continuity of supply during maintenance. By-pass valves shall be kept closed throughout the normal operation.

17.1.3.5 SIMPLE DOMESTIC INSTALLATION

For domestic installation using LPG cylinder of 15 kg or less, a clip-on regulator may be connected directly to the cylinder for drawing vapour LPG to the appliance through flexible hose, rubber tubing and/or metal piping. Clip-on regulator shall be of approved type acceptable to the Gas Authority.

17.1.3.6 STORAGE OF LPG CYLINDERS

The storage of LPG cylinders and the minimum separation distance to boundary building or fixed ignition source from the nearest cylinder shall be in accordance with the current issue of Code of Practice for Hong Kong LPG Industry Module 1 published by the Gas Standards Office.

Within a single storage, all LPG cylinders are considered to be full irrespectively of the state of their contents for the purpose of calculating the minimum separation distance.

The maximum capacity of a piped cylinder store shall be 1000 kg.

Wherever practicable LPG cylinders shall be stored in open air with top cover of non-combustible material for weather protection and shading from direct sunshine. Where an open storage is not practicable, a purpose-built storage room shall be provided and constructed in accordance with the ventilation and explosion relief requirements in this General Specification.

The storage arrangement of cylinders in standby cylinder stores shall conform to the following: -

(a) The gangway between palletised stacks shall be not less than 2.5 m while that between unpalletised stacks shall be not less than 1.5m; and

(b) The maximum height of a stack shall not exceed 1.6 m.

SUB-SECTION 17.1.4

VAPORISERS

17.1.4.1 TYPES

Vaporisers shall be of indirect heated type without naked flame or red-heated element, and utilising water as the heating medium. All electric elements and components installed within the vaporiser, shall be of flameproof design with enclosure to BS EN 60079-1:2014 or equivalent, unless they are being installed elsewhere and are physically separated at least 1 m from the vaporiser.

Vaporisers should be designed and constructed such that they are not required to be tested or examined more frequent than once every five years. Vaporisers of direct fuel/heated type with naked flame or of non-flameproof electrical type shall not be used.

Heating coil shall not be installed inside bulk tanks as means of vaporisation.

17.1.4.2 CAPACITY

The vaporiser shall have sufficient capacity to convert the liquid LPG at minus 10°C to vapour at a temperature above the dew point at the maximum inlet pressure to the vaporiser and at the maximum demand rate from the installation.

17.1.4.3 CONSTRUCTION

Pressure containing component of the vaporisers shall be designed, manufactured and factory tested in accordance with a recognised Pressure Vessel Code. The design pressure of the LPG containing component shall meet the highest pressure and temperature in service. Certificates shall be produced to verify the standard of construction.

Each vaporiser shall be permanently labelled on the outer surface of the casing to display the following data: -

(a) The design Pressure Vessel Code;

(b) The manufacturer's name, serial number and the date of manufacture;

(c) The maximum LPG working pressure and temperature;

(d) The outside surface area of the pressure vessel in m^2;

(e) The vaporising capacity in litre per minute or kg per hour; and

(f) The heat exchanger area in contact with liquid LPG in m^2.

Extra space shall be provided in the metal plate for subsequent periodic stamping of retest dates.

17.1.4.4 FUNCTIONAL COMPONENTS AND SAFETY DEVICES

Each vaporiser shall be equipped with at least the following facilities so as to ensure proper functioning and safe operation: -

(a) Pressure relief valve in direct communication with the vapour side for an immediate and effective discharge of vapour to atmosphere at full flow conditions in case of excess vapour pressure. The relief pressure shall be in accordance with the Pressure Vessel Code to which the vaporiser is designed and constructed. The relief capacity shall be 3.33 times the values using the surface area of the vaporiser shell in accordance with the method stated in Section on Bulk Storage Vessels of this Part of the General Specification and that of the heat exchanger that is directly in contact with LPG as the total surface area;

(b) Liquid control device (such as a magnetic valve or float valve) to prevent liquid LPG from penetrating through the vaporiser to the vapour discharge pipe during heat input failure, overloading and any other abnormal condition;

(c) Non-bimetal heat input control to prevent overheating and the pressure in the vaporiser vessel from reaching the start-to-discharge pressure of the pressure relief valves. Large vaporisers with multiple heating elements may be controlled by stages by more than one thermostat for regulating the temperature;

(d) A drain off point for the LPG circuit complete with an intentionally operated control valve for the periodic drain off of oil and residue collected at the vaporiser. End of the connection shall be blanked or plugged;

(e) Water level indicator and a low water level cut off to protect the vaporiser against damage due to low water level;

(f) Gauges or other indication devices to accurately monitoring the state of liquid and vapour LPG within the vaporisation system and to keep track of the water temperature during operation;

(g) A drain valve for the water chamber;

(h) Shut-off valves at both the liquid and vapour LPG lines connecting the vaporiser to the storage vessel in accordance with Regulation 13 of the Gas Safety (Gas Supply) Regulations, Cap. 51B. The emergency shut-off valves provided at upstream of the vaporisers shall be installed at a location as close to the vaporisers room entrance and as far away from the bulk tank as possible for access in the event of fire. Emergency shut-off valves shall be of fire-resistant type; and

(i) Fusible plugs and frangible discs shall not be installed in the vaporisation system.

17.1.4.5 LOCATION OF VAPORISERS

Table 17.1.4.5 (1) Minimum Distance from Vaporiser to Underground or Mounded Storage Vessel

Type of Vaporiser	Underground or mounded storage vessel up to 60 tonnes
Indirect heated or flameproof electric	1.5m

Table 17.1.4.5 (2) Minimum Distance from Vaporiser to Building or Boundary Lines of Adjoining Property

Type of Vaporiser	Minimum Distance
Indirect heated or flameproof electric	3 m

Electrical wiring and lighting for vaporiser room shall be designed and constructed in accordance with zone 1 electrical classification.

Pressure relief valves, pressure regulators and control equipment installed near the vaporiser shall not be located at where the ambient temperature is in excess of 60°C unless they are specifically designed for higher temperature.

17.1.4.6 DRAIN AND VENT

Liquid LPG drain valve shall be permanently connected to pipe of sufficient length and running away from the vaporiser so that discharge of liquid LPG will not take place near to the vaporiser. The pipe outlet shall be fitted with another intentional operated shut-off valve but of one size smaller than the drain valve. The point of discharge of the liquid LPG shall be so selected that the possibility of creating a hazard is minimal.

Vapour from the pressure relief valve shall be piped upward and away from the adjacent LPG storage vessels for free discharge to the atmosphere. Vent pipes shall be designed for the full flow characteristic of the pressure relief valve.

SUB-SECTION 17.1.5

PIPING AND FITTINGS

17.1.5.1 MATERIAL

All materials shall be compatible for use with LPG under the service conditions to which they are subjected. Pipes shall be of steel construction complying with Code of Practice for Hong Kong LPG Industry published by the Gas Standards Office. Materials such as cast iron, aluminium or its alloys, copper, rubber and plastic other than those specially designed for LPG shall not be used.

LPG mains and service pipes should only be run below ground where this is unavoidable, and under such circumstance consideration should be given to use medium density polyethylene pipes instead of steel pipes. Pipework should be protected from mechanical damage as appropriate.

17.1.5.2 STEEL PIPES

All liquid pipelines shall be Schedule 80 seamless steel pipes conforming to BS EN 10216-1:2013, BS EN 10217-1:2019 or ANSI/API Spec 5L:2007, and of a design working pressure of 2.75 MPa.

All vapour pipelines at high pressure stage shall be Schedule 80 seamless steel pipe conforming to BS EN 10216-1:2013, BS EN 10217-1:2019 or ANSI/API Spec 5L:2007 or ASTM A53/A53M-12 or equivalent.

All vapour pipelines at medium pressure stage and below shall be of heavy grade steel construction and conform to BS EN 10255:2004 or ISO 7-1 heavy grade or equivalent.

17.1.5.3 FLEXIBLE GAS HOSE AND TUBING

The flexible gas hoses and tubings shall be of the type which has been approved by the Gas Authority. Metallic tubing shall be used if an approved type which is suitable for the particular application is available. Corrosion resistant braiding shall be used. Each flexible hose shall be marked with “LPG” and be tagged with a label indicating the date of next replacement.

Emergency valves shall be installed in all liquid pipelines and in vapour pipelines at high pressure stage to which the flexible rubber hose are connected, to prevent discharge of LPG Gas in the event of hose failure. A manual shut-off valve shall be used for vapour lines designed to operate at medium pressure stage or below.

For installations up to 5kPa, the tubing shall be of minimum practicable length and shall not exceed 2 metre. The flexible tubing shall not extend from one room to another nor pass through wall or ceiling etc. and shall be easily accessible for inspection.

The end fitting of the flexible rubber hose or rubber tubing shall comply with BS 5315:1991 or the equivalent of applicable codes.

The clips, clamps or spigots used to secure flexible rubber hose or rubber tubing on the fittings shall be free from burrs and rough edges and shall not be over-tightened.

17.1.5.4 PIPE JOINTS

Joints in steel pipes of 50 mm nominal bore and smaller shall be welded, or where approved flanged or screwed. Steel pipe joints over 50 mm nominal bore shall be welded, or where approved welded flanged. LPG pipes shall be of welded construction as far as practicable. LPG pipes of flanged or screwed construction shall have the prior approval of the Supervising Officer before installation.

Jointing of steel pipes by electric arc welding shall be in accordance with BS 2971:1991 shall be used on pipes of 15 mm nominal bore or larger.

Jointing compounds for screwed connections shall be resistant to LPG and shall comply with BS 6956-1:1988, BS 6956-5:1992, BS EN 751-1:1997 and BS EN 751-2:1997. The use of PTEE tape is preferable but lead or hemp shall not be used.

All underground LPG pipe joints shall be welded unless otherwise approved by the Supervising Officer. Flanged connections shall be kept to a minimum.

17.1.5.5 PIPE FITTINGS

Steel flanges and flanged fittings shall be to ANSI/ASME B 16.5-2009 or BS EN 1759-1:2004 on liquid lines or vapour lines at high pressure stage. Flanges on vapour lines operating at medium pressure stage or below shall conform to BS EN 1515-1:2000, BS EN 1092-1:2018. Bolting shall comply with BS EN 1515-1:2000, BS EN 1515-3:2005 or BS 4882:1990 or the equivalent of applicable codes.

Steel butt-welded fittings shall be to BS EN 10253-1:1999 or at least the same schedule thickness as the pipes for use at high pressure stage.

Steel socket-welded aid screwed fittings and screwed coupling shall be to BS 3799:1974 or equivalent standard for use at high pressure stage.

Screwed fittings for use with steel pipes to BS EN 10255:2004 or ISO 7-1 on vapour lines operating at medium pressure or below shall conform to BS 143 & 1256:2000 or BS EN 10241:2000 or the equivalent of applicable codes.

Gaskets shall be resistant to LPG and natural rubber shall not be used.

Screwed union or compression fittings for piping installation within LPG compound and cylinder store shall be avoided and shall not be used without the prior approval of the Supervising Officer.

17.1.5.6 ALLOWABLE PRESSURE DROPS

Piping shall be sized that the pressure drop along the medium pressure stage shall not exceed 7 kPa, and that along the low pressure stage shall not exceed 0.15 kPa.

17.1.5.7 PIPING INSTALLATION

Only lateral pipework inside the premises feeding the gas appliances may be allowed to be buried in floor slab. They shall be protected against corrosion and mechanical damage. Installation risers shall be carried external to the building and exposed or may be enclosed inducts complying with BS 8313:1997.

All pipework shall be properly supported with strong hangers, anchors, brackets, saddles, guides etc. Pipe supports shall be arranged as near as possible to joints and changes of direction and each support shall take its share of load.

Supports for steel pipes shall be of mild steel, malleable iron or galvanised steel. Copper pipes shall be fixed by gunmetal or brass pipe clip. Brackets screwed to walls shall be secured by expanding plugs or other approved methods. The top half of the pipe clip shall be detachable without disturbing the fixing. The maximum distances of pipe supports shall be as shown in Table 17.1.5.7.

Table 17.1.5.7 Spacing of Support for Steel Pipe

Nominal Pipe Size (mm)	Maximum Distance between Supports (m)	
	Vertical runs	Horizontal runs
20	3	2.5
25	3	2.5
32	3	2.7
40	3.5	3
50	3.5	3
80	4.5	3
100	4.5	3
150	4.5	3
200	4.5	3

Vertical pipe risers shall be adequately supported at the base to withstand the total weight of the risers and shall be protected against mechanical damage to a minimum height of 2 metres from ground level.

All vertical and horizontal pipe runs shall have adequate flexibility and facilities to compensate for thermal expansion and contraction of pipes, or mechanical stress at branch pipes.

Insulation shall be provided in the pipe support for those sections of piping where cathodic protection has been provided.

All pipes shall be thoroughly cleaned and wirebrushed to remove all grease, dirt, rust, scale, and other defects before installation; and shall be protected against corrosion by wrapping, galvanising or painting as appropriate.

During the installation work in progress, all open ends of the pipework shall be blanked off with purposely made plugs or caps to keep foreign matters from entering the finished system.

Pipework laid in floor slab shall be protected by factory-bonded sheath or wrapping. The piping shall be covered to a depth of not less than 12 mm. The channel shall be cleaned of all debris, sharp edges, rubbish and surplus moisture before the pipe is embedded.

Pipework passing through wall or floors of a building, shall be wrapped and enclosed in metal sleeve for complete length through the walls or floors and sealed with a non-combustible sealing agent at both ends. The annular space between the sleeve and the pipe shall be of sufficient width to allow for the maximum movement of the pipe due to thermal expansion and contraction. No joint shall be located within the sleeve. The sleeve shall be of same material as the LPG piping. Where sleeve passes through a floor that may be wetted or a wall on which water or corrosive material may condense, the sleeve shall project at least 25 mm beyond the floor or wall finished surfaces.

A minimum clearance of 150 mm shall be maintained between the LPG pipe and electric conduits or cables.

Pipework buried underground shall be adequately protected against corrosion and mechanical damage. Pipework shall be treated with two coats of bituminous paint and wrapped with corrosion and water resistance self-amalgamating tapes and mastics, or other equal and approved wrapping for protection against corrosion. The pipeline channel shall be cleaned of all debris, rubbish and surplus moisture, and the pipe shall be supported to ensure that it is can be completely surround by crack free mortar.

Underground pipework outside the premises shall be buried at a depth of not less than 800 mm. In the case where gas pipes and underground electric cables are running in a common trench, a minimum clearance of 200 mm shall be maintained between the two services. Pipe markers shall be fixed to indicate the route of the buried pipelines.

Underground pipework at road crossing shall have sufficient mechanical protection to prevent crushing. The detail of protection shall be submitted for approval before installation.

SUB-SECTION 17.1.6

VALVES AND ACCESSORIES

17.1.6.1 GENERAL

Pressure containing metal parts of valves (except appliance valves), including manual positive shut-off valves, excess-flow check valves, back-flow check valves, emergency shut-off valves and remotely controlled valves (either manually or automatically operated), used in piping systems shall be of steel, ductile iron, malleable iron or brass. Ductile iron shall meet the requirements of ASTM A 395/ A 395M-99:2014 or equivalent and malleable iron shall meet the requirements of ASTM A 47/ A 47M-99:2014 or equivalent. All materials used, including valve seat discs, packing, seals and diaphragms, shall be resistant to the action of LPG under service conditions.

All diaphragm valves shall be fitted with renewable diaphragms. Back seating shall be provided to isolate the gland packing when the valve is open for repair or inspection. Screwed ends shall be to BS EN 10241:2000. Taper threads and flanged end shall be to BS EN 1759-1:2004 or BS EN 1092-1:2018.

All valves shall be fitted in accessible positions and shall carry clear indication of the direction of operation required to open and to close the valve. Clockwise rotation of the lever or spindle shall close the valve.

17.1.6.2 EXCESS FLOW VALVES

Excess flow valves or emergency valves shall be installed in the correct flow direction and shall intend to close upon excessive discharge of vapour or liquid resulting from a downstream rupture in hoses and piping system. The flow rate for closure of the valve shall be substantially above normal service flow rate to prevent premature closing, but shall in no case exceed 1.5 times the normal service flow rate.

17.1.6.3 NON-RETURN VALVES

Non-return valves shall be suitable for liquid or vapour use in LPG cylinders/bulk tanks or in-line application. The valve shall be fitted with soft seat for tight shut-off so that piping can be blown down for maintenance without leakage.

17.1.6.4 ISOLATING VALVES

Isolating valves shall be of globe type with ductile iron bodies and stainless steel stems to resist corrosion. The valve seat shall be suitable for long-lived leakproof service. Steel ball valves shall be to BS EN ISO 17292:2015.

17.1.6.5 QUICK-ACTING SHUT-OFF VALVES

Quick-acting shut-off valves shall be of lever operation and shall design to close tight in the direction of arrow.

17.1.6.6 EMERGENCY SHUT-OFF VALVES

A shut-off valve incorporating thermal and manual means of closing provide for remote means of closing. Emergency shut-off valves shall be provided and incorporate all of the following means of closing: -

(a) Automatic shut-off through thermal (fire) actuation. When fusible elements are used they shall have a melting point not exceeding 121°C;

(b) Manual shut-off from a remote location; and

(c) Manual shut-off at the installation.

17.1.6.7 PRESSURE RELIEF VALVES

Pressure relief valves shall be spring-loaded and be fully automatic in operation. The valves shall have an effective rate of upward discharge to protect a system against excess pressure. The outlet vent connection shall terminate vertically with a self-detachable weatherproof cap complete with chain at least 3 m above ground level with an ultimate vertical section of minimum 2 m in length. Pressure relief valves for bulk LPG storage vessel shall also refer the Section on Bulk LPG Storage Vessels of this Part of the General Specification.

Each pressure relief valve shall be plainly and permanently marked with the following: -

(a) manufacturer’s identification including catalogue or type number;

(b) start to discharge pressure; and

(c) certified capacity in terms of air at Standard Temperature and Pressure (STP).

17.1.6.8 HYDROSTATIC RELIEF VALVES

Hydrostatic relief valves shall be installed in pipelines and hoses located between isolating valves or blank flanges when liquid LPG can be trapped to protect a system against excessive pressure caused by thermal expansion of contents. The pressure relieving device shall be fixed in such a way that it will not discharge excessive pressure endangering personnel or equipment. The valve shall have a pressure setting in the range of 2.4 MPa to 2.75 MPa and be fitted with a self-detachable weatherproof cap complete with chain. The pressure setting shall not be higher than the weakest element in the system.

17.1.6.9 PRESSURE GAUGES

Pressure gauges shall have stainless steel case and burden tube with dials not less than 75 mm diameter. They shall be installed at high, medium and low pressure stages to indicate the service pressures. Calibration shall be in kPa. Pressure gauge connections shall be protected by a tapping reduced internally to a bleed hole not larger than 1.4 diameter or by a suitable excess flow valve and shut-off valve.

17.1.6.10 METERS

The design, material and construction of meters shall be suitable for the grade of LPG and the pressure and flow which they are to handle. The meter shall comply with the relevant parts of BS EN 12405-1:2021, BS EN 1359:2017, BS EN 12261:2018 and BS EN 12480:2018 and have corrosion resistant body and shall be of maintenance-free construction. If the meter is enclosed in a box for mechanical protection, the box shall be provided with sufficient ventilation.

SUB-SECTION 17.1.7

PRESSURE REGULATION

17.1.7.1 PRESSURE RANGES

It refers to ranges of high pressure stage, medium pressure stage and low pressure stage as defined under this Part of the General Specification.

17.1.7.2 CONSTRUCTION OF PRESSURE REGULATORS/GOVERNORS

Pressure regulators/governors shall be compatible for use with LPG in Hong Kong and designed in accordance with Regulation 21 of the Gas Safety (Gas Supply) Regulations, Cap. 51B. The material, construction, performance and testing requirements for regulators of different pressure stages shall conform to BS EN 12864:2001+A3:2009, BS EN 13785:2005+A1:2008 and BS EN 13786:2004+A1:2008 except otherwise specified.

All pressure regulators/governors shall be sealed and locked against unauthorised adjustment after final testing and commissioning.

17.1.7.3 PRIMARY PRESSURE REGULATOR

The primary pressure regulator is used for reducing the system pressure from high pressure stage to medium pressure stage or directly to low pressure stage.

The medium pressure of the LPG system shall be as specified in the Particular Specification. The pressure chosen shall not enable the LPG to re-condense due to fluctuation of ambient temperature. Thermal insulation may be used to prevent the re-condensation and the insulation shall be impervious to the ingress of water, resistance to fire and sufficiently robust to withstand minor mechanical damage.

If active-monitor regulator is used, the active regulator shall be of the fail open type. The monitor regulator shall be of a fail shut type or equivalent and equipped with an external static connection and shall be set at a slightly higher pressure than that of the active regulator downstream. The external static connection shall be connected at a point free of turbulence and preferably at a minimum of 5-pipe diameter downstream.

All first stage pressure regulating devices shall be located as close as practicable to the storage vessel or vaporiser and shall also be adequately supported and easily accessible.

Isolating valves shall be provided to facilitate removal of regulator(s) and shall be installed as close as practicable to the regulator(s).

17.1.7.4 SECONDARY PRESSURE REGULATOR

The secondary pressure regulator is used for reducing the system pressure from medium pressure stage to low pressure stage and shall be capable of maintaining an outlet pressure of not exceeding 6.9 kPa. The installation shall be fully protected against effects of both over-pressure and under-pressure downstream with a need to ensure adequate reliability and continuity of supply.

If the primary pressure regulator is not of the active-monitor type, the secondary pressure regulator shall be equipped with slam-shut valve, under pressure shut off (UPSO) and over pressure shut off (OPSO) devices for protection against regulator malfunctioning.

All secondary pressure regulators and associated protective devices shall be suitable for outdoor use. They shall be able to work well at overpressure and underpressure condition and shall normally be installed outside building except otherwise specified.

17.1.7.5 SERVICE GOVERNOR

The service governor is used to reduce the system pressure from low pressure stage to the operating pressure of the gas appliances connecting to it and shall be of spring-loaded type. The nominal outlet pressure of the service governor shall be adjustable by means of a tool and shall normally be set at 2.9 kPa except otherwise specified. The service governor shall be capable of maintaining its outlet pressure with a maximum fluctuation of 10%.

The service governor shall be suitable for installation on horizontal or vertical pipe lines.

17.1.7.6 REGULATORS WITH OVER PRESSURE AND/OR UNDER PRESSURE SHUT OFF DEVICES

The over pressure shut off (OPSO) device shall prevent excessive pressure from entering a building. The OPSO device shall close automatically and require manually reset if the regulator outlet pressure rises above a maximum set point.

The under pressure shut off (UPSO) device shall prevent any abnormal low inlet pressure and/or too great downstream demand. The device shall close automatically and require manual reset.

The OPSO and/or UPSO device(s) may be integral with a regulator.

17.1.7.7 REGULATORS/GOVERNORS WITH FULL CAPACITY OF INTERNAL RELIEF

Regulators/governors equipped with full capacity internal relief valve shall be capable of limiting the increase of outlet pressure of not more than 7 kPa or the maximum acceptable operating pressure of gas appliances downstream, whichever is the lower, even if the regulator is blocked open at full inlet pressure. The relief valve shall begin to operate at a pressure increase of 2 kPa at the regulator outlet and shall remain open until the over pressure condition is relieved.

Vent pipes shall be used to discharge the gas through the internal relief valve to freely ventilated locations when the escaping gas may constitute a hazard. Obstruction-free tubing or piping of at least 20 mm diameter shall be used and a screened vent shall be installed at the end of the vent pipe. On all installation, the bent or the end of the vent pipe must be protected from anything that may clog it.

SUB-SECTION 17.1.8

HAZARD PRECAUTION AND FIRE PREVENTION

17.1.8.1 ELECTRICAL & ELECTROSTATIC HAZARD PRECAUTIONS

Area Classification shall be in accordance with Section 6 of Code of Practice for HKLPG Industry module 1.

All electrical equipment, apparatus and luminaries to be used in the designed hazardous area shall comply with the recommendations of BS EN 60079-14:2014 & BS EN IEC 60079-10-1:2021 and shall be of a type suitable for the intended use in the appropriate zones. The certificates from the appropriate authority shall be provided for approval before installation. All electrical equipment shall indicate clearly the type of service for which the equipment is designed, i.e. intrinsically safe or flameproof, etc.

Electrical wiring for flameproof installations and earthing of the power supply system shall be in accordance with the Section on Electrical Installation of this General Specification.

With the exception of the insulation which is required to break the continuity of piping to meet the cathodic protection requirement, all other LPG piping and equipment shall be electrical continuous and earthed. Continuity tests shall be carried out to the satisfaction of the Supervising Officer.

LPG piping shall not be used as electrical circuit protective conductor or earth electrode for other systems although their bonding to the circuit protective conductor may be necessary.

Whenever it is not contradict to the cathodic protection requirement, all bulk storage vessels shall be electrically earthed to protect against the accumulation of static electricity.

An earthing terminal shall be provided near the LPG filling point for the connection of the bulk tanker vehicles. The earthing resistance of the earthing terminal shall not exceed 1 x 106 ohm for dissipation of static electricity from the bulk tanker vehicles.

17.1.8.2 FIRE PREVENTION AND CONTROL

Fire prevention and control shall be in accordance with Code of Practice for Hong Kong LPG Industry Module 1.

Provision of fire fighting equipment/systems e.g. fire extinguishers, water drencher, etc., shall be as advised by the Director of Fire Services. The installation of these equipment/systems shall be in accordance with the Part on Fire Service Installation of this General Specification.

Vessel supports excluding those 450 mm or less in height shall be constructed or protected to have a standard of fire resistance of at least two hours.

Weeds, long grass and any combustible material should be kept clear from an area within 3 m of any LPG vessel of up to 2250 litres water capacity and 6 m of larger vessels. Weed killers containing chemicals such as sodium chlorate, which are a potential source of fire danger, shall not be selected for this purpose.

SUB-SECTION 17.1.9

MISCELLANEOUS

17.1.9.1 GAS DETECTION

Gas leakage or suspected gas leakage shall be checked by the use of a gas detector, soapy water or by smell BUT NEVER WITH A NAKED FLAME.

Work in the affected or suspected gas leakage areas shall only be resumed subject to satisfactory gas detector readings.

Inflammable gas detectors shall be used only by Competent Persons.

17.1.9.2 LPG TRANSFER PROCEDURES

The following procedures shall be applied before LPG is transferred from road tankers to bulk storage vessels: -

Any driving unit or electrical equipment not required and not specifically designed for the transfer operation shall not be used and be isolated.

Fire extinguishers shall be located in easily accessible positions and temporary warning notice displayed prominently.

Any accumulated static electricity on a road tanker shall be safety discharged to the earth terminal provided for this purpose before the LPG transfer connections are made.

A responsible person of the oil company shall remain both in attendance and control during all transfer operations to ensure that all the safety operation measures established by the oil company are enforced.

The road tanker shall be parked in the unloading space and shall be directly under the water sprinkler or drenching system, if provided.

17.1.9.3 INSTRUCTION, LABELS, SIGNS AND NOTICES

Adequate and appropriate identification labels, emergency instructions, warning signs and line diagrams shall be provided.

“NO SMOKING”, “LPG HIGHLY FLAMMABLE” and “LPG STORE” signs in the English and Chinese languages with letters and characters not less than 120 millimetres in height shall be provided. The signs shall be prominently displayed on or adjacent to each point of entry to the LPG installation.

At the bulk storage vessels, at least TWO sets of the above mentioned signs shall be provided. The warning signs shall be made of sandwich plastic material with white outer layers and a black or red inner layer as required. Lettering shall be engraved on the plastic material by cutting away one of the outer layers to outline the required letters, and

exposing the inner underneath. Details shall be submitted to the Supervising Officer for approval prior to engraving.

Adequate warning signs, emergency notices, operating instructions and framed schematic and line diagram shall be provided and installed in accordance with the requirement of the Gas Authority.

All LPG piping shall be identified with a colour band in accordance with BS 1710:2014. The basic identification colour shall be yellow ochre with black letters and signs on top to show the word “LPG”, the “liquid” or “vapour” phase where the piping are inside the storage compound and the direction of flow.

All emergency control/valves shall be labelled to show their ON and OFF positions. The label may be in the form of a continuous roll of self-adhesive material or a permanent notice clearly marked “LPG Emergency Valve” and prominently displayed near such control/valves. Similarly, a permanent notice marked “LPG Main Control Valve” for the LPG main control valve outside the building shall also be provided.

Operating instructions shall be provided at appropriate locations to ensure safe, continuing and reliable operations. The operating instructions shall be made on a durable material and be properly fixed.

Labels shall be provided to all pipeworks, valves, electric circuits, indicators, cables, and all other equipment to facilitate operation and proper maintenance of the installation.

Labels and notices required by statutory requirements shall be inscribed accordingly whereas other labels shall indicate name and purpose of the equipment together with ratings where applicable. All labels shall be in both Chinese and English.

Labels and notices shall be fixed by screws. Where drilling and tapping is impracticable, approved adhesive may be used subject to prior approval by the Supervising Officer.

Warning notice sufficiently durable and legible throughout the life of the equipment shall be fixed in a prominent position drawing the attention of the operator to any potential hazard.

SUB-SECTION 17.1.10

PLANT LOCATION AND SAFETY REQUIREMENTS

17.1.10.1 LPG COMPOUND

To prevent trespassing or tampering, the LPG compound which houses the underground or mounded storage vessels, vaporisers, regulators, etc. shall be enclosed by fence with two means of exit preferably positioned at opposite end of the compound. The fence shall be of industrial type, at least 1800 mm high and perforated to maintain good ventilation. The solid concrete kerb for supporting the perforated fence shall form a bund to a height of not less than 150 mm and not be higher than 380 mm above finished floor level.

The floor of the LPG compound shall be concreted and those parts underneath the underground or mounded storage vessels shall be sloped. The vicinity of the vessels shall also be free from pits and depressions other than those necessary for drainage or the containment of spillage.

Water drains, where provided, shall be of the U shape with water seal preferably situated well away from the storage area.

A sterile area of at least 1m shall be provided and paved with concrete around the LPG compound and conspicuously marked with yellow lines on the floor.

17.1.10.2 ENCLOSURE FOR LPG CYLINDER/PLANT

Rooms containing LPG cylinders/plant shall be well ventilated and made of non-combustible materials. The floor shall be raised with a higher level than the surrounding and shall be concreted and sloped down towards an external door which shall not be provided with kerb. The door shall be open outwards and shall not be self-locking. The walls, ceilings, roofs and doors (including door frame and hinge assembly) shall be able to withstand a static pressure of 4.8 kPa. Those parts common with other structure shall be imperforated and have a fire resisting period of 2 hours minimum. Drain shall not be provided in the room and should be avoided in the immediate vicinity i.e. within 3 m of the room. A sterile area of at least 1 m shall be provided around the cylinder room and conspicuously marked on the floor with yellow lines.

17.1.10.3 VENTILATION AND EXPLOSION RELIEF APERTURES

The natural ventilation and explosion relief requirements of the room with one external wall to 4 external walls are provided in Code of Practice for Hong Kong LPG Industry Module 1. The apertures shall be situated as uniformly as practicable in the external walls.

If the requirement for natural ventilation cannot be met, mechanical ventilation shall be provided.

LPG installations shall be provided with explosion relief apertures located in external walls, the explosion relief area shall be at least 0.07 m2 per m3 of enclosed volume for

open vents, or at least 0.1m2 per m3 of enclosed volume for louvered vents. A louvered angle shall not be in excess of 45º to horizontal. The method for calculating the "effective area of ventilation/explosion relief" shall be in accordance with Code of Practice for HK LPG Industry Module 1.

Imperforated explosion relief panels shall be used. Ventilation apertures may be included as explosion relief apertures.

LPG cylinders and/or equipment shall not be located within 150 mm of ventilation apertures. Suitable measures shall be taken to prevent blockage of ventilation apertures.

17.1.10.4 TRENCHES

Trenches for underground pipe installations shall have a minimum depth of not less than 800 mm. There shall be no pebble or small stones at the bottom of the trench. Electric cables and other services are not permitted to share the same trench.

17.1.10.5 WALLS, CEILING OR FLOORS

Sleeves of the same material of the LPG piping shall be embedded in holes for the whole length through walls or slabs. Wall, ceilings, roofs and doors shall be designed such that if imperforated, they shall be capable of withstanding a static pressure of at least 4.8 kPa.

17.1.10.6 RADIATION WALLS

Radiation walls for separating the vaporisers and storage vessels /cylinders shall be substantially constructed of concrete, brick or other suitable material having a fire resisting period of not less than 2 hours in accordance with BS476 Part 20 – 24:1987. The wall shall not be more than 2.5 m high.

17.1.10.7 WARNING SIGNS AND LABELS

Warning signs and emergency instructions in both English and Chinese shall be posted near each entrance on the outside wall/fence of the installation. The size of the letters shall be of 120 mm minimum in height.

SUB-SECTION 17.1.11

LPG APPLIANCES

17.1.11.1 SCOPE OF GAS APPLIANCES

The "Gas appliances" covered in this Section are appliances designed for use by a consumer of gas for domestic, catering and commercial purposes such as heating, cooking, hot water supply, lighting, motive power or other ordinary purposes for which LPG can be used.

17.1.11.2 GENERAL REQUIREMENTS

A gas appliance to be supplied and installed in Hong Kong shall comply with codes of practices and guidance notes issued by the Gas Authority including GU03, GU04, GU05, GU06, GU09, GU12, GU13 (Module Two), GU16 and other codes / guidance notes.

If a gas appliance is primarily designed to be used in domestic premises, it shall be approved by the Gas Authority and borne the relevant "GU" Mark. Such gas appliance shall be suitable for operation with LPG of pressure of 2.9 kPa. All materials used for the construction of the appliance shall be fire and heat resistance, non-flammable, strong and durable for the expected conditions of intended service and shall comply with the Gas Safety Ordinance, (Cap. 51).

The gas appliance shall be robust in construction, reliable and efficient in performance and shall meet the heat output with respect to the fuel input as specified in the Particular Specification.

All gas appliances shall be designed, installed and certified by a Registered Gas Installer in accordance with Part V (Gas Appliances) of the Gas Safety (Installation and Use) Regulations, Cap. 51C.

The gas appliance shall incorporate adequate means for the removal of products of combustion as necessary.

The gas appliance shall incorporate facilities for drawing sufficient permanent supply of air for proper and efficient combustion.

The gas appliance and its associated gas fittings shall be stabilised in a secure position free from damage as affected by the foreseeable environmental dynamic conditions and accidental factors.

The gas appliance shall incorporate a fine control over the initial release of gas during ignition phase and shall also be capable of withstanding any undue explosion within the combustion chamber without damage to any part of the appliance in the event of ignition delay.

Any gas appliance requiring the supply of water and electricity shall be suitable for operation under the local supply conditions particularly with respect to the water pressure

at the uppermost floor of the building and electrical voltage, viz. 380 V 3 phase or 220 V single phase 50 Hz.

Water heater, cooker, hotplate and domestic gas appliances shall comply with the latest Green Specification published by Environment Protection Department. Unless otherwise specified, water heater, cooker and domestic gas appliances shall have obtained Grade 1 under the Voluntary Energy Efficiency Labelling Scheme where applicable, or be of recognition type under the Voluntary Energy Efficiency Labelling Scheme from Electrical and Mechanical Services Department if relevant scheme are available for the type and rating of the water heater, cooker and domestic gas appliances.

17.1.11.3 BURNERS AND ASSOCIATED PARTS

Burners shall be made of robust and durable metallic alloy and capable of producing the maximum heat capacity as specified with the proper mixing of gas and air.

The burner shall be designed for maximum efficiency, even flame distribution and generating as little noise as practically allowed.

The main and pilot flames shall be protected against draughts.

The products of combustion when tested in accordance with BS 7977-1:2009 +A1:2013 shall not result in a CO/CO2 ratio in excess of 0.02. The CO/CO2 ratio shall not exceed 0.004 after 5 minutes of operation at normal gas rate.

Ignition may be manual or automatic sparks ignition by means of battery power, mains electricity, piezo-electric device or electronic device as indicated in the Particular Specification.

Combustion chamber and heat exchanger if applicable shall be constructed of high grade thermal conductivity alloy with high heat transfer efficiency.

17.1.11.4 OUTER CASING

The outer casing of the gas appliance shall be smooth with no sharp edges and insulated from heat transfer such that the contact temperature at any position shall not exceed the maximum allowable values as specified in BS EN 297:1994.

17.1.11.5 CONTROL AND REGULATING DEVICES

The gas appliance shall incorporate regulating devices for supply of gas, air and water as applicable.

The inlet gas and air shall be adequately filtered from dirt and dust before being mixed for combustion. Non-return valves shall be incorporated in the separate gas and air stream such that no mixing shall be possible in either supply stream.

17.1.11.6 FORCED DRAUGHT COMBUSTION

If mechanically forced draught is employed for combustion, the flow rate of air shall be carefully designed and adjusted such that optimum combustion efficiency is achieved.

Calculations verifying the selection of the blowers, fans, etc. with respect to the burners used in the offered gas appliance shall be submitted.

Ignition, combustion and air supply shall be properly sequenced for automatic combustion system for safe and proper purging and such as to avoid the extinguishments of the pilot or main flame during the course of operation.

17.1.11.7 SAFETY DEVICES

The gas appliance shall incorporate a reliable safety shut-off valve to the gas supply.

Suitable flame failure device shall be provided to shut off the gas supply by actuating a relay or solenoid valve if no flame is detected.

Where a thermostat is specified to control the temperature attained in a compartment of the gas appliance, a back-up overheat protective device shall also be provided to shut-off the gas supply in the event of failure of the thermostat.

A gas water heating appliance shall be provided with the low water pressure automatic gas shut-off device.

If a gas appliance is constructed with a built-in power operated flue extract system, it shall be prevented from operation if the draught fails to operate.

Wherever applicable for a gas heating appliance, safety guards shall be provided to prevent accidental contact of clothing or inflammable materials with the heat surfaces.

17.1.11.8 FLAME FAILURE DEVICES AND ASSOCIATED SAFETY SHUT-OFF VALVES

The flame failure device shall be manufactured to an international acceptable standard such as JIS S 2103:2015.

Wherever a flame failure device is required, the type of device and its coupling safety shut-off valves shall be incorporated in the following manner: -

(a) Below 45 kW, thermo-electric type flame failure device may be used;

(b) 45 kW to 600 kW, electronic type flame failure device coupled with one safety shut-off valve shall be provided;

(c) 600 kW to 3 MW, electronic type flame failure device coupled with two safety shut-off valves in line shall be provided; and

(d) Above 3 MW, electronic type flame failure device coupled with two safety shut-off valves in line together with a vent in between the valves shall be incorporated.

The electronic type flame failure device specified in this Section shall operate on the principle of current rectification of the flame which in this application shall rectify an alternating current flowing between an electrode and the burner as the opposing electrode connected to the ground potential. The rectified signal so generated shall be amplified to control the operation of a gas relay or solenoid valve.

The flame failure device shall be installed in a proper position suitable for performing the required function and sheltered from over-spilling and over-heating as the circumstances prevail.

17.1.11.9 ASSOCIATED GAS INSTALLATION

All the gas pipework in association with the gas appliance installation shall be carried out in accordance with the requirements specified in this General Specification.

All appliances with a fixed flue shall be connected to the gas supply by means of a permanently fixed rigid pipe.

Flexible rubber tubing complying with the requirement specified under this Sectionmay only be used for connecting unflued or portable appliances. Each length of connection shall not exceed 2 m. It shall not extend from one room to another nor passing through walls, ceilings etc. and shall be easily accessible for inspection and replacement. Connection to gas pipe by means of integral threaded metal ends or secured to a gas supply nozzle by crimping or using suitable hose clip as acceptable. Flexible rubber tubing shall not be exposed to temperature exceeding 50 °C.

A gas shut-off valve shall be provided at a readily accessible position at the gas inlet of the appliance.

17.1.11.10 FLUES

Where a flue is required to be connected to a gas appliance, it shall be constructed and installed in conformity with BS 5440-1:2008 for a rated input of up to 70 kW. Flues shall be so designed and constructed as to conduct away the products of combustion in an efficient manner.

A flue shall be readily accessible for inspection and maintenance. If it enters a brick or masonry chimney, access shall be made for inspection and maintenance of the seal between the flue pipe and the chimney.

Where a flue passes through a tiled or slated roof, the joint shall be weather-proof by using a purpose-made metal plate with a 150 mm upstand.

Where a flue passes through a ceiling, it shall be fitted with an insulating sleeve.

A flue, if required to be insulated against combustible materials, the surface temperature shall not reach 65 °C. The annular space between the metal sheets shall be packed with an approved non-combustible material not less than 25 mm thick.

A flue system incorporating electric powered exhaust draught shall have the control integrated with the gas appliance such that it shall be prevented from operation if the draught fails to operate.

If a manually operated damper is incorporated with a flue, it shall always be maintained in the fixed open position. An automatically operated damper for a flue shall be interlocked with the gas supply to the burner such that the burner shall be prevented from ignition in the event of failure of the damper when not in the open position.

17.1.11.11 DOMESTIC INSTANTANEOUS TYPE GAS WATER HEATER

Instantaneous water heater shall be room sealed, balanced flue type and shall be so constructed that the combustion air shall be drawn from and the flue gas conducted away outside the room by means of a concentric flue duct.

For gas water heater of heat output less than 70kW, Grade 1 energy label under the Voluntary Energy Efficiency Labelling Scheme shall be obtained.

The water heater shall be of modern, compact design and pleasant appearance. It shall be capable of providing instantaneous hot water with a temperature rise of 25 °C at a minimum flow rate as specified in the Particular Specification.

A domestic gas water heater shall comply with GU05 requirements and approved by the Gas Authority with “GU” mark.

The water heater shall be approved by the Water Supplies Department for direct connection to the town mains. Appropriate inlet and outlet pipe fittings shall be provided for connection to the external pipes. The minimum water supply pressure required for the water heater shall not be excessive such that it allows the installation of the water heater at the uppermost floor of the building without problem.

The water heater shall be equipped with built-in temperature regulator, flame failure detector, automatic gas shut-off valve, manual regulation valves, pilot burner and an automatic piezo-electric ignition device unless otherwise specified.

The heat exchanger and combustion chamber shall be constructed of high thermal conductivity alloy with high heat transfer efficiency.

The fan shape burner shall give even flame distribution with as little noise as practically allowed.

The outer casing shall be made of heavy gauge sheet metal, properly treated to prevent rusting and corrosion and finished in high quality white stoved enamel or equivalent. Any insulation materials used shall be free of asbestos.

The inlet pipe connections shall be arranged in such manner that the gas pipe shall be preferably positioned between the hot and cold water pipes.

Balanced flue/room-sealed water heaters shall be installed in purpose built flue aperture, the location of which shall comply with the Building (Planning) Regulation 35A and the Practice Note to Authorized Persons issued by the Building Authority.

The water heater shall be installed on the wall by means of a number of substantial bolts and nuts. The process of fixing the heater in position shall not impair the supporting structure. The indoor portion of the appliance shall be installed to allow sufficient clearance from the side walls, ceiling and other structures for maintenance or replacement. The flue duct shall be adjusted to allow effective rejection of flue gases and, if for balanced flue, to allow also sufficient inlet vents for the intake air for combustion. The portion of flue duct passing through the external wall shall be thermally insulated and sealed for weather proofing. All ducts and pipes shall be checked for cleanliness and clearance of obstacle prior to commissioning.

Fan assisted room sealed instantaneous water heater shall be provided where specified in the Particular Specification. The fan assisted heater shall be complete with built-in flue fan. The flue fan shall have an over-run time before the ignition and after shutting down of the burner in accordance with the applicable design code. The electric fan, wirings and all parts of electrical installation of the heater shall comply with the requirements of the Electricity (Wiring) Regulations and suitable for electricity supply of 220V a.c., 50 Hz. The heater shall either have a viewing window for the user to check at any time that the heater is in operation by visual observation of the flame or have an indication lamp indicating the heater is on.

Terminals for earthing or equipotential bonding shall be provided where applicable.

17.1.11.12 DOMESTIC TYPE GAS COOKER

The gas cooker shall be of modern design, pleasant appearance and suitable for installation in domestic kitchen. Facilities shall contain an oven, hot plates and a grill of various ratings as specified in the Particular Specification.

For gas cooker of heat output less than 7kW for each burner, Grade 1 energy label under the Voluntary Energy Efficiency Labelling Scheme shall be obtained.

The gas cooker shall comply with GU05 requirements and approved by the Gas Authority with “GU” mark.

Unless otherwise specified, the cooker shall comprise open ring burners for the hot plates and jet burners for both the oven and grill.

All burners shall give low noise level in operation and a minimum noise in turning off to extinguish. All burners shall be regulated by “push and turn” control knobs; stable flames shall be maintained at all knob’s position. All burners shall be suitable for simmering by adjusting the control knobs.

Unless otherwise specified, the oven shall be of the internally heated type with side hinged door. The oven shall be equipped with a temperature control regulator by means of thermostat with back-up overheat gas shut-off device. A flame failure device shall be fitted to shut-off the gas supply in the event of failure of the pilot or main flame.

Solid top hot plates if specified shall be fitted with flame failure device.

Unless otherwise specified, the grill shall be of the open-fired type with the source of heat radiated from a metal fret above the food.

Ignition means to the various cooking facilities shall be specified in the Particular Specification or otherwise it will be assumed to be all manual without the use of a spark gun and to the manufacturer's standard product. Battery if required shall be included.

Means shall be provided to cater for spillage from the burner and the spill receivers shall be designed for easy cleaning.

A storage compartment with door beneath the oven shall be provided. Means of levelling the cooker shall also be available.

The casing shall be made of heavy gauge sheet metal properly treated to prevent rusting and corrosion and finished in high quality white or cream vitreous enamel or acceptable equivalent. The casing shall be insulated internally.

The cooker shall be supplied with a standard baking tray, a roasting tin and a ring type wok adaptor suitable for 300 mm diameter nominal size Chinese Wok.

The cooker shall be positioned at sufficient distance from the adjacent wall, overlaying shelves or other appliances or structures to prevent overheating of the surrounding. It shall be installed and commissioned all in accordance with the manufacturer's instructions.

SECTION 17.2

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 17.2.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

17.2.1.1 GENERAL

On top of the requirements stipulated in Part 1 and other relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

17.2.1.2 TESTING AND COMMISSIONING WORKS

All tests shall be witnessed and certified by a Competent Person who has been recognised by the Gas Authority under Gas Safety Ordinance (Cap. 51), Laws of the Hong Kong Special Administrative Region to perform or supervise or inspect or certify Liquefied Petroleum Gas Installation, testing and maintenance work.

Before the testing and commissioning of the LPG installation, the Competent Person shall check and ensure that the fire protection system for the LPG installation, if provided, should have been tested and accepted by Fire Services Department and put into operation.

The relevant information, test certificates and drawings shall be submitted to the Supervising Officer for applying Approval of Use from the Gas Authority well before commissioning of the LPG installation. All submission fees, if any, shall be included under the Works. All tests shall be completed and certified by the Competent Person before forwarding the relevant information to the Supervising Officer for applying Approval of Use.

Approval of Use shall be obtained from Gas Authority before filling up the LPG storage tank or supplying LPG cylinders for commissioning of the LPG installation.

Inspection and witness of the tests, including the pressure test and 'holiday test' for the underground pipeline and storage tanks prior to cover up/back-filling, shall be arranged with the Gas Authority.

Prior to the test, the following commissioning works shall be carried out: -

(a) All equipment, joints, valves, etc. shall be checked for leakage, integrity and proper function;

(b) Pressure regulators shall be set to their lowest outlet pressure initially and gradually adjusted to their required operating pressures. The regulators shall be checked for their pressure control function over the entire range of the design conditions including shut-off capability;

(c) LPG trap shall be checked to ensure it is filled with water;

(d) Active and monitor regulators shall be set for the designed function; and

(e) Vaporiser including the heat and level controls shall be checked for satisfactory operation.

Unless otherwise specified, the Installations also includes the initial supply of sufficient quantity of LPG for testing and commissioning, the specified quantity of LPG as indicated in the Particular Specification or Drawings, and the loan of Liquefied Petroleum Gas bottles. Subsequent replacement of the Liquefied Petroleum Gas after the initial supply has been exhausted, will be provided by others. It shall include taking back the on loan bottles after the replacement has been made.

17.2.1.2 BULK LPG STORAGE VESSELS

17.2.1.2.1 LPG storage vessels should be tested and certified by a Competent Person to prove that the vessel is up to the required standard: -

(a) Ultrasonic/radiographic tests for examining internal flaws in accordance with the applicable design code; and

(b) Magnetic particle or penetrant tests for examining surface flaws in accordance with BS EN ISO 17638:2016 and BS EN ISO 23278:2015.

17.2.1.2.2 In addition, the following tests shall be carried out on-site: -

(a) Hydraulic test at testing pressure 1.5 times of the design pressure of the storage vessels;

(b) Commissioning pneumatic test at 700 kPa or 90% of design pressure, whichever is lower;

(c) Paint thickness test (400μm minimum);

(d) For underground vessels, “holiday” test after the vessel is coated; and

(e) Leak test for the connections up to a minimum pressure of 689 kPa.

Format of the test certificate shall follow the Code of Practice for Hong Kong LPG Industry Module 1 issued by the Gas Standards Office.

17.2.1.3 VAPORISERS

Vaporisers and associated relief valves shall be hydraulic tested and certified by a Competent Person at 1.5 times of the design pressure. The components of the vaporiser not capable of accepting the test pressure shall be isolated or removed whichever appropriate during the hydraulic test.

Satisfactory operation of liquid control and heat input control device shall be checked. Flame failure devices, pilot and main burner systems shall be checked and adjusted to give satisfactory and safe operation. For indirect heated vaporiser using water as heating medium, water level safety controls shall be checked for proper operation.

Format of the test certificate shall follow the Code of Practice for Hong Kong LPG Industry Module 1 issued by the Gas Standards Office

17.2.1.4 PIPEWORK TESTING

17.2.1.4.1 All pipework shall be tested after construction and before being placed in operation to ensure that it is structurally sound and gas-tight. In carrying out the test, precautions shall be taken to protect against any dangers which may arise if such pipe fails the test: -

(a) the person carrying out the test;

(b) any persons working in the vicinity; and

(c) members of the public.

17.2.1.4.2 All pipework shall be pressure tested as follows: -

(a) All liquid lines shall be hydraulically tested at 1.1 times the HRPV setting after isolation of elements that could be damaged by the test pressure. Pressure test certificates shall state HRPV setting in addition to hydraulic test pressure. After the hydraulic test is completed, all isolated elements shall be properly installed and the whole system shall be tested pneumatically at a minimum pressure of 689 kPa;

(b) High pressure vapour lines shall be tested either pneumatically or hydraulically at a minimum pressure of 1034 kPa; and

(c) Medium and low pressure vapour lines shall be tested either pneumatically or hydraulically at a minimum pressure of 103 kPa and 69 kPa respectively.

17.2.1.4.3 For pneumatic testing, the test shall be undertaken in phases as follows: -

(a) Initially pressurise the system to 140 kPa and hold it for sufficient time to ensure that all fittings have been adequately fastened;

(b) The pressure shall then be raised in stages until the required test pressure is reached; and

(c) After each pressure increase, sufficient time shall be allowed to ensure system integrity.

17.2.1.4.4 Pipework pressure tests shall be recorded and the test report shall include the following: -

(a) company name of installer and signature of the Competent Person who supervise the tests;

(b) test date;

(c) maximum working pressure;

(d) test pressure, medium and duration;

(e) test results; and

17.2.1.4.5 Time shall be allowed for temperature stabilization during pressure testing. The line pressure shall be adjusted to the test pressure after stabilization. The time allowing for temperature stabilization depends on the ambient temperature, test medium, pipe size and length. In general, the time shall not be less than 15 minutes.

17.2.1.4.6 All exposed pipework shall be subject to annual visual examination and leak test using soap solution.

17.2.1.4.7 For hydraulic and pneumatic pressure test, the test period shall be of a minimum of 30 minutes and there shall be no sign of pressure decay during this period.

17.2.1.4.8 Pressure decay indicates leakage and leaks shall be identified by sight and sound or soap solution.

17.2.1.4.9 All open ends of a piping system shall be suitably blanked before testing.

17.2.1.4.10 The pressure of the pipework shall be reduced to zero as soon as is practicable after the pressure tests (see Regulation 20 of the Gas Safety (Gas Supply) Regulations, Cap. 51B). Upon satisfactory completion of pressure tests, the pipework shall be purged into service prior to commissioning and operation of the LPG installation.

17.2.1.4.11 Format of the test certificate shall follow the Code of Practice for Hong Kong LPG Industry Module 1 issued by the Gas Standards Office.

17.2.1.5 REGULATORS

Regulators shall be checked for the required pressure control functioning over the required range of flows and for tight shut-off at zero flow.

17.2.1.6 EMERGENCY VALVES

All emergency valves shall be checked for proper functioning.

17.2.1.7 PRESSURE RELIEF VALVES

Pressure relief valves shall be calibrated and sealed by the manufacturer of the Competent Person before installation; and

Check shall be carried out to ensure that relief valve vent caps are in place and mobile.

17.2.1.8 VESSEL CONTENT GAUGES AND FIXED MAXIMUM LIQUID LEVEL DEVICES

Vessel content gauges and fixed maximum liquid level devices shall be checked for correct functioning and accuracy.

17.2.1.9 GAUGES

Gauges shall be checked for accuracy and proper functioning.

17.2.1.10 EARTHING

Installation earthing shall be tested and test results shall be submitted.

17.2.1.11 CATHODIC PROTECTION SYSTEM

The cathodic protection system shall be tested and test results shall be submitted. It shall be checked at intervals not exceeding 6 months.

17.2.1.12 PURGING/GAS FILLING OF VESSELS AND SYSTEMS

The method and procedure for purging or gas filling of vessels and systems shall be in accordance with the Code of Practice for HKLPG Industry Module 1.

17.2.1.13 THE GAS AUTHORITY INSPECTIONS AND WITNESS OF TESTS

Tests and inspections, where not specified above, shall also be carried out to meet the statutory requirements to the satisfaction of the Gas Authority.

17.2.1.14 TESTING OF GAS APPLIANCE

17.2.1.14.1 Gas appliance shall be tested and commissioned by registered gas installer and in accordance with manufacturer's instruction and Regulation 30 of the Gas Safety (Installation and Use) Regulations, Cap. 51C and Code of Practice issued by the Gas Standards Office.

17.2.1.14.2 Upon completion of the installation of a gas appliance, the gas connection pipework shall be tested for soundness. The appliance, the gas fittings and other associated Installations, flue system, condition of ventilation of the room etc. shall be examined for the purpose of ascertaining whether: -

(a) the appliance has been installed to the required standard and regulations;

(b) the appliance has been installed in accordance with the manufacturer's instructions;

(c) the safety controls of the appliance are in proper working order; and

(d) the supply gas pressure, water pressure, electrical voltage and frequency etc. are within the operating range of the gas appliance.

17.2.1.14.3 When testing the performance of the appliance, its satisfactory operation condition shall be verified with regard to the following aspects: -

(a) the safe functioning of all protective controls;

(b) the heat output of the appliance as specified in compatible with the fuel input;

(c) the correct gas/air ratio for proper combustion; and

(d) the effectiveness of the flue extract system.

SUB-SECTION 17.2.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

[RESERVED]

PART 18 - FOUNTAIN INSTALLATION

SECTION 18.1

INSTALLATION AND EQUIPMENT REQUIREMENTS

SUB-SECTION 18.1.1

WATER CIRCULATION

18.1.1.1 GENERAL

18.1.1.1.1 Water Circuits

A typical water circuit of fountain installation consists of the following components:-

(a) water circulation;

(b) filtration;

(c) pH control and chemical treatment; and

(d) Disinfection.

18.1.1.1.2 Water Turnover Rate

Unless otherwise specified, the water turnover rate of fountain installation shall be not less than once in every 6 hours.

18.1.1.1.3 Water Balancing

In the case that 1 circuit is used to serve more than 1 fountain, water balancing for each fountain is important to maintain the turnover rate and the water level of each fountain. The use of level sensors, flow meters, balance tank and automatic control system to maintain the water balancing shall be facilitated. Refer to the Particular Specification for the water balancing methodology to be used.

18.1.1.1.4 Balance Tank, Level Control and Infill Tank

Balance tank is used to compensate automatically the loss of water through the perimeter overflows, backwashes, evaporation and other loss. The compensating function of a balance tank shall be achieved by an automatic level control mechanism, with manual bypass fill valve provided. The pumping rate shall be large enough to reduce the recovery time.

Automatic infilling fresh water shall also be provided to the balancing system. Manual infill shall be included in case of automation failure.

18.1.1.2 WATER PUMP

18.1.1.2.1 All pump motors higher than 120 W shall be with the motor efficiency of IE4 or better.

18.1.1.2.2 Main Circulating Water Pump

(a) Type

Pumps for water circulation or other fresh water pumping duties unless otherwise specified, shall be of one of the following types: -

(i) centrifugal type with volute casing split on the centreline of the shaft with suction and delivery connections flanged and fitted to the non-removable half of the casing;

(ii) end suction type, the pump set shall be installed with spacer type coupling so that the pump impeller can be dismantled from the motor side for servicing without disruption of the pipework nor dismounting the motor; or

(iii) vertical centrifugal pump.

Where large static heads have to be pumped against, the end suction type or vertical centrifugal type shall be used in multi-stage configurations. Generally the type of pump required will be specified in the Particular Specification and/or in the Tender Drawings. However, if this is not so, the end suction type shall be adopted.

The pneumatic booster pump set shall comprise of a duty and standby pump complete with a pneumatic vessel and control unit. The pumps shall be vertically mounted, with direct drive motors. If necessary, the pumps shall be of multi-stage construction and each stage/section shall be interchangeable.

(b) Materials of Construction

Unless otherwise specified, the materials of construction of the pumps shall be as follows: -

Casing	:	Bronze to BS EN 1982:2017/ Cast iron to BS EN 1561:2011/ Stainless steel to BS EN 10088-3:2014
Impeller	:	Stainless steel to BS EN 10088-3:2014/ Bronze to BS EN 1982:2017
Shaft	:	Stainless steel to BS EN 10088-3:2014
Sleeves	:	Stainless steel same as shaft or cast bronze
Wearing rings	:	Copper-tin alloy to BS EN 1982:2017

(c) Standards

Stuffing Boxes shall have material same as the casing. Housing of cast iron stuffing boxes shall comply with ISO 185:2020 or BS EN 1561:2011 and shall be of ample length with bronze lined gland and neck bush, fitted with approved packing and lantern ring water seal. Drain outlet and piping to remove gland leakage shall be provided. Alternatively, a mechanical seal may be offered. The mechanical seal shall be of leak free operation. The mechanical seal shall be the product of a specialist proprietor and the materials used shall be suitable for the pumped liquid.

For vertical in-line pump, suction and discharge flanges shall be of equal size. The impeller shall be dynamically balanced. The shaft shall have stainless steel/bronze sleeves keyed to prevent rotation and secured against axial thrust. For multi-stage pump, each stage/section shall be interchangeable.

18.1.1.2.3 Cooling Water Pump

In case the ozonator is water cooled, where water circuit of fountain is pumped through the generator for cooling purpose, the cooling water pump shall be one of the above types as deemed necessary unless otherwise specified in the Particular Specification.

18.1.1.2.4 Water Equipment Pumps

Pumps for water play equipment, make-up water, and other use shall be one of the above types as deemed necessary unless otherwise specified in the Particular Specification.

18.1.1.2.5 Sewage Sump Pump

(a) General Requirements

All bolts, nuts and fasteners shall be of stainless steel and electric cable entry shall be of watertight construction.

Materials for sump pumps shall be suitable for the pumping fluid being conveyed, such as, neither reacting to any parts in the pump by its fluid nor changing the content of the fluid by the pump. The sump pumps shall operate automatically by float level control. The guide bars for wet sump installations shall be of stainless steel of Grade 316.

Cable supports shall be of stainless steel. A safety provision shall be incorporated for automatic electrical disconnection of the supply in case of cable entry seal failure. Pumps for flammable zones shall be equipped with flameproof submersible motor in compliance with BS EN 60079-0: 2018, BS EN 60079-1: 2014 and IP 68 of BS EN 60529: 1992 + A2: 2013.

(b) Materials of Construction of Dry Pit Pump

Unless otherwise specified, the materials for dry pit non-clog pump shall be as follows: -

Casing	:	Cast iron to BS EN 1561:2011
Impeller	:	Cast iron to BS EN 1561:2011 or stainless steel to BS EN 10293:2015 grade 316
Shaft	:	Stainless steel to BS EN 10088-3:2014
Casing bolts	:	Stainless Steel
Cap screw and washer, impeller	:	Stainless steel
Key	:	Stainless Steel

(c) Materials of Construction of Submersible Pump

Unless otherwise specified, the materials for submersible non-clog pump shall be as follows: -

Casing	:	Cast iron to BS EN 1561:2011
Impeller	:	Cast iron to BS EN 1561:2011 or stainless steel to BS EN 10293:2015 grade 316
Shaft	:	Stainless steel to BS EN 10088-3:2014
Double Mechanical seals	:	Silicon Carbide; Carbon or ceramic faces
Discharge elbow	:	Cast iron to BS EN 1561:2011

18.1.1.2.6 Bore Well Pumps

All bolts, nuts and fasteners shall be of stainless steel and electric cable entry shall be of watertight construction.

Unless otherwise specified, bore well pumps specified shall be of all Grade 316 stainless steel construction.

The level switch shall be of the maintenance free mercury type or electrode type.

18.1.1.2.7 Pump Base-plate

When pump base-plate is necessary, the base-plate shall be proprietary made with the pump. The material of the base-plate shall be same as the pump.

18.1.1.2.8 Pump Vibration Connectors

Vibration connectors shall be fitted to the inlet and outlet connections of other vibrating equipment as deemed necessary.

Vibration connectors shall be full line size of the equipment connection and fitted as close to the source of vibration as is practicable.

Vibration connectors shall be provided with end restraint to counteract the pressure thrust should the piping be subjected to longitudinal movement.

Manufacturers' recommendations on restraints, pressure, and temperature limits shall be strictly followed during the installations.

18.1.1.2.9 Flexible Metallic Hose

For higher operating temperatures and pressures, vibration movement generated by pumps, shall be accommodated by braided flexible metallic hoses.

The lengths of the flexible metallic hoses shall be in accordance with manufacturer's recommendation.

Two hoses at right angles to each other shall be provided when major vibration motions to be isolated exist in two planes.

18.1.1.2.10 Flexible Rubber Connectors

Flexible connector shall consist of a single or twin-sphere body manufactured with reinforced rubber, the ends of which are raised and wire reinforced to form the cuffs for sealing purposes. The cuffs shall be backed by floating steel flanges.

The rubber body shall be reinforced by multi-layered nylon tire cord fabric.

The rubber membranes shall have an indelible identification system to clearly identify the model and hence the suitability for the application and working conditions and have the date of manufacture moulded into the cover to ensure that no units that have exceeded the recommended shelf life are used.

Straight connectors shall be of the twin-sphere construction whilst elbow connectors shall be of the single-sphere construction.

Straight connectors connected to resiliently supported equipment shall be equipped with rods to prevent excessive elongation of the connectors if the system operating pressure is in excess of the value recommended by the manufacturer.

Acoustical control rods assembly shall consist of not less than 4 large triangle anchor plates, 2 control rods with large wedged-on end fittings and 13 mm thick acoustical washer bushings of sufficiently large load bearing area to isolate the end fittings, axially and laterally.

18.1.1.3 GENERAL WATER PUMP INSTALLATION REQUIREMENTS

18.1.1.3.1 Pumps at 5 kW motor capacity and above shall be "Type-tested" in accordance with the requirements of BS EN ISO 9906:2012 or approved equal. Test certificate for each pump shall be issued and signed by the manufacturer and submitted for checking. The certificate shall clearly record the pump model, serial number and the materials of the casing, shaft and impeller. Any certification with requirements not in strict compliance with BS EN ISO 9906:2012 shall be submitted to the Supervising Officer for approval prior to pump ordering.

18.1.1.3.2 Each pump or each batch of pumps shall also be provided with a certificate on their place of manufacture. The certificate shall be issued by a recognised Chamber of Commerce of the place of manufacture concerned. A certification issued by an organisation other than the recognised Chamber of Commerce shall be submitted to the Supervising Officer for approval prior to pump ordering.

18.1.1.3.3 Pumps and their drives shall be segregated such that failure of pump seals shall not result in damage to the drive motors.

18.1.1.3.4 The installation details shall be in accordance with the instruction prepared by the manufacturer.

18.1.1.3.5 The pump shall be stored in a dry space when they are delivered to site. Special rust preventive measures to protect the internal parts shall be applied if it must be stored for an extended period of time. Such provisions shall be removed completely before final installations and the bearings shall then be re-lubricated.

18.1.1.3.6 Centrifugal Pump

(a) Driving Arrangement

The horizontal pump and motor shall be direct coupled and mounted on a substantial machined bedplate; accurately aligned, and fitted with guards. The whole assembly including the bedplate shall be designed and supplied by the pump manufacturer. Coupling with spacer shall be used for end suction pump so that the impeller may be dismantled from the motor side for servicing without neither disrupting the pipework nor dismounting the motor.

For vertical pump, the driving motor and the pump shall be factory aligned before shipment.

(b) Stand-by Pumps Arrangement

Where stand-by pumps are specified with automatic changeover provision, the changeover shall be initiated by means of flow sensing devices of an approved pattern. The necessary non-return valves shall be incorporated in the pipework to interconnect such pumps.

18.1.1.3.7 Sewage Sump Pump

The sump pump shall be of vertical centrifugal design suitable for dry sump or wet sump installations. Each pump shall be constructed with double mechanical shaft seal and close-coupled to a submersible electric motor.

The sump pump shall operate automatically under level control with an alarm to alert the operator when high water level is being exceeded.

Each pump shall be equipped with factory built-in suspension device, and a factory mounted discharge elbow shall be provided for wet sump installations. Cast iron or steel supporting base shall be provided for dry sump installations. The pump unit itself shall be able to be easily removed from its base for inspection, repair and service. The pump for wet sump installations when lowered into the pit shall automatically be connected to the discharge piping, such that there shall be no need for the maintenance personnel to enter the wet pit to carry out the work.

The pump discharge shall be fitted with a resilient seal that provides a positive hydraulic seal for maximum pump efficiency. Each impeller shall be trimmed to meet the specified flow requirements.

For installations in flammable zones, each sliding guide bracket shall have non-sparkling material to prevent ignition of explosive gases.

18.1.1.3.8 Bore Well Pump

The bore well pump shall be vertical multi-stage centrifugal construction that is suitable for submersible installations. Each pump shall be of a single-shaft non-shaft-coupling type. The pump suction shall complete with a perforated strainer. The pump bearings shall be water lubricated and shall not cause any contamination to the water handled. The submersible motor shall be cooled by water moving around the motor casing.

Each pump shall be equipped with a non-return valve located between the pump discharge and rising main to prevent from the flow back of water in the rising main. A level switch shall be provided for the automatic cut-off of the pump as dry running protection when the water level inside the pit falls below the pump safety suction lift. The type of level switch shall be selected free from maintenance as practicable.

Except for water feature application, the bore well pump shall be installed vertically in the pit. No foundation shall be required for the pump on the bottom of the pit. Instead, the pump shall be hung from the pit cover which seals the pit and absorbs all stress resulting from the weight of the bore well pump, cable, rising main and water column. The length of each section of the rising main shall be limited to 3 m long to facilitate the withdrawal of the pump from the pit for maintenance.

18.1.1.3.9 Plant Room Location

It shall be checked and assured that adequate working space shall be provided to access for maintenance and sufficient headroom to lift the parts for repair is provided. For large pump, a hoist with travelling crane or other facility shall be provided over the pump location.

For an open loop system, the location of pump shall be sited so that it will use the shortest and most direct suction and smallest vertical lift. Where possible, the pump centreline shall be placed below the level of the liquid in the suction tank.

18.1.1.3.10 Pump Foundation

The foundation shall be of sufficient size and rigidity to properly support the full area of the pump base-plate, to absorb any normal strains and to maintain correct alignment for the pump assembly.

Space between the pump unit and the foundation bolts shall be allowed in accordance with the manufacturer's recommendation.

For vertical pump, the foundation shall be of sufficient size and rigidity to properly support the full base area of the pump. The foundation shall be surrounded by 50 mm thick cork and housed in a 100 mm thick concrete plinth. The cork shall enclose the 4 sides and the bottom of the foundation to isolate vibration generated by the pump to the floor structure. The cork and the concrete plinth and foundation shall be filled up with bitumen.

For horizontal pump, an inertia block shall be provided, with minimum mass of concrete not less than 2.5 times the mass of the pump assembly and with at least 100 mm thick and 150 mm wider than the pump base-plate. Unless otherwise specified, the pump base shall be mounted on the raised housekeeping plinth using appropriate anti-vibration spring mountings. Each spring shall be individually selected according to load distribution and shall have an additional free travel equal to one half of the rated deflection. Spring mounts shall have a levelling bolt and shall be mounted to the concrete inertia block via height saving brackets that allows a base clearance of 50 mm. When the horizontal pump motor size is less than 5.5 kW and the pump is located in a pump room which is not susceptible to structural bond noise, the use of inertia block may not be necessary subject to Supervising Officer's approval.

18.1.1.3.11 Pump Alignment

The pump unit shall be accurately aligned in accordance with the manufacturer's instructions prior to operation. The alignment shall be rechecked after the suction and discharge piping have been bolted to the pump to test the effect of piping strains. The pump and driver alignment shall be rechecked and adjusted correctly within ±0.05 mm tolerance.

18.1.1.3.12 Support for Piping

Suction and delivery pipes shall be supported independently of the pump. The connecting pipes to a pump shall not strain the pump. Pipes installations shall match up to the respective flanges without being strained into position. The faces of the coupling shall be checked with a straight edge to make sure that they are parallel and concentric.

18.1.1.3.13 Connection Piping to Pump

(a) Suction Piping

The suction piping shall be properly installed for a satisfactory pump operation. This shall be achieved by keeping as direct and as short as practicably possible with a minimum number of bends,

and by avoiding air pockets forming. Concentric reducers shall not be used on suction branch.

The size of the suction pipe shall be larger than the pump inlet and when applicable eccentric reducer may be used. If the source of supply is located below the pump centreline, the reducer shall be installed straight side up. If the source of supply is above the pump, the straight side of the reducer shall be at the bottom.

A straight section piping at least 4 to 6 diameters long at the pump inlet with long radius bend shall be used for suction pipeline installations to create less friction and provide more uniform flow distribution as deemed necessary.

(b) Delivery Piping

Unless otherwise specified, the size of the delivery pipe shall be at least one size larger than the pump delivery. The check valve shall be installed between the pump and the gate valve. The gate valve shall be installed close to the pump discharge for pump priming and repairing.

Air release valves shall be installed at the highest points on each rise to allow accumulated air or vapour or other gases to escape from the pipe.

Adequate support and anchorage shall be provided if the pipes are laid above or below ground. For this purpose, it is acceptable to have thrust blocks in either corner type or puddle flange type that are designed to absorb reactions or turning forces to ensure no mechanical and hydraulic forces are imposed on the pump.

(c) Pipe Flanges

Pipe flanges shall match with the sizes of pump flanges with full-face gaskets.

(d) Expansion Joints

Expansion joints shall be installed in suction and delivery pipelines to avoid transmitting any piping strains. A suitable pipe anchor shall be installed between the expansion joint and the pump.

If expansion joints are not specified, expansion loops that are formed by looping the pipe shall be provided to prevent the transmission of strains to the pump.

(e) Intake

The installation work shall be carried out properly to prevent air being entrained as bubble within the water. The intake pipe shall run well below the sump tank level. High level entry into the sump tank shall be avoided as air may be entrained by the falling jet.

Vortex inhibitor shall be installed inside the water tank to prevent air being drawn from bottom of vortex into the intake. Vortex inhibitor is not required for chemical or brine tank.

18.1.1.3.14 Flushing Strainer

The suction strainer shall be installed as close as practicably possible to the pump and shall not be used for flushing the pipe. A temporary strainer fitted with a finer mesh than the permanent strainer shall be used for flushing all piping and cleaning thoroughly all possible mill scale and other foreign matter. The temporary strainer shall be removed afterwards.

18.1.1.3.15 Venting Valves for Pump-set

Venting valves shall be installed at one or more points of the pump-casing waterway to provide a means to escape for air or vapour trapped in the casing. These valves shall be connected so as not to endanger the operation staff in handling toxic, inflammable or corrosive liquid.

18.1.1.3.16 Drains for Pump-set

All drain and drip connections shall be piped to a point where the leakage can be disposed of or collected for reuse if specified.

18.1.1.3.17 Instrumentation

Each pump set shall include pressure gauges and a gauge cock to measure the system pressures and pressure drop. Instruments shall be mounted in a suitable location so that they can be easily observed.

All measuring and isolation instruments, such as pressure gauge, check valve, globe valve, gate valve and strainer, etc., or as specified in the Particular Specification shall be installed properly to maintain a close check on control on the performance and condition of the pumps.

18.1.1.4 PIPEWORK

18.1.1.4.1 Connections in Pipework

For non-welded pipework, connections shall be by means of screwed fittings, flanges or unions. The use of "long screws" will not normally be permitted.

Unless otherwise specified, flanges complete with appropriate gaskets, steel nuts, bolts and washers together with spring washers, all of stainless steel, shall be used to connect up all equipment, valve or device such that the pipework, equipment, valve or device can easily be removed for servicing or replacement.

18.1.1.4.2 Change in Pipe Size

Change in pipe size can be facilitated at tees by reduction on branch or outlet. Reduction on bend elbow or by bush is not permitted without prior permission of the Supervising Officer. Reduction by means of straight through reducing socket is permitted.

Care shall be taken in carrying out reduction to ensure that air is not entrapped at high points. In such case, it shall be necessary to install eccentric reducing sockets with the "flat" at the top for horizontal pipework and concentric reducer for vertical pipe riser.

18.1.1.4.3 UPVC Pipe

(a) Unplasticised polyvinyl chloride (UPVC) pipe shall comply to ISO 3127:1994 and ISO 1452-1:2009 to ISO 1452-5:2009, or DIN 8061:2016/DIN 8062:2009, or BS EN ISO 1452-1:2009 to BS EN ISO 1452-2:2009, BS EN ISO 1452-3:2010, BS EN ISO 1452-4:2009 to BS EN ISO 1452-5:2009 (300 mm diameter and below).

(b) All pipes and fittings shall be manufactured by the same manufacturer of the same standard. Should different types of pipe are joined together, they shall be joined with suitable proprietary adaptor. Modification to the pipe or fitting to fit different pipe materials or standards is not acceptable. Bending of pipe to form elbow shall not be allowed.

(c) When UPVC pipe is installed at outdoor, it shall be protected from ultra-violet radiation by shielding or painting with suitable primer to prevent degradation.

(d) Where it is required to form a spring in the pipe run, the pipe shall be softened by immersion in (or by pouring on) heated brine, glycerine oil or water as recommended by the pipe manufacturer. The use of a naked flame on the pipe surface will not be accepted.

(e) Joint and Fitting for UPVC Pipework

(i) Joint for UPVC pipe and fitting shall be solvent joint for pipes at 65 mm and below.

(ii) Within plant room, joint for UPVC pipe and fitting at 80 mm and above shall be flanged connection or of stub flange assembly.

(iii) Flanged connection of pipework, for either chemical or non-chemical system, shall be of steel bolt, nut & washer together with spring washer, all of stainless steel.

(iv) Fittings shall be of the same material as the pipework to which they are joined. They shall be made or approved by the pipe manufacturers and suitable for the solvent welding process. Where screw threads are required (e.g. at connections to metal valves, strainers, etc.), a factory made threaded adapter shall be used. Adapters shall be made from heavy weight tube with an appropriate thread at one end; the other end shall form part of a socket and spigot solvent welded to the plastic pipe. As a general rule UPVC pipe shall only be made threaded and screwed into metal "Female" threaded fittings.

(v) Joints between pipe and pipe fittings shall be made by the solvent welding process. No cleaning fluid or solvent cement other than that supplied or recommended by the pipe manufacturer shall be used.

(vi) Unless otherwise specified, connections to items of plant such as pumps shall be made by means of flanged joints. The plastic pipe shall terminate with a socket flange of the full face or stub type welded on by the solvent process and having a loose metal backing ring; the ring and the flange shall be drilled to match the mating flange. The joint shall be made with a neoprene or similar gasket.

(vii) Where UPVC is used for inlet and outlet to pumps, it shall be effectively isolated from the vibration of the machine. This shall be achieved by the insertion of flanged synthetic rubber vibration de-couplers installed between UPVC pipework and plant on all connections.

18.1.1.4.4 Ductile Iron Pipe

Ductile iron pipe shall comply with one of the following standards subject to the applications: -

ISO 2531: 2009/ Corr1: 2010	Ductile iron pipes, fittings, accessories and their joints for water applications
BS EN 545: 2010	Ductile iron pipes, fittings, accessories and their joints for water pipelines. Requirements and test methods
BS EN 598: 2007 + A1: 2009	Ductile iron pipes, fittings, accessories and their joints for sewerage applications. Requirements and test methods

Cement lining shall be provided for all ductile iron pipe and fitting. Lining inside shall be cement mortar lined in compliance with BS EN 545:2010, BS EN 598:2007+A1:2009, BS EN 969:2009 or Type A – Portland pulverised fuel ash cement (PFAC) in accordance with BS EN 197-1:2011 with a minimum pulverised fuel ash content of 25%.

Joints and fittings for ductile iron pipework: Class K9 and K12 pipes joint shall either be flanges screwed or flanges welded-on subject to Supervising Officer's approval.

18.1.1.4.5 Polyethylene Pipe and Fittings

(a) The following specifications apply: -

Description	Specification	Nominal Size	Application
Medium Density Polyethylene Pipe (MDPE)	BS EN 12201-1: 2011, BS EN 12201-2:2011+A1:2013, BS EN 12201-3: 2011 + A1: 2012, BS EN 12201-4: 2012, BS EN 12201-5: 2011, ISO 4427-1:2019 and ISO 4427-2:2019,	20 mm - 1000 mm	water pipe for underground and above ground (blue pipe and black pipe)

High Density Polyethylene Pipe (HDPE)	ISO 4427-1:2019 and ISO 4427-2:2019,	90 mm – 1000 mm	water pipe for underground and above ground (blue pipe and black pipe)
Electrofusion fitting for use with MDPE pipe	*WIS 4-32-14:1995	20 mm – 355 mm	Fittings for underground and above ground (blue and black colours)
Spigot fitting for butt fusion or electrofusion jointing	*WIS 4-32-15:1995	63 mm – 315 mm	Jointing of pipe

(b) The pressure rating of the MDPE and HDPE pipes shall not be greater than 10 bar and 16 bar respectively.

(c) When polyethylene pipes are installed at outdoor, they shall be protected from ultra-violet radiation by shielding or painting with suitable primer to prevent degradation.

(d) Joints and Fittings for Polyethylene Pipework: The polyethylene socket and spigot fittings, saddles and drawn bends for fusion jointing shall be in compliance with WIS 4-32-15:1995. When flanges and bolting for pipes, valves and fittings are used, they shall be in compliance with BS EN 1092-1:2018, BS EN 1092-2:1997 or BS EN 1515-1:2000.

(e) Electrofusion of Pipes

(i) Pipes and fittings can be joined by electrofusion. The socket of the fitting incorporates an electrical heating coil. When energised by electricity, the coil causes the material adjacent to it melt and fuses into contact with the surface of the pipe. The heating coil shall be wound on to a moulded pre-form section of the fitting.

(ii) An electrofusion control unit shall be used to power the electrofusion process. The unit shall comply with that recommended by the pipe manufacturer or approved by the Supervising Officer.

(iii) Pipe ends to be jointed shall be thoroughly scraped to remove the outer surfaces and burrs. Scraped surfaces

shall be protected from contamination before jointing. Fit the electrofusion socket fitting into both pipe ends and connect the control unit leads to the terminals onto the fitting. Energise the control unit as guided by the manufacturer until the fusion process has been completed. Leave the joint cooling before use.

(f) Butt-fusion jointing shall not be used unless as specified by the Supervising Officer.

18.1.1.4.6 ABS Pipe

Acrylonitrile Butadiene Styrene (ABS) pipes shall have sizes detailed in ISO 161-1:2018 and ISO 727-1:2002 from 16 mm up to 315 mm outside diameter, which can be used under a wide temperature range from –40°C to +80°C. Pipes and fittings shall be rated at or above 10 bar pressure at 20°C.

The pipe fitting joint shall be of solvent welding, flanges, stub flanges, shouldered pipe couplings, or unions and thread: -

(a) Solvent cement welding

This is done by chemically softening in the outside of the pipe and the inside of the fitting. The pipe end over a length equal to the depth of the socket fitting and the socket internal surface shall be abraded thoroughly using clean coarse emery cloth. Remove dust from surface and apply solvent cement to both matching surfaces, and push fit the socket onto the pipe end by using longitudinal strokes.

(b) Thread joint may be applied to small diameter pipe that connect valve or fitting. The male threads shall be wound by PTFE tape prior to jointing the fittings.

(c) Flanges and bolting for pipe, valve and fitting shall be in compliance with BS EN 1092-1:2018, BS EN 1092-2:1997 or BS EN 1515-1:2000.

18.1.1.4.7 Copper Pipe

Copper tube shall be in accordance with BS EN 1057: 2006 + A1: 2010 for pipe size smaller than 80 mm, capillary joint to BS EN 1254-1: 1998, 1254-2: 1998 & 1254-3: 1998 for 50 mm and below, flange joint for 65 mm and above.

Copper tube up to and including 54 mm diameter bore shall be assembled with capillary fittings with solder suitable for pipe and water condition.

Joints on copper pipe and fitting of 67 mm diameter and over are to be made with copper slip-on bosses brazed to the pipes in accordance with BS EN 14324:2004, BS EN 12797:2000, BS EN 12799:2000, BS EN ISO 13585:2012, BS EN 13134:2000 and copper alloy flanges of BS EN 1092-1:2018, BS EN 1092-2:1997 or BS EN 1515-1:2000 bolted together including bolts.

Flange shall be flushed and truly aligned and shall utilise full faced corrugated grooves.

18.1.1.4.8 Stainless Steel Pipe

Stainless steel pipe shall comply with BS 6362:1990 or BS EN 10312:2002, all with material grade 316.

(a) BS 6362:1990 stainless steel pipe ranging from 15 mm to 150 mm shall comply with the following: -

Nominal size (mm)	Designation of thread	Outside diameter (mm)		Nominal wall thickness (mm)
		Maximum	Minimum	
15	1/2"	21.8	21.0	2.6
20	3/4"	27.3	26.5	2.6
25	1"	34.2	33.3	3.2
32	1-1/4"	42.9	42.0	3.2
40	1-1/2"	48.8	47.9	3.2
50	2"	60.8	59.7	3.6
65	2-1/2"	76.6	75.3	3.6
80	3"	89.5	88.0	4.0
100	4"	115.0	113.1	4.5
125	5"	140.8	138.5	5.0
150	6"	166.5	163.9	5.0

(b) BS EN 10312:2002 stainless steel pipe ranging from 15 mm to 54 mm shall comply with the following: -

Nominal size (mm)	Outside diameter (mm)		Nominal wall thickness (mm)
	Maximum	Minimum	
15	15.045	14.940	0.6
22	22.055	21.950	0.7
28	28.055	27.950	0.8
35	35.070	34.965	1.0
42	42.070	41.965	1.1
54	54.070	53.840	1.2

(c) BS EN 10312:2002 stainless steel pipe covered with polyethylene and foam coating shall comply with the following:-

Nominal size (mm)	Outside diameter (mm)		Nominal wall Thickness (mm)	Polyethylene and foam coating thickness (mm)		
	Maximum	Minimum		Foam	PE	Total
15	15.045	14.940	0.6	1.5	0.8	2.3
22	22.055	21.950	0.7			
28	28.055	27.950	0.8			

(d) Jointing for BS EN 10312:2002 stainless steel pipe shall be facilitated by suitable solvent cement as recommended by manufacturer. Jointing for BS 6362:1990 stainless steel pipe shall be of either argon welding, compression fittings or screwed fittings as recommended by manufacturer.

18.1.1.4.9 Lined Galvanised Steel Pipe

Galvanised steel pipe shall be UPVC internally lined with screw joints for pipe connections. All fittings shall be beaded with built-in plastic core. Lined galvanised steel pipe shall comply with BS EN 10255:2004 medium grade.

Unions or flanged joint shall be used for joint subject to disconnection for future maintenance near to the connections of the equipment.

No yarn shall be permitted in any joint, plastic plumber's PTFE tape shall be used throughout the installations or as recommended by manufacturer.

For jointing of faucets, use faucet elbows and sockets of the same galvanised pipe manufacturer. Cutting of pipe shall be facilitated by metal saw, and no cutting of pipe by pipe cutter is allowed. When cutting, avoid over-speed the saw to damage the internal lining.

Threading of pipe shall follow the relevant standard of the pipe manufacturer. Pipe chamfering of the inner wall lining of pipe shall be facilitated by proprietary reamer or scraper specifically for the lined galvanised pipe.

Jointing of threaded pipe shall be facilitated with anti-corrosive sealant and seal tape.

18.1.1.5 PIPEWORK INSTALLATION DETAILS

18.1.1.5.1 General

(a) The Tender/ Drawings indicate the size and general layout of the required pipework. The exact positions may not be indicated on the Drawings, as for the purpose of clarity, they are generally shown separately spaced out from one another as if they were at the same plan level. Various pipelines in the installations shall be accurately set out in compliance with the Particular Specification or so specified elsewhere in this General Specification.

(b) Where drawings with details for pipework supports and brackets, vibration connectors, expansion joints and anchor points are issued with the Contract, the standard details referred shall be followed "in-principle" but adjusted as to the detail in order to suit the particular circumstances. Such adjustments shall be indicated on the Installations/ Shop drawings and be approved by the Supervising Officer before work commences.

(c) Generally, the clearance between pipework (or the lagging) and the wall and any other fixtures shall not be less than 25 mm. Pipework shall not run near to or above electrical appliances, cables, trunkings and conduits.

(d) Where two or more pipes run follow the same route, all pipes shall run parallel with one another and to the building structure. Any pipework which requires subsequent insulation shall be adequately spaced to allow for individual finish.

(e) Movements of the pipework due to changes in temperature shall be accommodated by the natural flexibility of the pipework run or by bellow expansion joints, in either case allowable stress levels shall not be exceeded.

(f) Tubes shall be reamed after cutting and shall be free from burrs, rust, scale and other defects and shall be thoroughly cleaned before erection. Pipe ends left open during the progress of work shall be temporarily closed with purpose-made metal or plastic plugs or caps, or blank metal flanges and protect from corrosion.

(g) Joints shall not be made in the thickness of any wall, floor or ceiling and pipework shall not be embedded in the structure of floors. Where pipework passes through walls, floors or ceilings, sleeves shall be provided. Pipework passing through floors shall, where specified, be provided with approved type floor and ceiling plates and fastened securely to the sleeve. Sleeves shall be of the same metal as the pipe. The space between pipework and sleeve shall be plugged with an approved sealant.

(h) All entry and exit holes to or from a building for a pipework service shall be sealed and plugged. The sealant shall be a mastic compound or silicone rubber. Where the pipework enters the building through a large hole or duct, which cannot be backfilled, a mild steel blanking plate not less than 6 mm thick shall be built into the wall of the hole or duct. The service pipes shall pass through clearance sockets welded to the plate. The space between pipe exterior and socket interior shall be sealed and plugged.

18.1.1.5.2 Elbows and Bends

(a) Elbows shall be used, where practicable, in preference to bends. However, square elbows will not be permitted. Unless otherwise specified, long radius elbows shall be used in order to minimise hydraulic resistance.

(b) For forming bends in small bore copper pipe up to size 25 mm, pipe bending springs may be used but again there shall be no distortion of the pipe involved.

(c) In the case of all bends formed in the pipe, these shall constitute long radius bends. Short radius elbows shall only be used at the discretion of the Supervising Officer where long radius elbows will not fit or are not manufactured.

18.1.1.5.3 Jointing

(a) Galvanised pipes which are to be screwed shall be galvanised before servicing. Pipes which are to be fitted with welded flanges shall be flanged before galvanising. Galvanised treatment on all welding joints shall be required after welding.

(b) Joints on all permanently concealed mild steel and galvanised pipework shall be welded unless otherwise agreed by the Supervising Officer. Other mild steel and galvanised pipework may be of screwed or welded joints. When screwed joints is used, at least one of the two engaging components shall be taper-threaded to ISO 7-1:1994/ Corr 1:2007 and the joints between them shall be made with approved jointing material, and selected to suit the appropriate type of services. For pipework without anti-rust threaded joints, it shall be patched up with galvanised painting before making such joints.

(c) Pipework connections to the suction and delivery outlets of pumps and other vibrating machines shall be isolated from such sources of vibration by means of anti-vibration connectors. The vibration connectors shall be capable of attenuating the vibration of the plant such that the bulk of the vibrations are prevented from being

transferred to the pipework. Wherever vibration connectors are installed, the adjacent pipework shall be adequately supported by guide type brackets.

(d) All flanged connections for pipeworks shall be fixed by stainless steel bolts, nuts & washers with spring washers.

(e) At dismantling points or where the pipework is connected to an appliance, ground-in spherical seated unions shall be used for pipework up to 50 mm size, and flanges shall be used for pipework at 65 mm size and above. The flanges shall be to ISO 7005-1: 2011 and ISO 7005-2: 1988 or BS EN 1092-1: 2018, BS EN 1092-2: 1997, BS EN 1515-1: 2000 of appropriate type. Flanged joints shall be made with flat ring gaskets suitable for the pressure and temperature and extending to the inside of the bolt circles.

(f) Screwed fittings, other than sockets, shall be malleable cast iron, banded or beaded pattern. Standard but welding fittings shall be used on welded pipework. Use of mixed joints shall be prohibited.

(g) Flanges for mild steel pipework shall be forged steel and machined over the raised or flat faces. Headers shall be of flanged mild steel tube with flanged outlets welded on, and spare outlets shall be blanked off with bolted flanges.

(h) Where specified, and/or subject to the Supervising Officer's written agreement, in plant rooms and building ducts where pipework appearance is not considered so critical, mechanical pipe couplings may be employed for pipe connection.

(i) Mechanical pipe couplings shall be self-centred, engaged and locked in place onto the grooved or shouldered pipe and pipe fitting ends. The pipe connection shall result in a positive watertight couple providing reasonable allowance for angular pipe deflection, contraction and expansion. The coupling housing clamps shall consist of two or more malleable iron castings or rolled steel segment holdings with a composition water sealing gasket so designed that the internal water pressure will increase the water tightness of the seal. The coupling assembly shall be securely held together by two or more track head track head square or oval-neck heat treated carbon steel bolts and nuts. All pipe fittings connected to mechanical pipe couplings shall have groove and shouldered ends and shall be malleable iron castings. Flanged or threaded end valves may be used with grooved adapters.

(ii) Before couplings are assembled, pipe ends and outsides of gaskets shall be lightly coated with grease or graphite paste to facilitate installations.

(iii) Pipe grooving shall be formed in accordance with the pipe coupling manufacturer's latest specification. Pipes may be cut-grooved or roll-grooved except for those pipes with wall thickness less than the minimum recommended by the manufacturer. The cut-grooving shall be roll-grooved without the removal of any metal.

(iv) The entire coupling installations shall be in accordance with manufacturers' recommendations.

(v) Couplings or flange adapters for plain ended pipework shall be steel, slip-on type as approved by the Supervising Officer.

(vi) Coupling shall consist of sleeve (without centre register), end flanges, sealing rings and bolts and nuts.

(vii) Flange adapter shall consist of end flanges/sleeves, sealing rings, and studs and nuts.

(viii) To provide hard and durable protection against impact, abrasion, chemicals and low temperature, all couplings and flange adapters shall be coated with Rilsan Nylon 11 or equivalent and approved by the Supervising Officer, by either a dip process giving a coating thickness of 250-375 microns or an electrostatic spray process giving a coating thickness of 150-250 microns.

18.1.1.6 PIPEWORK BRACKETS AND SUPPORTS

18.1.1.6.1 All outdoor brackets and supports for non-copper pipes shall be stainless steel except otherwise as specified in the Contract. The fixing bolts and nuts for the brackets and supports shall have the same materials with the brackets and supports that are used.

18.1.1.6.2 All indoor brackets and supports for non-copper pipes shall be hot dip galvanised iron except otherwise as specified in the Contract. The fixing bolts and nuts for the brackets and supports shall be galvanised.

18.1.1.6.3 Brackets for copper pipes shall be brass, which shall be mounted on stainless steel supports. Fixing of copper to steel shall be separated by insulated sheet to avoid the occurrence of galvanic corrosion. Details shall be submitted for Supervising Officer's approval.

18.1.1.6.4 Pipework shall be supported so as to permit free movement due to expansion and contraction. Pipework supports shall be installed as near as practicably possible to joints and changes in direction. Each support shall take its due proportion of the load. The spacing of the supports shall not exceed the centres given in Clause 18.1.1.8. Where there are two or more pipes, the spacing shall be based on the centres required by the smallest bore pipework.

18.1.1.6.5 Vertical rising pipework shall be supported at the base or, as indicated, to withstand the total weight of the riser. Branches from risers shall not be used as a means of support for the riser. If such base has to be rested on an intermediate floor slab, Supervising Officer's attention shall be drawn for structural reinforcement to the floor slab and also allow for additional treatment to the base as required by the Supervising Officer.

18.1.1.6.6 Where pipework up to 50 mm size is fixed to solid wall, brackets may be of the screw-on or long shank built-in type; in case the walls are plastered, only the long shank built-in type shall be used. For fixing to woodwork and lightweight partitions or walls, brackets shall be of the screw-on pattern of adjustable two-piece type. Brackets for copper pipework shall be brass or gunmetal. The upper half of the pipe clip shall be detachable without disturbing the fixing.

18.1.1.6.7 Brackets screwed to walls shall be secured by expanding plugs. Other purpose designed fixing devices shall be submitted for Supervising Officer's approval.

18.1.1.6.8 Unless otherwise specified, hangers for horizontal pipework at high level shall be supported from steel angle or channel sections or approved proprietary devices supplied by the supplier, suitable for building-in or otherwise securing to the structure by the Building Contractor. Adjustable steel hangers shall be used. Pipe rings shall be of stainless steel or galvanised fabricated steel, made in halves and secured by bolts or screws of the same materials. Caliper type hooks will not be permitted.

18.1.1.6.9 Where pipework is fitted in service duct or trenches or where it is of 65 mm size or greater and supported from walls, the design of the pipe supports, guides and anchors shall be in accordance with the Drawings. Otherwise, details and proposal shall be supplied to the Supervising Officer for approval. Where roller supports are required, they shall be of an approved type. If insulation is on the outer shelf, the preformed insulation shall be kept free of the rolling surface. Load-bearing insulation at supports, where required, shall be fitted at the time of erecting the pipework.

18.1.1.6.10 All cleats, brackets and steelwork required for anchor points shall be supplied, and fixed in position ready for building-in. Anchor steelwork secured to the bottoms of ducts or trenches shall be coated with hot-poured bitumen to inhibit future corrosion.

18.1.1.6.11 Supports for non-metallic pipework may be of any approved pattern that prevents free axial movement of pipe at all temperatures and have radial edges to prevent cutting into the pipe. All bearing surface shall be sufficiently wide to prevent indentation.

18.1.1.6.12 Valves, meters and other heavy "in-line" equipment shall be rigidly supported or independently supported as deemed necessary.

18.1.1.6.13 Supports for pipes shall be such that no compression or deformation of the insulation occurs.

18.1.1.6.14 Provision for movement due to expansion and contraction shall be generally as indicated and/or shall be by changes in direction of the pipework, by loops or by other approved expansion devices. Supports and guides shall be arranged to ensure that all movement is taken up by the change in direction of the pipework or by the loop or device.

18.1.1.6.15 Cold bridge shall be prevented between the insulated pipework and the associated hangers and pipework supports.

18.1.1.7 PIPEWORK EXPANSION JOINTS, ANCHORS AND GUIDES

18.1.1.7.1 Expansion Joints

(a) Where expansion joints are utilised, they shall be manufactured in accordance with the design philosophy for thin walled bellow membranes as laid down by the Expansion Joint Manufacturers Association (EJMA latest Edition).

(b) Axial movement bellow expansion joints on all services shall comprise of thin wall multi-plied omega formed convoluted bellows of stainless steel material to BS EN 10029:2010, BS EN 10051:2010 and BS EN ISO 9445-1:2010 to 9445-2:2010 of appropriate type. Bellows shall be argon arc welded to carbon steel end fittings utilising a stainless steel seal ring to reinforce the bellow cuff end.

(c) The bellow expansion joint shall be provided with a close fitting stainless steel internal liner to reduce turbulent flow.

(d) End termination of expansion joints shall be carbon steel threaded male to ISO 7-1:1994/Corr 1:2007 or carbon steel flanges to ISO 7005-1:2011 and ISO 7005-2:1988 Standard to suit the line pressures.

(e) For copper or non-ferrous pipework systems, expansion joints shall be manufactured in stainless steel throughout. The bellow

expansion joints shall be installed with pre-cool/heat setting to their required length to suit the temperature condition at the time of installations. The joints shall be rated suitable for the required amount of designed axial movement. Mild steel outer protection sleeves shall be fitted to the bellows only when the units are open to the environment and exposed to risk of damage or when it is necessary to carry lagging over the joint.

(f) Expansion joints shall be installed in strict accordance with the manufacturer's recommendations. The manufacturers of the expansion joints shall be approved to ISO 9001:2015.

(g) Expansion joints shall be designed to meet the required angular movement or the required movement in all directions perpendicular to the axis of the bellows.

(h) Expansion joints shall be provided, wherever appropriate, with hinge and shackle or centre joining tube, tie bars and spherical nut arrangement, which shall be of carbon steel to ISO 9692-1:2013 and ISO 9692-2:1998 fully designed to contain the pressure thrust. End termination shall be flanged to ISO 7005-1:2011 and ISO 7005-2:1988 to suit the line pressures.

18.1.1.7.2 Anchors

Anchors shall be installed according to the recommendations of the expansion joint manufacturer and the details shall be submitted to the Supervising Officer for approval before manufacture commences.

(a) Allowances shall be made for anchors capable of withstanding the maximum stresses created within the pipework system, and have adequate safety margin. These shall be positioned as indicated on the layout drawings or as necessary shop drawing/details.

(b) On steel pipework, the pipe shall be welded to the anchors via heavy steel straps. On copper pipework, the pipe shall be brazed to the anchors via heavy copper straps.

18.1.1.7.3 Guides - Axial Movement Pattern

(a) The pipework shall be guided along its length and the guides shall be capable of withstanding not less than 15% of maximum stresses within the pipework system and have an adequate safety margin.

(b) Guides shall be adjustable in both directions in the lateral plane, so that pipework can be aligned with the expansion joint.

(c) Each guide shall not be less than 2 pipe diameters long and shall have a minimum manufacturing clearance of the pipe diameter.

(d) The distance from expansion joint to the first guide shall not be greater than 4 pipe diameters, and the distance between the first guide and the second guide shall not be more than 14 pipe diameters. Guides thereafter shall be spaced in accordance with normal pressure performance requirements as a minimum.

18.1.1.7.4 Guides for Angular or Lateral Movement Pattern

Directional guiding shall apply, such as side plates, local to the expansion joint, the remainder of the pipework shall be supported in the nominal way, by roller or frictional supports, or pipework hangers.

18.1.1.8 PIPEWORK SUPPORT SPACING

Support for pipework shall be spaced in accordance to the following:-

Table 18.1.1.8 (1) Supports for Steel Pipework

Size of tube	Intervals for Horizontal runs		Intervals for Vertical runs
	Bare	Lagged	Bare and Lagged
mm	m	m	m
15	1.8	1.8	2.4
20	2.4	2.4	3.0
25	2.4	2.4	3.0
32	2.7	2.4	3.0
40	3.0	2.4	3.7
50	3.0	2.4	3.7
65	3.7	3.0	4.6
80	3.7	3.0	4.6
100	4.0	3.0	4.6
125	4.5	3.7	5.5
150	5.5	4.5	5.5
200	8.5	6.0	8.5
250	9.0	6.5	9.0
300	10.0	10.0	10.0

Table 18.1.1.8 (2) Supports for Copper Pipework

Size of tube	Intervals for horizontal runs		Intervals for vertical runs
	Bare	Lagged	Bare and lagged
mm	m	m	m
15	1.2	1.2	1.8
22	1.2	1.2	1.8
28	1.8	1.5	2.4
35	2.4	1.8	3.0
42	2.4	1.8	3.0
54	2.7	1.8	3.0
65	3.0	2.4	3.7
76	3.0	2.4	3.7
108	3.0	2.4	3.7
133	3.7	3.0	3.7
159	4.5	3.7	3.7

Table 18.1.1.8 (3) Supports for Non-metallic Pipework

Nominal Bore of Pipe (mm)	Intervals for horizontal runs (m)	Intervals for Vertical Runs (m)
15	0.75	1.5
22 to 28	1	1.8
28 to 35	1	2
42	1.2	2.4
53 to 65	1.4	2.8
76	1.8	3.5
108 and over	2	4

18.1.1.9 WELDING AND BRAZING

18.1.1.9.1 The procedure and the competence of the operator shall be in accordance with the recommendations contained in the following British HVCA publications: -

(a) "Welding of Mild steel Pipework"; and

(b) "Code of Practice - Brazing and Bronze Welding of Copper Pipework and Sheet".

18.1.1.9.2 Welding operations shall comply in particular with:-

(a) BS 2633:1987 and BS 2971:1991 - relevant subsections for metal-arc welding (steel pipe);

(b) ISO 9692-1:2013 and ISO 15609-2:2019 -relevant subsections for gas welding (steel pipe); and

(c) ISO 5187:1985 - Brazing (copper pipe).

18.1.1.9.3 Where the visual inspections and tests reveal those welding joints which are reasonably believed to be unacceptable, the Supervising Officer shall be entitled to have such welding examined by radiography or other approved inspection method and independently assessed. The cost of the tests and the subsequent remedy work to the satisfaction of the Supervising Officer shall be included in the Works if tests prove the welding joints to be non-compliance with the specification.

18.1.1.10 VALVES, COCKS AND STRAINERS

18.1.1.10.1 General

(a) All valves and fittings that are used for chemicals applications for fountain shall be capable to resist the corrosion of such chemicals. For water circuit of fountain, all valves and fittings shall be capable of handling salt water application.

(b) Provision such as a sprocket rim wheel and chain shall be provided for manually operated valves that are difficult to access.

(c) All plant room valves and circuit control valves shall be provided with approved plastic labels.

(d) A circuit control diagram of appropriate size showing the location of each isolating, regulating and control valve shall be provided and fixed in a glazed hardwood frame in a position indicated by the Supervising Officer.

18.1.1.10.2 Ball Float Valve

(a) Equilibrium ball valves to BS 1212-1:1990 & BS 1212-2:1990 shall be provided to the water tanks.

(b) Fresh water ball valves up to 50 mm shall be bronze with copper ball float. Fresh water ball valves 65 mm and above shall be cast iron with nickel alloy working parts and copper ball float.

(c) Ball valves used for salt water or water circuit of fountain up to 50 mm shall be bronze, 65 mm and above shall have cast iron body and stainless steel or zinc free bronze trimming with construction entirely suitable for use with sea water. Ball float shall be stainless steel or in zinc free bronze or rubber lined to prevent corrosion.

18.1.1.10.3 Butterfly Valves

Butterfly valves shall have resilient seats which are replaceable with moulded-in O-rings to serve as a flange gasket. For sizes of 50 mm diameter to 150 mm diameter inclusive, a notched plate handle shall be provided for the control of the valve and indication of disk position. For sizes of 300 mm diameter and above, gear actuator shall be used. All butterfly valves shall be capable of bubble tight shut off. Butterfly valves shall comply with the recognised international standards.

(a) The manufacturer shall provide independent laboratory tests by independent regulatory/testing bodies, organisations accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or by the Hong Kong Accreditation Service (HKAS), or organisations accredited by an accreditation scheme mutually recognised by HOKLAS or HKAS or elsewhere as approved such as Underwriters Laboratory or Factory Mutual Research for pressure rating. All testing records and data shall be submitted to the Supervising Officer for approval.

(b) Bodies shall be made of ductile iron grade 400-18, completely coated with polyamide or products having equivalent functions or performance against corrosion, suitable for the temperature range of 0°C to 50°C. The valve shall provide dead end service at maximum rating.

(c) The discs shall be made of stainless steel to Grade 316.

(d) The shafts stems shall be made of stainless steel to Grade 316.

(e) The control handles and the gear operators shall be suitable for locking in any position. Micro switches shall be built in the actuators and factory adjusted at full /partly open and full closure. Manufacturer shall provide certificate of factory adjustment.

(f) Valve electric operators shall be mounted on valves and tested at factory.

(g) The valves shall have marking tag in accordance with ISO 5209:2019 standard.

(h) The valves body and seat shall be designed for the maximum working pressure of at least 10 bar.

(i) The valve disc shall be able to protrude into the pipework on either side of the valve without damaging the disc or the lining on the pipes. Pipework either side of the valve shall be so designed that the valve can be removed even when jammed in the fully open position.

(j) Where specified for manual operation valves shall be provided with hand wheels fitted with reduction gearing to enable one man to operate the valve, in a reasonable time, when it is subjected to the maximum unbalance pressure.

(k) Grooved ends butterfly valves shall be bubble tight closing to ISO 5208:2015 standards, enabling quick assembly with mechanical grooved coupling on ISO standard pipes.

18.1.1.10.4 Isolating Valves

(a) For Water Circuit of Fountain and Non-fresh Water Application

(i) Up to and including 50 mm bore

PVC diaphragm valves to BS EN 13397:2002 with reinforced spindle, rising stem. All parts of the valve shall be suitable for use with salt water equivalent to sea water. Ends of the valves shall be suitable for flanged connection to PVC pipe flanges.

(ii) Above 50 mm bore

Full way gate valves shall be constructed of cast iron body with zinc free bronze trim, bolted cast iron bonnet, malleable iron hand wheel, zinc free bronze stuffing box, gland, thrust, plate, yoke, wedge, seat and yoke sleeve with nickel alloy faces, stainless steel spindle with outside screw of rising stem or of inside screw of non-rising stem, whichever is specified, gunmetal nuts, and graphite packing compressed fibre packing.

(b) Fresh Water Application

(i) Up to and including 50 mm bore

Full way gate valve of bronze body construction to BS EN 12288:2010 wedge and valve seat shall be in bronze, non-rising spindle and screw collar in high tensile bronze. Valves shall have screwed female ends for taper treads to BS EN 10226-1:2004.

(ii) Above 50 mm bore

Full way gate valve of bronze body construction to BS EN 12288:2010 bolted bonnet, wedge and valve seat in bronze, rising or non-rising spindle and screw collar in high tensile bronze. Valves shall have flanged connection

to BS EN 1092-1:2018, BS EN 1092-2:1997 and BS EN 1515-1:2000.

18.1.1.10.5 Regulating Valves

Regulating valves in fresh water systems shall have gunmetal body to BS EN 12288:2010 with screwed female connections for sizes up to 50 mm bore, and shall be of flanged connections for size above 50 mm.

Regulating valves in salt water system shall be similar materials as the cast iron gate valves and suitable for use with sea water. Valves shall have parabolic shaped discs to give a "straight line" characteristic of water flow to spindle lift. All valves shall be lock-shield type.

18.1.1.10.6 Motorised Control Valves and Solenoid Valves

For application in water circuit of fountain, valve suitable for sea water application is required.

Motorised valves shall be of the modulating type with a turn down ratio of at least 50 to 1. Valve bodies shall be cast gunmetal, brass cast iron or as otherwise indicated. Seat and inner valve material shall be brass, stainless steel or as otherwise indicated. Valve sizes 50 mm and smaller shall be screwed and supplied with union fittings. Valve sizes 65 mm and larger shall be flanged. Valves shall be of the straight-through type as required by the sequence or shown on the Drawings. Valves actuator shall be equipped with manual opener to allow manual positioning of valve in the absence of control power. Valves shall have authority of at least 0.5 (50%) and shall have suitable actuator to close against full pump head. Valve body shall be rated for differential pressure stroke less than 20 mm.

For valves that are incorporated within the system or units, they shall fit for the purpose and applications.

Valves schedules for all valves modulations/on-off shall be submitted detailing the maximum allowed and actual pressure drops, authority, turndown ratio, maximum pressure the actuator will close against and other valve data.

18.1.1.10.7 Check Valves

The body of the check valves shall be made of cast iron to BS EN 1561:2011 and ISO 185:2020 while the flaps/discs shall be made of bronze to ISO 197-4:1983 or ductile cast iron. The discs of swing check valves shall be of light construction and pivot on a spindle secured by 2 phosphor-bronzed hangers. Each valve shall be fitted with a stop to prevent undue movement of the flap and shall be as silent as possible in operation.

The discs of lift check valves shall be provided with means of guiding the discs and preventing components from becoming detached in services.

Recoil check valves with size 100 mm and above shall have removable cover on top of the outlet body casing to facilitate inspection of bearings and movement door.

Silent check valves shall have large bearing surfaces, functions equally well in all positions, drop-tight seating, and stainless steel trim.

For chemical handling, ball type UPVC check valves at 50 mm diameter or below may be used.

18.1.1.10.8 Stainless Steel Valves and Accessories

Where stated in the Particular Specification, valves and accessories for use with ozone or ozonated water such as valves and accessories for reaction tanks, carbon filter tanks, etc. shall be made of stainless steel materials to Grade 316 (BS EN10088-3:2014). This includes body, stem, disc, cover and spring of gate valves, check valves, globe valves and other accessories as specified in the Particular Specification. The gasket shall be made of PTFE. Butterfly valves shall be in accordance with the requirements of Clause 18.1.1.10.3 of this General Specification.

18.1.1.10.9 Cocks

Cocks, taps and other accessories shall be of the type and working pressure suitable for the applied system and shall be supported by valid documents with approval from the appropriate authority. They shall be in accordance with the appropriate ISO Standard with marks.

Bodies of cocks of up to and including 50 mm size shall be of cast gunmetal or bronze; approved valves having hot-pressed bodies may be offered as an alternative. For carbon and reactions tanks, size of drain cock shall be 50 mm and above which shall be of UPVC cocks with UPVC pipes below union end.

Except otherwise specified all cocks that convey ozonised or chemical fluid shall be chemical resistant types.

18.1.1.10.10 Strainers

Strainers shall be of screwed thread connection for bores of up to and including 50 mm, and of flanged connection for bores of 65 mm and above.

Strainers of up to 50 mm shall be of gunmetal or bronze. The bodies of single strainers of 65 mm bore and above and all double strainers shall be of cast iron.

Strainer cages and their supporting structure shall be stainless steel with 1.5 mm diameter perforations or as specified in the Particular Specification. Cage shall be at least 5 times the cross-sectional area of the pipe.

Double strainers shall incorporate a changeover device to enable either strainer to be selected and to isolate the idle strainer from the fluid flow.

In case where the strainers have to be frequently cleaned, such as the strainers for the main circulation pumps, a bucket type strainer with clamp type cover to facilitate quick removing of cages without the need for wrench or other special tool shall be used. The flanged cast iron bucket type strainers shall have grade 316 stainless steel screen cage with perforations to suit fluid handled. 1 set each of spare screen cages shall be provided for alternate replacement.

18.1.1.10.11 Foot Valves with Strainers

Foot valves with strainers shall be used for chemical dosing systems when diaphragm pumps have been used. The body shall be corrosive resistant material and strainers shall be stainless steel to resist the chemical fluids.

18.1.1.10.12 Automatic Air Vents

Automatic air vents for general venting of air shall have gunmetal or brass bodies, non-ferrous or stainless steel floats and guides, and non-corrodible valves and seats. Each automatic air vent shall be controlled by a lock-shield valve. Air release pipes shall be run to discharge at the nearest suitable and visible point and agreed by the Supervising Officer.

Whether indicated on the drawings or not, automatic air vent shall be installed at the top of all risers as well at high points in pipework systems.

Automatic air vent complete with cocks shall be provided at all high points on water circulating pipework and tanks. Body of the automatic air vents shall be of stainless steel. The venting capacity and operating pressure shall meet the venting requirements of the ozonators as informed by the manufacturer.

Proprietary made automatic venting system for carbon and reaction tanks may be accepted subject to the approval of the Supervising Officer.

Automatic air vent on UPVC pipe shall be protected by guard. The guard details shall be submitted for Supervising Officer’s approval.

Devices for air venting shall be provided at all high points in the pipework. They shall be installed in the highest points of the sections where they are intended for venting.

Vent valves from reaction and carbon tanks shall discharge gas to outdoor through an ozone destroyer.

18.1.1.10.13 Sight Glass

The sight glasses shall be corrosion resistant type which shall be securely fixed to the pipework. Inline inspection glasses shall be corrosion resistant type which shall be installed at the discharge of each chemical feed pumps. Protective guard shall be installed to protect the sight glass. Details shall be submitted for Supervising Officer's approval.

18.1.1.10.14 Valves for Drain

For flushing down cock or valve, 15 mm diameter key-operated drain cocks with hose unions shall be fitted to the lowest accessible points of the system pipework and also on individual items of plant to ensure complete drainage.

Larger drain valves will be required for rapid flushing down in connection with water tanks.

Drain valves for back washing of sand filters or carbon tanks shall have diameter equal to the inlet and outlet pipes.

18.1.1.10.15 Pressure & Temperature Gauges, Orifice Plate, Flow Meter and Energy Meter

(a) Pressure Gauges

Pressure gauges fitted to plant and pipework shall comply with BS EN 837-1:1998 calibrated in kPa from zero to not less than 1.3 times and not more than twice the operating pressure of the respective equipment/system and shall be accurate to 1.5% of full scale reading, unless otherwise specified. Gauges for ozone or chemical application shall be stainless steel.

The dials of gauges shall not be less than 100 mm diameter and the cases shall be of polished brass or chromium-plated mild steel with optical sight glass.

Pressure gauges used solely to indicate the head and pressure of water shall be provided with an adjustable red pointer set to indicate the normal working pressure or head of the system.

(b) Thermometers shall be of the alcohol -in-glass type of at least 150 mm long with accuracy of ±0.5ºC. Thermometers shall be complete with cylindrical brass case, be of straight or angle type, and be installed in pockets. Unless otherwise specified, material

of thermometer pocket shall be of stainless steel grade 316.

(c) Where orifice plate metering are to be installed, the orifice plates shall be of stainless steel and of proven performance characteristics in compliance with ISO 5167-1:2003 and ISO 5167-2:2003. The resistance across the orifice shall not exceed 5 kPa. The plate shall have 2 stainless steel valve tappings for connection to manometer or responder meter.

(d) Electromagnetic and Ultrasonic Flow Meters

(i) The flow meter shall be of the direct reading type, i.e. in l/s, and shall be suitable for the chemical and physical properties of the fluids to be measured and suitable for both horizontal and vertical installations.

(ii) Each flow meter shall consist of the flow sensor, an integral signal converter/transmitter and a digital display unit. The flow sensor shall be installed on the water pipework without obstructing the flow. The protection class of the sensor and converter/transmitter housing shall be at least to IP 67 and IP 65 respectively. The flow meter shall have a constant accuracy to a maximum error of ±0.5% of the actual flow for flow velocity of greater than or equal to 0.5 m/s. The Installations of the flow meter shall be as per the manufacturer's recommendation with sufficient length of straight pipe run both at the upstream and downstream piping.

(iii) The flow meter shall conform to BS EN IEC 61000-6-1:2019 to 61000-6-2:2019, BS EN 61000-6-3:2007 + A1: 2011 and BS EN IEC 61000-6-3:2019 or similar international standards on Electromagnetic compatibility (EMC) compliance for industrial and commercial applications.

18.1.1.11 FIBRE GLASS WATER TANKS

18.1.1.11.1 General

(a) Wherever indicated on the drawings, all non-concrete tanks shall be supplied and installed except water storage tanks constructed by concrete which shall be casted by the Building Contractor.

(b) All fibreglass water tanks shall be of removable panel construction and bolted to form the required tank size by flanges.

(c) Each tank shall be provided with the following:-

(i) one 500mm x 500 mm or 500 mm diameter access opening with lockable cover to prevent the ingress of dirt;

(ii) the required numbers of inlets, outlets, drains, vents, overflow and electrode connections, positions of which shall be determined and submitted for approval; and

(iii) one internal and external cat ladder for maintenance. (Ladders shall be constructed in stainless steel)

(d) All connections in the tanks shall be made by flanges to BS EN 1092-1: 2018, BS EN 1092-2: 1997 and BS EN 1515-1: 2000 and the materials of the flanges shall be identical to that of the pipework to be connected.

(e) All bolts, nuts and washers used in the tanks, whether or not in contact with water, shall be of stainless steel and shall not deteriorate due to chemical or atmospheric actions.

(f) Proper gaskets shall be used in all joints at panel flanges and pipe flanges. Details of gaskets shall be submitted for approval by the Supervising Officer.

(g) Tank construction shall follow the WSD's requirements.

(h) Fittings including puddle flange for all necessary pipework connections and controls shall be supplied and installed.

(i) All cast-in fittings shall be ensured correctly positioned.

(j) The dimension of the tanks shown on the drawings are indicative only, exact sizes of all tank shall be adjusted to suit site conditions as well as to suit the manufacturing tolerance.

(k) Materials of the fibreglass tanks shall be of the type approved by Water Authority, Buildings Department and FSD. Details of materials shall be submitted for approval.

(l) Details of construction method of non-concrete tanks shall be submitted for approval.

18.1.1.11.2 Tank Panels

(a) In general, each panel of the tank shall have uniform dimensions of 1000mm x 1000 mm or 1000mm x 500 mm or 500mm x 500 mm modules and shall be interchangeable between tanks for the same application.

(b) The panel pattern shall be of "F" panel design to give extra strength to the wall of the panel to withstand water pressure. Alternative patterns may be considered and shall be submitted for approval.

(c) Thickness of each panel shall be adequate to withstand at least 3 times the static pressure likely to be created by the depth of the water stored therein. Adequate bracings shall be provided to maintain the tanks in shape when fully charged with water. Any leakage /rectification work resulted from inadequate bracing /supports shall be responsible under the Works. Damages to other trades and to the owner's properties resulted from flooding will also be chargeable to the contractor responsible for the Works.

(d) Tank panel shall be of reinforced glass fibre with a minimum thickness of 10 mm. The material of the tank shall not deteriorate due to chemical, atmospheric or thermal action when in contact with water treated with relevant chemicals for disinfection. Special attention shall be paid to the temperature of the water which will be as high as 35°C. The jointing material shall also be suitable for the chemical and temperature conditions of the water.

18.1.1.11.3 Supports

(a) Adequate supports shall be made to all connecting pipework from the building structure. The tank body shall not be used for supporting the pipework in any case.

(b) In general, tanks shall be supported on steel channels placed on top of concrete plinths. The steel channels shall be anchored to the concrete plinths and in turn bolted to the flanges of the panels as shown on the Drawings.

(c) Fibreglass tanks shall only be supported at the panel flanges and adequate anchoring points shall be provided to prevent movement.

(d) Adequate bracing shall be provided in the fibreglass tanks to eliminate vibration caused by the closing float valves and any other external sources.

18.1.1.12 POOL FITTINGS

18.1.1.12.1 Inlet Fittings

The inlet fitting shall be of adjustable type with full range of flow adjustment by turning the internal plate. Total opening area of the grating shall not be less than cross-section area of the connection pipe. It shall be constructed of ABS or chrome plate cast bronze.

The inlet fitting for water feature shall be of chrome plate cast bronze construction, adjustable "eyeball" type with smooth rounded exposed surface. The minimum orifice diameter shall be 25 mm.

18.1.1.12.2 Gutter Drains

Gutter dome scum drain shall be installed wherever so specified, in the gutter channel. Gutter dome scum drain grating shall have opening area 1.5 times the cross-section area of the connection pipe. The grating shall be designed to prevent entrapment of toes or fingers of fountain users. It shall be constructed of ABS or chrome plated cast bronze.

18.1.1.12.3 Main Drain Grating

Wherever so specified, main drain grating shall be installed and be of square type.

Multiple suction outlets system shall be adopted. The main drain grating shall be installed on a concrete sump pit constructed by Building Contractor. It shall be installed at the lowest point of the fountain of adequate size and design to ensure a maximum velocity of 0.3 m/s even if one of the suction outlets becomes blocked.

The distance between the nearest points of the perimeters of outlets shall be at least 2 metres. Should there be any physical constraints that this requirement cannot be met, i.e. small fountain size, justifications and proposed distance apart shall be submitted for Supervising Officer’s approval.

The opening area in the grates shall be of such design to prevent vortex and physical entrapment of fingers, toes, etc. The cover for the main drain grating shall be designed so that it cannot be removed except with tools. The main drain grating shall be constructed of ABS or chrome plated cast bronze. Twin drain outlets shall be provided in accordance with CIBSE Guide G Chapter 10.

18.1.1.12.4 Vacuum Fitting

The vacuum fittings shall consist of body and plug. The fittings shall be constructed with ABS or chrome plated cast bronze and shall have

connection for flexible vacuum hose. The plug shall be provided with mating threads at the hose adaptor connection and shall have 2 integral cast recessed finger gripping ribs for ease of removing from body. The selected adaptor shall be PVC or ABS construction with 38 mm FIP for connection to pipework, or as specified by the Supervising Officer.

18.1.1.12.5 Overflow Drain

Overflow drains shall be provided in form of skimmer box at location shown on the Drawings. All drain outlets shall be of streamlined ABS gratings, and completed with thread for UPVC overflow drain pipes connection, or as specified by the Supervising Officer.

18.1.1.12.6 Channel Outlets

The selected outlets and the associated gratings shall be of PVC or ABS construction with 50 mm diameter connection. The grate free area of the drain grating shall be minimum 1.5 times the transverse area of the connecting pipe, or as specified by the Supervising Officer.

18.1.1.12.7 Skimmers

Skimmers shall be installed as indicated on the Drawings. This shall be moulded type of 5 mm thick rugged ABS construction, or as specified by the Supervising Officer.

18.1.1.12.8 Water Depth Indicators

Where stated in the Particular Specification, water depth indicators shall be provided on the side walls of the fountain by the Building Contractor.

18.1.1.12.9 Safety Vacuum Release System

Where stated in the Particular Specification, Safety Vacuum Release System (SVRS) shall be installed as indicated on the Drawings and complied with the BS EN 13451-3:2011+A3:2016.

By measuring the suction pressure mechanism, the performance requirements to automatically shut off circulation pumps shall comply with the ASME A112.19.17. A test report regarding this standard shall be submitted to the Supervising Officer for approval.

Alternatively, by measuring the flow mechanism, the ultrasonic transducer shall be capable to measure the flow as the specified pipe material/size and the design temperature adopted in the fountain. The measuring accuracy of the provided ultrasonic transducer shall be within+/-1%.

SUB-SECTION 18.1.2

SAND FILTER

18.1.2.1 GENERAL REQUIREMENTS

18.1.2.1.1 Sand filter shall be air scoured sand pressure type. Each sand filter shall comprise a steel electrically welded shell complete with supported nozzle, balance tank, adequate strength stainless steel nozzle plate and filtering media supports, internal distribution and draw-off trough, flanged inlet and outlet, wash-in, drain and air connections, adequately sized "McNeil" type manholes (minimum 4 nos. for each filter), filter supporting feet, necessary filtering media and sundry accessories. The design and position of manholes shall be convenient for maintenance staff entering the shell to service, replace internal parts and repaint the internal surface wherever necessary. For each horizontal filter, two numbers of 250 mm diameter hand doors complete with shell fixing bolts shall be provided along the longitudinal side just above the nozzle plates. For each vertical filter, two numbers of 250 mm diameter hand doors complete with shell fixing bolts shall be provided on the opposite sides just above the nozzle plates. Sight glasses shall also be provided just above the level of filtering media. Detailed Drawings with design stress calculation of sand filters construction (at least 2 times above design working pressure) including the tank, nozzles, tank supports and sand filter bed & supports shall be submitted to the Supervising Officer for approval. Special attention shall be given to the methods of supports for the nozzle plates. These shall have adequate supports so that no bending of any of the support members will occur.

18.1.2.1.2 The tanks shall be treated as follows: -

(a) Interior Surface

(i) Surface Preparation:-

Blast cleaning shall be carried out in accordance with BS EN ISO 12944-1:2017 to BS EN ISO 12944-4:2017, BS EN ISO 12944-5:2018, BS EN ISO 12944-6:2018, BS EN ISO 12944-7:2017, BS EN ISO 12944-8:2017,BS EN ISO 14713-1:2017, BS EN ISO 14713-2:2009 2020 and BS EN ISO 14713-3:2017. The quality of blast-cleaning shall be to second quality as given in BS 7079:2009 "General introduction to standards for preparation of steel substrates before application of paints and related products".

(ii) Coating System:-

Primer: one coat of heavy duty epoxy paint up to a dry film thickness of 80 microns. It shall be epoxy orange primer or approved.

Undercoat: one coat heavy duty epoxy paint with light yellow finish. It shall have a dry film thickness up to 100 microns, and epoxy white primer (undercoat) or approved.

Finish: two coats of heavy duty epoxy paint with blue finish. It shall have a dry film thickness up to 30 microns per coat and epoxy sky blue or approved.

(b) Exterior Surface (unexposed)

Before placing the filter tank in position on the concrete plinths, the areas that will be in contact with the concrete shall be wire brushed and applied a thick coat of bitumen. For horizontal tank, the tank shall be laid on a pack of bituminous felt such that the interface between concrete and filter tank is adequately protected against corrosion for all times. Any bitumen between remaining on the exposed areas outside the interface shall be cleared off in preparation for the protection described below.

(c) Exterior Surface (exposed)

On completion of filter tank fabrication, wire brush the whole of the external surface thoroughly to remove all scale rust, dirt and grease. The outer surfaces and attachments shall be treated as follow:-

Primer: as for interior;

Undercoat: one coat of good qualities undercoat paint of colour consistent with finishing coat; and

Finish: one coat of good quality heavy duty epoxy green paint or approved.

(d) Painting Precaution

Submit detailed painting methods and procedures recommended by the paint manufacturer. These instructions shall then be followed without deviation unless instructed by the Supervising Officer. These instructions shall be submitted to the Supervising Officer for approval. All paints used shall be of the same brand from the same manufacturer. All shot-blasted surfaces shall be

inspected by site representative of the Supervising Officer immediately after blasting. Primer shall be applied immediately after the inspection.

(e) Tank Assembly

Factory assembled, pressure tested and certified filter tanks to be offered as practical as possible. Unless, in view of the actual difficult site conditions and to the approved of the Supervising Officer, the tanks may be shipped in small plates formed and ready for electrical welding on Site. Finished filter tanks shall be subjected to a pressure test for 6 hours of not less than 2 times the design working pressure or 600 kPa whichever is higher, in the presence of a Registered Professional Engineer (Mechanical) appointed by the contractor responsible for the Works and the Supervising Officer's Representative on Site.

(f) Test Certificates

Test certificates issued by an Appointed Examiner under the Boilers and Pressure Vessels Ordinance, (Cap. 56) and other testing documentation as required by Labour Department and other relevant authorities shall be submitted to the Supervising Officer for each filter tank. Detailed design report of the filter tank regarding its strength shall also be submitted to the Supervising Officer for approval before fabrication which shall be certified by the Appointed Examiner.

18.1.2.2 FILTER BED

Filter bed shall consist of at least two but preferably more layers of filter media, each having a different particle size properly supported by a suitable under drain. Where nozzles are provided as a form of under drain, they shall be completely manufactured from poly-propylene or UPVC screwed into a high quality heavy gauge steel plate and shall not have any metal screws or holding bolts. The steel plate shall have adequate support and shall be strong enough to withstand the weight of the filter bed plus the water pressure differential across the bed when dirty. A margin shall be provided to take the additional pressure in the event that any other filter is temporarily valved off. Manufacturer's fully dimensioned shop drawings together with details of the nozzles and filter media shall be submitted for approval prior to fabrication. 10% spare nozzles shall be provided for each filter tank.

18.1.2.3 FILTERING MEDIA

The filtering media shall consist of even graded quartz sand with at least one layer of 0.4 to 0.8 mm grain and one layer of 0.71 to 1.25 mm grain. The depth of sand shall be sized according to the plant capacity and the manufacturer's recommendation for low to

medium filtering rate. 0.3 mm water free board shall be provided above the sand.

18.1.2.4 WELDING REQUIREMENTS

All welding shall be carried out by metal arc or gas process and shall conform to the requirements to BS 2971:1991, BS 4515-1:2009 and BS 2633:1987. Undercutting and hammering of completed welds are not permitted. Arc welding of carbon and carbon manganese steels shall conform to BS EN 1011-2:2001. The welding process shall be submitted to the Supervising Officer for approval.

All welder employed shall be holder of a valid certificate of competency which has been issued by an approved authority. Copies of these certificates shall be submitted for inspection before any welding is to be proceeded.

Allow 5% of the total welds when selected by the Supervising Officer be examined by X-ray non-destructive test carried out by an independent testing body approved by the Supervising Officer. All test result shall be submitted. In the event of any welds proving unsatisfactory, the weld shall be rectified by approved welding process until a satisfactory test result is obtained. Extra cost for the repair and non-destructive X-ray test shall be included under the Works.

18.1.2.5 OTHER REQUIREMENTS

In case the filter tanks/vessels are manufactured outside Hong Kong, the hydraulic pressure test and X-ray test shall still be required to be carried out on Site after delivery. In addition, test report and certificate shall be submitted which is endorsed by the manufacturer professional engineer that hydraulic pressure test and X-ray test to the same requirements as that on Site have been carried out in the factory before delivery and all test results are satisfactory. All defects on the vessels found on Site after delivery shall be rectified. Where defects are found which in the opinion of the Supervising Officer is substantial, the whole filter vessel shall be removed and replaced at no extra cost.

Service platform and cat ladders shall be designed and provided for all filter tanks. The platforms and cat ladders shall be designed and painted for future maintenance of all instruments and parts of vessels and access to the manholes. The platform and cat ladders shall be made of mild steel, steel chequer plates and accessories of adequate strength to facilitate servicing. Details of these fabrications and shop drawings shall be submitted to the Supervising Officer for approval prior to erection. The platforms and cat ladders shall be painted in accordance to relevant parts of this General Specification.

Internal inspection of each of the filter tanks shall be required towards the expiry of Maintenance Period. Drain down and open up to facilitate this inspection shall be carried out at the expiry of the Maintenance Period at no cost. Any defects found at this stage shall be rectified at no additional cost to the Employer. For the purpose of this inspection it will not be required to remove the filter media unless it is found to be in an unsatisfactory condition.

SUB-SECTION 18.1.3

OZONE GENERATION SYSTEM

18.1.3.1 GENERAL REQUIREMENT AND PRINCIPLE

18.1.3.1.1 Where stated in the Particular Specification, ozone generating system shall be provided as a disinfecting agent for fountain. Ozone generating system comprising of ozonator, mixing equipment, ozone analyser, reaction tank, carbon filter tank/vessel, control panel, and associated piping & wiring for the system shall be supplied and installed.

18.1.3.1.2 Disinfection of the filtered water shall be achieved by inducing ozone gas into an injected water supply to form ozonated water and then into the delivery main of fountain. Ozone is generated by passing an oxygenated gas (commonly air) through a high- energy electric field of corona discharge. It is then introduced into the water circuit of fountain in the plant room and given sufficient time to react with the contaminants. Any residual ozone is removed by means of activated carbon filters following the ozonation process before passing back into the fountain area.

18.1.3.1.3 Ozone generator shall comply with DIN 19627:2018. Ozone concentration in the ozonated air mixture shall be in accordance with the requirement of the Particular Specification. Ozone shall be added constantly to water while the system is in operation, at a concentration according to the Particular Specification. The reaction time of ozone after mixing with water shall exceed 3 minutes.

18.1.3.1.4 Ozone leakage alarm system and devices shall comply with Dangerous Goods Ordinance, (Cap. 384). Ozone detectors shall be located at low level inside the ozone generator room and near the destructor. Local alarm in the plant room and remote alarm shall be provided.

18.1.3.1.5 The ozone leakage alarm system inside the ozone generator room shall be activated if the ozone concentration reaches 0.1 ppm inside the room. Activation of the ozone leakage alarm system shall automatically switch off the ozone generator and switch on the mechanical ventilation system inside the room.

18.1.3.1.6 Manual switches with clear labels and instructions shall be provided outside the ozone generator room for direct on/off control of the ozone generator and mechanical ventilation system inside the room during emergency.

18.1.3.1.7 To minimise the volume of air injected into the water circuit of fountain, use of multiple smaller capacity ozone generators with step control operating at nearly full load for duty disinfection level and the others acting as booster is recommended.

18.1.3.2 OZONATOR

18.1.3.2.1 Unless otherwise specified, ozonator shall be of full vacuum unit. Ozone production and transport shall be effected under vacuum to exclude any risk of ozone escaping from the system such that in the event of breakage of pipe containing ozone, air is sucked in rather than ozone escaping. The ozonator shall comprise the following: -

(a) Two air dryers (one duty one standby) shall be used to remove any contaminants and moisture from the ambient air prior to the ozone generation process. Two dryers shall be operated in such a way that one is operating in drying mode for a preset period of time while the second is in regenerating mode to expel the absorbed moisture with an automatic change-over function. The dryer shall be designed such that regeneration of the dryer can be in operation even when the ozonator is stopped. Air supplied to the air drier will be through an air duct.

(b) Ozone Generator shall consist of electrodes to which a high alternating voltage is applied. For tubular type electrode, the grounding or earthing electrode shall be formed by the cooling media surrounding the dielectric gap of glass/ceramic through which dried air is drawn under vacuum. A proper design for protecting glass tubes from potential damage due to thermal stress induced by the contact with coolant is to be featured. One spare ozone generator module shall be provided.

(c) High Tension Transformers of air cooled, dry type to provide high voltage for the electrodes in order to produce corona discharge across the dielectric gap rendering bi-atomic oxygen molecules O2 to regroup to form tri-atomic ozone molecules O3. The variable ozone production shall be achieved by varying the input to the high tension transformer so as to vary its output. In any case, no harmonic frequency shall be generated from the transformer, which could adversely affect the operation of the generator.

(d) Control panel with control components for automatic air-drying, ozone generation and safety features as depicted in Clause 18.1.3.2.5.

18.1.3.2.2 The ozonator shall have controls to allow automatically adjustment of ozone output in response to the redox signal from ozone sensor placed after the discharge of reaction tank by varying the transformer output voltage. Manual adjustment of ozone output by same principle shall also be facilitated.

18.1.3.2.3 The ozonator shall be of compact construction cabinet with lockable doors at the front, side and/or rear for access to all parts for maintenance. All panels shall be easily removable. Voltmeter, ammeter, indications lamps

and control switches shall be provided on the front panel with polycarbonate windows for continuous observation and monitoring of the operation of the ozone generation units, air dryers and air flow indication. All individual units, such as dryers/absorbers, ozone generators, and transformers shall be separated from one another by safety compartmentation. Moreover, the compartment housing the electrical equipment and air drier shall be separated from compartment housing the ozone generator. The generator shall be suitable for operation up to a room temperature of 40°C and suitable for continuous operation. Materials in contact with ozone shall be resistant to ozone attack.

18.1.3.2.4 The dielectric glass tube housing the electrodes in the ozonator shall be of robust and reliable construction to withstand the temperature and thermal stress during discharge. It shall be of a proven design with little chance of glass tube breakage and/or control failure. The whole ozonator shall be replaced at no extra cost if glass tube breakage occurs for more than two times during the Maintenance Period. During glass tube breakage in any one glass tube module/bank, the ozonator shall be able to allow for individual isolation of the module/bank of glass tubes to allow the generator to continue to function. Not less than 20% of total numbers of new glass tubes per ozone system shall be supplied as spare, which shall be handed over to the Employer 1 month before expiry of Maintenance Period.

18.1.3.2.5 The following minimum controls and safety features are required for the ozonator with visual indications, regardless of whether shown on Drawings or not: -

(a) Ozonator shall shut down completely on the following conditions: -

(i) air drier failure;
(ii) air flow failure;
(iii) cooling water (if applicable) failure and/or high water temperature;
(iv) excess air pressure or loss of vacuum in the air and ozone lines;
(v) excess or low current;
(vi) low water flow in main water stream/stopping of main water circulation pumps;
(vii) glass tube breakage (on one unit);
(viii) activation of the external cut-off device of the generator; and
(ix) other abnormal conditions that may lead to abnormal function of the ozonator.

(b) Interlock shall be provided such that ozonator can only be energised after the main circulation pumps are energised.

(c) Interlock with the cabinet door shall be provided to shut down power supply to the high tension transformer in case the cabinet door is opened.

18.1.3.2.6 A cooling circuit shall be included to cool down the ozone generator for water- cooling unit. The cooling water shall come from the main flow and return to the pump header. Allow for the supply of cooling water pumps as recommended by manufacturer. Additional chiller units for cooling as recommended by the manufacturer to maintain the temperature within acceptable limit shall be allowed. Make allowance for any decrease of generator capacity due to high cooling water temperature from fountain in hot summer weather and increase the plant capacity accordingly.

18.1.3.2.7 In addition to the local control panel provided on the ozonator, the signals of the ozonator shall be wired to the supervisory control panel in the control room wherever so specified to indicate the following:-

(a) Fault indication lamps for each ozone generator which shall light up with buzzer alarm when there is any fault/tripping/stopping of the ozone generator (buzzer alarm can be muted); and

(b) Start/stop switches for each ozone generator with visual indication.

18.1.3.2.8 A warning lamp with buzzer shall also be provided on the supervisory control panel wherever so specified to warn operators to shut down or to reduce ozone output of the ozone generator in case the ozone sensor located at pool supply pipe detects ozone after deodorisation.

18.1.3.2.9 The system control shall be incorporated with an earth leakage detector, which shall provide fail-safe protection for system operators working on the equipment.

18.1.3.3 MIXING EQUIPMENT

After the ozone is produced in the ozone generator, it shall be mixed with the water flow through an injector stream which shall then mix with the main flow. The mixing equipment shall consist of a mixer, a sight glass in the mixing chamber, an ozone eductor, booster pumps, manometers, piping, valves and accessories to help mixing and dissolving ozone into the water stream. The mixer shall be of material resistant to ozone attack such as reinforced UPVC, PTFE, or stainless steel Grade 316 (low carbon) as specified in the Particular Specification. The sight glass shall be able to withstand the test pressure of the system.

The eductor shall comprise of a nozzle followed by a venturi. A proportion of the water to be treated shall be drawn off by a suitable booster pump and fed under pressure and a high velocity to the nozzle. The emerging jet of water shall cause a vacuum which in

turn draw air through the ozone generator where it is entrained in the venturi together with the water jet. The quantity of ozone gas to be mixed with water by suction can be regulated by means of the flow regulating and shut off valve in the gas line at the eductor. There shall be 2 non-return valves on both side of the shut-off valve and other safety protections to prevent water from entering the gas line. Pressure gauge shall be fitted upstream and downstream of the eductor.

18.1.3.4 ORP ANALYSER

An ORP analyser including a sensor shall be provided to measure the ozone concentration in the water and control the ozone generation of the ozonator. The reading shall be shown on a liquid crystal display. Extra output shall be provided to transmit the ozone concentration and water temperature signals to the supervisory panel wherever so specified.

18.1.3.5 REACTION TANK

18.1.3.5.1 The reaction tank shall be made of electrically welded mild steel of sufficient thickness to withstand the system pressure.

18.1.3.5.2 The reaction tank shall be designed to allow ozonated water to stay in the vessel for at least 2 minutes with careful planning of the inlet and outlet piping position. It shall be made of materials suitable for contact with ozonated water and shall be resistant to electrolytic corrosion and chemical attack. Some acceptable materials are: -

(a) Electrically welded mild steel with proper coating, the coating manufacturer's recommendation on pre-treatment procedures shall be strictly followed; or

(b) Stainless steel Grade 316 (low carbon)

18.1.3.5.3 The surface of tank shall be required to undergo the same pressure test and test standard on electrical welding for steel tank as the pressure sand filter tank.

18.1.3.5.4 Test certificates issued by an Appointed Examiner under the Boilers and Pressure Vessels Ordinance, (Cap. 56) shall be submitted to the Supervising Officer for approval. All other tests and certificates as required by Labour Department and other relevant authorities shall as well be done and provided.

18.1.3.5.5 Reaction tank shall comply with requirements of sand filter tanks where relevant except with no nozzle plate and sand. The reaction tank shall be complete with all necessary accessories such as stainless steel automatic air vent connected to ozone destroyer, drain, valves, flow meter at inlet and outlet pipe, maintenance platform, supports, etc.

18.1.3.6 CARBON FILTER TANK

The carbon filter tank (deozonising filter) shall have pellet activated carbon for complete removal of all ozone in water. It shall be made of approved material resistant to the attack of ozonated water same as reaction tank. It shall comprise an electrically welded shell with adequate strength nozzle plate on which carbon are placed, internal distribution, filtering media supports, flange inlet and outlet, drain, air connection and manholes for maintenance. The internal and external surface shall be treated with the same standard as the reaction tank. Distribution inlet and outlet pipes which cross the whole length of filter shall be UPVC pipes with holes.

The pellet activated carbon filter shall be able to completely remove ozone in water including the carbon depth, carbon media and filtration rate. Dimensions shown on the drawings are minimum requirements only.

The volume of carbon shall be adequate to ensure the ozone removal time within 1.5 minutes.

The pellet activated carbon shall have diameter 3 – 4 mm with 4 – 8 mm mesh, hardness greater than or equal to 95%, moisture content less than or equal to 5%, iodine number greater than or equal to 950 mg/g, carbon tetrachloride activity (CTC) 45 - 55, specific surface area 800 - 850 m^2/g, ash content less than or equal to 15%, bulk density 450 – 550 g/litre, and pH value 7 - 9.

The carbon filter tank shall be required to undergo the same pressure test and test standard on electrical welding for steel tank as the pressure sand filter tank. Test certificates issued by an Appointed Examiner under the Boilers and Pressure Vessels Ordinance, (Cap. 56) shall be submitted to the Supervising Officer for approval. All other tests and certificates as required by Labour Department and other relevant authorities shall as well be done and provided.

The carbon filter tank shall also comply with all other requirements of sand filter tanks where relevant. The carbon filter tank shall be complete with all necessary accessories such as stainless steel automatic air vent connected to ozone destroyer, drain, valves, pressure gauges, flow meter at inlet and outlet pipe, strainer, sight glass at filter media level, maintenance platform, supports and so on similar to sand filter tank.

18.1.3.7 RESIDUAL OZONE AND EXHAUST GAS TREATMENT

The air and undissolved ozone escaping from the vents and air release valves of the reaction tanks and deozonising carbon filter tanks shall pass through the ozone destroyer (residual ozone catalytic/chemical converter) to remove the ozone in the air and the condensate shall drain down via a water trap. The ozone destroyer shall contain activated carbon filling, thermal or a heated catalytic destructor. It shall be of sufficient capacity of maintaining 8 to 12 months operation at design flow without replacement. The actual duration will be specified in the Particular Specification. More than one ozone destroyer for each group/bank in the system (for periodic switch over after 2 to 3 months or similar) may be needed to install in addition to those shown on the Drawings to meet the 8 to 12

months operational criteria. Submit detailed calculation to the Supervising Officer for approval to prove this before ordering. In addition, 1 ozone destroyer in each group/bank shall be supplied and installed as standby which shall be used to maintain system operation if any one ozone destroyer in the bank has to be refilled/regenerated for any reason.

The exhaust vent pipe after ozone destroyer shall be led to an open position for exhaust. Locations as shown on the Drawings are schematic only. Co-ordinate with other relevant parties on exact location of exhaust and allow for any change on Site to meet the exhaust criteria.

The vents of the reaction tanks and the deozonising carbon filter tanks shall also have a bypass to a separate ozone destroyer; the destroyer shall be provided & installed. This bypass will normally be closed and shall assist the air bleed off on system start-up as required.

SUB-SECTION 18.1.4

SODIUM HYPOCHLORITE GENERATION SYSTEM

18.1.4.1 GENERAL REQUIREMENT AND PRINCIPLE

Where stated in the Particular Specification, sodium hypochlorite generation system shall be provided as a disinfecting agent for fountain. The sodium hypochlorite generator, rectifier/transformer, chemical metering pump, brine storage tank, hypochlorite storage tank, automatic pH & chlorine controller, control panel and all necessary piping & wiring for the system shall be supplied and installed.

The electrolytic hypochlorite generation shall work on the basis of partial electrolysis of sodium chloride contained in the brine solution flowing through the generating cells with D.C. current energising at the anodes and cathodes of the cells. Successive chemical reactions will take place in the brine solution between the products of the electrolysis.

In such chemical process, the brine solution shall be totally dissociated into Sodium and Chloride ions. Free chlorine shall be generated at the anode while hydrogen shall be evolved at the cathode with the corresponding formation of hydroxide ion. The migrated hydroxide ion from cathode shall be reacted with Sodium and Chloride ions near the anode to produce Sodium Hypochlorite solution.

The electro-hypochlorite generator shall be mounted on a separate pedestal assembly consisting of water flow meters with low-flow set point, brine flow meter with low-flow set point, water pressure regulating valve, cell electrolyte level switch, cell temperature switch, valve connections for acid cleaning and draining of cell, back pressure valve for brine inlet and epoxy-coated steel structural frame with points for securing to floor.

18.1.4.2 ELECTROLYTIC CELL

The cell body shall be constructed of non-corrosive and electrically non-conductive moulded polypropylene with integral inlet and outlet flanges. A transparent cell cover shall be provided to allow easy inspection of cell internals. Dimensionally stable anodes (DSA) such as anode of titanium substrate with ruthenium oxide coating, and corrosion resistant cathode shall be provided to minimise power consumption.

The cell is designated for one flow direction and high velocity flow to minimise hardness deposit.

Means shall be provided to prevent the cell from operating on low solution flow by having a flow switch at the outlets of the electrolytic cell. Flow switch shall be suitable for operation in the solution. Flow switch made of stainless steel is not acceptable as it may suffer from pitting by the sodium hypochlorite solution generated.

The cell shall be of plate type. Tube type is not acceptable as it requires high velocity of the flow switch which leads to erosion of the cell body easily. Transparent acrylic cell

cover shall be used for visual inspection of the cell internals and also to check the effectiveness of the acid cleaning operation. Non transparent cell cover or casing shall not be acceptable.

18.1.4.3 RECTIFIER/TRANSFORMER

Power for the electrolysis of brine shall be provided by a solid-state controlled forced-air-cooled transformers/water-cooled rectifier.

The transformer/rectifier shall be of heavy duty industrial type suitable for input voltage of 380 V, 3-phase and 50 Hz.

The rectifier shall include self-monitoring with alarm contact output for cell voltage, thermal overload and internal faults.

The rectifier shall allow infinite adjustment of the hypochlorite production rate from zero to 100% of the rated capacity.

The transformer/rectifier shall be housed in a control cubicle c/w control components, measuring instruments, indicating lamps, etc.

Devices for high temperature and over current protection shall be incorporated for automatic shut down of the electrolytic chlorinator.

18.1.4.4 BRINE INJECTION PUMP

The brine injection pump shall be of bellows-type with adjustable stroke/diaphragm type with variable output.

The discharge volume shall be preset at the factory for normal operation but can be adjusted to fit different site operational conditions.

18.1.4.5 BRINE STORAGE TANK

The brine storage tank shall be constructed from reinforced concrete, reinforced fibreglass or high density polyethylene or equivalent materials.

The size of the tank shall be based on the numbers of working days, operating hours, circulation flow rate and chemical dosing concentration.

The tank shall be complete with outlets, valves, overflows to drain and accessories. Level indication such as level glass tube shall be provided.

18.1.4.6 METERING PUMP FOR HYPOCHLORITE & BRINE FEED

The hypochlorite metering pump shall be of the positive displacement type with a mechanically actuated diaphragm.

The pump shall be constructed with plastic and complete with clear plastic moulded cartridge-type check valves to facilitate service and provide integral sight flow indication. (Conventional threaded valves and external sight flow indicators are not acceptable.)

The pumping diaphragm shall be fabric-reinforced elastomer with an imbedded steel backing plate to ensure accurate repeatability for each stroke.

The output capacity for the chemical pump shall be manually infinitely controlled from 0-100% via a built in control knob.

The pump shall be complete with suction hose and accessories.

18.1.4.7 WATER SOFTENER

Water softener shall be an ion exchange resin that removes calcium and magnesium from the source water to reduce the deposits on the cathodes.

The softened water shall be used for dissolving salt in the brine tank, cooling the rectifiers and diluting the concentrated brine solution.

An automatic three-way control valve shall be provided for regeneration of the resin with the salt solution from brine storage tank.

A time delay flow switch in the outlet line from the water softener shall be installed to shut down the unit if the required flow is not present for a 5-second period.

18.1.4.8 HYPOCHLORITE STORAGE TANK

The hypochlorite storage tank shall be constructed from reinforced concrete, reinforced fibreglass or high density polyethylene or equivalent materials.

The tank shall be designed for ambient temperature and atmospheric pressure and suitable for indoor/outdoor installations.

The size of the tank shall be based on the numbers of working days, operating hours, circulation flow rate and chemical dosing concentration.

The tank shall be complete with outlets, valves, overflows to drain and accessories. Level indication such as level glass tube shall be provided.

The flanged connections for the inlet and outlet from the air dilution blower shall be provided.

Safe level control for start-stop operation of electro-hypochlorite generator, overflow alarm, low storage level alarm, stop operation of metering pump induced by low storage level alarm and disable metering pump signal shall be provided.

18.1.4.9 HYDROGEN BLOWER

The hydrogen blower shall be installed to force-ventilate the solution tank, reducing the concentration of hydrogen gas in the tank and interlock with electro-chlorinator.

A standby blower shall be installed to automatically start if the primary blower fails. Both blowers shall be connected with a 'Y' piece to a common entry into the storage tank.

The blower shall be air-cooled explosion-proof type and the motor shall be of requisite size running at 1450 r.p.m. of the drip proof squirrel type totally enclosed.

Supply and fit range of PVC piping shall be complete with all necessary fittings between the air blower, filters and sodium hypochlorite tank, non-return valves and air inlet filters.

Automatic control shall be incorporated to shut the electro-chlorinator in the event of the failure of both blowers.

The blower shall at least remain operation for 15 minutes when the electro-chlorinator system is shut down.

The power supply cabling shall be of explosion-proof type.

18.1.4.10 HYDROGEN GAS DETECTION SYSTEM & AIR VENT

Hydrogen gas detection system shall be provided in sodium hypochlorite tank room. The required performance of the hydrogen gas detector shall be as follows: -

Measurement Range	:	0-100% of lower explosion limit of hydrogen (i.e. 4%) with initial alarm set to be 0.05% of hydrogen in air.
Life Expectancy	:	5 years
Operating Temperature	:	-5°C to +40°C (±10%)
Humidity	:	0-99% RH

The air vent for the hydrogen gas shall be installed with the air flow sensor which would provide actuation for the standby blower via a control panel in case of the failure of the primary blower.

The automatic air vent shall incorporate with no built-in valve and the discharge pipe shall be run to the nearest agreed terminal with mesh outlet in accordance with the Supervising Officer's instruction.

The system completion shall be incorporated with explosive-proof type extraction fan and its accessories in accordance with FSD statutory requirement.

18.1.4.11 CHEMICAL CLEANING SYSTEM

An acid cleaning system shall be complete with recirculation pumps, fibreglass or PE chemical storage tank and other accessories to clean the electrolytic cell in a convenient manner.

All pipework connected shall be constructed of materials suitable for chemical resistance.

18.1.4.12 AUTOMATIC PH & CHLORINE CONTROLLER

The automatic chlorine and pH controller shall be installed to monitor and control the concentration of free chlorine and pH level within the specified range stated in the Particular Specification.

The automatic chlorine and pH controller shall be either installed at the return water pipe from the fountain or be complete with the pH and ORP sensors at numerous sampling water return points at regular intervals around fountain for the measurement purpose.

Standby pump with auto changeover shall be incorporated to ensure system reliability.

Alarm shall be provided upon failure of pump.

18.1.4.13 OTHER ACCESSORIES

The alarm sensors of the electrolytic assembly shall be complete with high & low temperature alarm, low electrolytic level, low dilution water flow and low brine flow.

PVC Y-type strainer shall be installed at the inlet of the electro-hypochlorite generator to filter any incoming water with particle size of 1 mm or more.

A pressure gauge and flow indicator shall be installed to show the electrolytic assembly system pressure and flow rate.

Ammeter and voltmeter shall be provided to display the electrolytic assembly current and voltage.

PVC pressure relief valve shall be installed to protect the electrolytic assembly from over-pressure.

Motorised/solenoid valves shall be installed at the inlet of the electro-hypochlorite generator to stop the incoming water flow through the cell when the system is switched off.

Sample valves shall be provided at the electro-hypochlorite generator outlet to facilitate the measurement of chloride concentration.

A local control panel shall be provided to provide on, off & modulating control, change-over control, and functions monitoring & status indication of the system components and to generate alarm signals.

18.1.4.14 TESTING & COMMISSIONING

18.1.4.14.1 This procedure is intended to lay down the general testing and commissioning requirements to be carried out r for the chemical dosing system prior to handing over.

18.1.4.14.2 Apart from the recommended procedures as suggested from the product manufacturers and the Testing & Commissioning Procedures as published by ArchSD, the following additional inspection, testing and commissioning requirements shall be satisfied.

18.1.4.14.3 General

(a) check if the emergency stop button is released;
(b) check if sodium hypochlorite line is connected to the Hypochlorite Tank;
(c) check if fresh water supply is connected to the system;
(d) check if all the alarms are reset;
(e) check and allow the system to run for 15 minutes;
(f) check if the D.C. voltage is below the rated value at full load; and
(g) check if the status of the pressure regulators and gauges in controlling the water supply to the dosing system is in proper condition.

18.1.4.14.4 Electrolytic Cell

(a) check for any damage or cracks on the cell box and clear acrylic cover;
(b) check whether the gasket of cell cover is in proper and secure position and any compression for the gasket under the faceplate;
(c) check whether the cell box bolts are tightened;
(d) check for any deposits and sludge accumulation in the cell; and
(e) check if the water flow meter readings are unchanged from the pre-set value.

18.1.4.14.5 Transformer/Rectifier

(a) check for any damage on the cabinet panels and meter faces;
(b) check if all the wirings are in proper connections;
(c) check if rectifier control panel is turned to "On" position;
(d) check the auto start of rectifier when the desired brine concentration has been achieved at the hypochlorite delivery point; and
(e) check the shutdown operator of rectifier upon the indication of high cell temperature or low water level.

18.1.4.14.6 Brine Injection Pump

check the injection pump to ensure it is rotating;
check if brine pump stops when level in Brine Tank reaches LOW LEVEL;
regulate the concentrated brine flowrate via the pump dial; and
check if the brine concentration has been achieved at the hypochlorite delivery point.

18.1.4.14.7 Brine Storage Tank

(a) check any impact damage for the tank and tank lid;
(b) check if the brine level assembly are in place and undamaged; and
(c) check if the mixing condition in the Brine Storage Tank is satisfactory.

18.1.4.14.8 Metering Pump for Hypochlorite & Brine Feed

(a) check if hypochlorite pump starts when the level in hypochlorite tank reaches its pre-determined operating level; and
(b) check if hypochlorite pump stops when the level in hypochlorite tank falls below its pre-determined cut-off level.

18.1.4.14.9 Water Softener

(a) check the shutdown operation of the water softener when the required flow is not present for the pre-set period of the time delay flow switch; and
(b) check the time based operation of the auto control valve in regenerating softener into the unit.

18.1.4.14.10 Hypochlorite Storage Tank

(a) check the operation of the high/low liquid level for the Hypochlorite Storage Tank;
(b) check any impact damage for the tank and tank lid; and
(c) check if the brine level assembly are in place and undamaged.

18.1.4.14.11 Hydrogen Blower

(a) check and start the air blower; and
(b) check if hydrogen gas air vent connection to the atmosphere is proper.

18.1.4.14.12 Chemical Cleaning System

(a) check whether the cell is overfilled with acid cleaning solution;
(b) check if the acid level is just covering the top of the electrodes; and
(c) check the shutdown operation of the acid pump when the liquid level in the cell is low.

18.1.4.14.13 Automatic pH & Chlorine Controller

(a) ensure the proper calibration of the pH and free chlorine sensors; and
(b) check pump start/stop operation when the pH level and free chlorine concentration fall within the pre-determined cut-in and cut-off levels.

SUB-SECTION 18.1.5

MIXED OXIDANT DISINFECTION SYSTEM

18.1.5.1 GENERAL REQUIREMENT AND PRINCIPLE

Where stated in the Particular Specification, mixed oxidant disinfection system shall be provided for fountain. The principle of mixed oxidant disinfection takes the advantage of various oxidant species to overcome the shortcoming of a single oxidant.

The mixed oxidant shall be generated by electrolysis of NaCl and the solution shall be safe and contain chloro-oxygen species with disinfection efficiency in term of CT values less than 120. (CT value is the function of disinfection concentration x time, the lesser the better.)

The mixed oxidant generator shall have proven history of satisfactory application in fountain. The tenderer shall submit the job reference of the manufacturer for assessment with the tender.

18.1.5.2 GENERATION SYSTEM

The mixed oxidant generation system shall include electrolytic cell capable of providing streams of mixed oxidant and control panel with automated control system and diagnostic system for fault indication.

The mixed oxidant generator shall also include twin tower (one duty one stand by with auto change-over) softener, brine generator tank suitable of receiving salt and providing brine solution, pressure switch, solenoid valve, pressure regulator, oxidant tank and associated piping & wiring.

18.1.5.3 ELECTROLYTIC CELL

Mixed oxidant solution shall be generated by passing brine solution through an electrolytic cell. Flow control to cell shall be provided by solenoid valve.

The electrolytic cell shall be fully enclosed and constructed of plates composed of a suitable conductive metal with a catalytic coating contained within a plastic housing. The cell shall contain no membrane.

Brine shall be pumped to the electrolytic cell using a variable speed positive displacement gear pump. The material of construction for brine pump components in contact with brine shall be corrosion resistance. Mixed oxidant solution will be drawn from both anode and cathode side of the cell.

Prior to entry into the electrolytic cell, the saturated brine shall be diluted to the proper concentration for oxidant generation.

The mixed oxidants generated shall be stored in a holding tank and fed into the main water line by a venturi injection system or by metering pump system.

18.1.5.4 MIXED OXIDANT SOLUTION

The mixed oxidant solution generated shall include various chloro-oxygen oxidant species (e.g. hypochlorous acid is one of the various constituent) with disinfection function CT value less than 120 or equivalent proven disinfection capability.

The mixed oxidant solution shall be safe and not classified as dangerous good under FSD regulations. Material safety data sheet shall be provided for approval.

18.1.5.5 CONTROLS

18.1.5.5.1 General

The system control for the mixed oxidant generator shall automatically monitor system functions by means of a discrete logic controller and provide fault indications and electrical contacts for alarm system operation. A local control panel shall provide on, off & modulating control, change-over control, functions monitoring & status displays of the system components and generate alarm signals & displays. The control panel shall also have a display which monitor cell performance and indicate system operation and faults.

Amperage drawn by the cell shall be monitored by the discrete logic controller. In the event the amperage drawn by the cell falls outside acceptable operating limits, the logic controller shall cause the amperage drawn to return to within these limits.

Control voltage to operate the system will be provided by a transformer generating 24 V D.C. current.

Monitoring signal point and control points shall be provided to allow remote indication of fault condition and remote start/stop.

18.1.5.5.2 Diagnostics

Where specified in the Particular Specification, when an alarm condition has been activated, or a fault has been detected in the system, a diagnostics routine shall be executed from the control to determine the conditions of each of the inputs to the system.

18.1.5.5.3 Datalogging

Where specified in the Particular Specification, the logic controller shall include an on-board datalogging capability which supports 9600 band steaming serial data. The datalogging captures key operating parameters shall include cell amperage, brine pump signal voltage, cell voltage, and other operational parameters including a date and time stamp. The purpose of this datalogging is to capture long-term operational data that can be useful in diagnosing long-term trends in system operation.

18.1.5.5.4 Serial Data Port

Where specified in the Particular Specification, the controller shall have a serial data port that can transmit any data shown on the display as well as all fault indications and data not shown on the display.

18.1.5.6 BRINE TANK

The capacity of brine tank shall be capable for 2 weeks operation. The tank shall be equipped with float valve for high and low level control. The material of brine tank shall be reinforced concrete or high density polyethylene material. Overflow port shall be located at the top of the tank.

18.1.5.7 MIXED OXIDANT SOLUTION TANK

The mixed oxidant storage tank shall have the capacity of providing at least 4-hour consumption unless otherwise specified.

The material of mixed oxidant solution tank shall be reinforced concrete or high density polyethylene material. The tank shall be equipped with liquid level switch for high and low level control.

Supply for mixed oxidant to the tank shall enter at the top and be fed through a drop tube to the bottom. Supply tube inlet shall include a vent at the entrance to the tank for venting. UPVC piping shall be attached to the top of the tube for venting to the atmosphere outside the building. A solution level indication tube and tank drain shall be provided.

18.1.5.8 SOFTENER

The softener shall be of automatic twin tower and self-backwash operation type. It shall provide continuous soft water and instantaneous switching of tanks. Check valve shall be provided to prevent backflow of water from the softener to the brine tank.

The water source shall be city mains water. Other sources including fountain circulating water shall not be used as water source. The feed water temperature shall be maintained between 10°C and 38°C.

18.1.5.9 HYDROGEN BLOWER

The hydrogen blower shall be installed to ventilate the solution tank, reducing the concentration of hydrogen gas in the tank and interlock with mixed oxidant generator.

A standby blower shall be installed in parallel to the duty blower, which shall be connected with a 'Y' piece to a common entry into the storage tank. Control valves to enable the choice of air transfer from either one of the blowers shall be facilitated.

The blower shall be of air-cooled explosive-proof type and the motor shall be of requisite size running at 1450 r.p.m. of the drip proof squirrel type totally enclosed.

Supply and fit range of PVC piping shall be complete with all necessary fittings between the air blower, filters and mixed oxidant tank, non-return valves and air inlet filters.

Automatic control shall be incorporated to shut the generator in the event of the failure of both blowers.

The blower shall at least remain operation for 15 minutes when the generator system is shut down.

The power supply cabling shall be of explosion-proof type.

Hydrogen gas detection system shall be provided in mixed oxidant generation room. The required performance of the hydrogen gas detector shall be as follows:-

Measurement Range	:	0-100% of lower explosion limit of hydrogen (i.e. 4%) with initial alarm set to be 0.05% of hydrogen in air.
Life Expectancy	:	5 years
Operating Temperature	:	-5°C to +40°C (±10%)
Humidity	:	0-99% RH

The air vent for the hydrogen gas shall be installed with the air flow sensor which would provide actuation for the standby blower via the control panel in case of the failure of the primary blower.

The automatic air vent shall incorporate with no built-in valve and the discharge pipe shall be run to the nearest agreed terminal with mesh outlet in accordance with the Supervising Officer’s instruction.

The system completion shall be incorporated with explosive-proof type extraction fan and its accessories in accordance with FSD statutory requirement.

18.1.5.10 OTHER REQUIREMENTS

The salt used for generating mixed oxidant solution shall be sodium chloride 99.5% pure coarse granular salt without additives or preservatives. Concentrations of calcium (Ca) shall be less than or equal to 0.03%, magnesium (Mg) be less than or equal to 0.02%, and manganese (Mn) be less than or equal to 0.005%.

The system control cabinet shall be incorporated with an earth leakage detector, which shall provide fail-safe protection for system operators working on the equipment.

SUB-SECTION 18.1.6

ULTRA-VIOLET DISINFECTION SYSTEM

18.1.6.1 GENERAL REQUIREMENT AND PRINCIPLE

Where stated in the Particular Specification, in-line type Ultraviolet Disinfection System (hereafter called "UV system") shall be supplied and installed for use in disinfection and deozonisation of fountain.

Ultra-violet (UV) is located in that part of the electromagnetic spectrum which extends beyond violet light, UV is invisible and kills micro-organism by destroying their DNA. In the wavelength region between 240 nm to 280 nm, UV is effective against bacteria, viruses, moulds and their spores. When water circuit of fountain is treated by an UV system capable of producing UV, the risk of transmission of stomach, skin and respiratory tract infections to fountain users can be reduced. UV can also initiate photo-chemical and photo-oxidation reactions which destroys chloramines, a range of compounds responsible for unpleasant smells in fountain.

The UV system shall be capable of performing the above-mentioned requirements to suit the design water turnover rate. UV wavelength shall cover spectrum 220 nm to 400 nm.

The UV system shall have proven history of satisfactory application in fountain.

18.1.6.2 UV CHAMBER

18.1.6.2.1 The UV system shall consist of a UV disinfection chamber (hereafter called "UV chamber"); the chamber shall be a self-contained unit including the following: -

(a) system control cabinet;

(b) flow and output safety control;

(c) an UV medium pressure arc tube capable of producing UV energy in wavelength from 220 nm to 400 nm;

(d) a quartz sleeve mounted axially to house the UV arc tube which permits replacement without interrupting the flow inside the UV chamber;

(e) an automatic, adjustable, electric motor driven quartz sleeve cleaning system; and

(f) an UV dose control system for controlling the quantity of UV delivered to the fountain.

18.1.6.2.2 The UV chamber shall be capable to operate continuously under a pressure rating at 10 bar. The UV chamber shall be hydraulically factory tested at 15 bar prior to delivery.

18.1.6.2.3 Unless otherwise stated, all materials exposed to UV light and in contact with water shall be stainless steel grade 316. The wetted surfaces shall be chemically inactive with all welds grounded to minimise corrosion.

18.1.6.2.4 Unless otherwise stated, the UV chamber shall be incorporated with the following features: -

(a) A temperature sensor shall be provided to turn off the UV arc tube automatically when there is inadequate water flow across the UV chamber.

(b) An UV intensity monitor shall be provided for monitoring the UV dosing level. The UV intensity monitor shall display real time UV lamp intensity on the system control cabinet in unit mW/cm^2, and initiate an alarm when the preset UV dosing level for proper operation cannot be achieved.

(c) The UV intensity monitor shall be wet probe type, wavelength specific to 240 nm - 280 nm and allow monitor probe to be cleaned by automatic wiper mechanism. Relative type UV intensity monitoring device or dry-probe type will not be accepted. The UV intensity monitor shall have been pre-calibrated against a traceable UV standard.

(d) UV chamber end plate where electrical cables accommodate shall be protected by a stainless steel cover. (Plastic cover or cap will not be accepted.)

(e) Water flow inside the UV chamber shall be laminar in order to provide maximum efficiency in the transfer of UV to the water. (Baffle plates or similar devices which create turbulent flow and dead spots inside the UV chamber will not be accepted.)

18.1.6.2.5 The connection of the inlet and outlet shall be flange type to PN 16 to BS EN 1092-1:2018, BS EN 1092-2:1997 or BS EN 1515-1:2000.

18.1.6.3 AUTOMATIC CLEANING SYSTEM

The quartz sleeve and the UV sensor probe for the UV chamber shall be cleaned periodically by an automatic cleaning system. The arrangement, operation principle and all the necessary technical details for the automatic cleaning system shall be submitted for approval by the Supervising Officer.

The automatic cleaning system shall travel the full length of the quartz sleeve twice per cleaning cycle.

The cleaning frequency shall be variable and nearly infinitely adjustable from 15 to 480 minutes to suit actual operational requirements.

The automatic wiper in its "parked" position shall not cover any portion of the arc tube that affects the efficiency of the UV lamp or create a "hot" spot on the arc tube.

18.1.6.4 ULTRA-VIOLET LAMP

The UV lamp shall be of medium-pressure high intensity type capable of emitting a continuous UV spectrum from 220 nm to 400 nm into the water.

Each lamp shall be capable of producing an UV spectral output at 245 nm, 297 nm and both 260 nm and 336 nm for destroying monochloramine, dichloramine and trichloramine respectively. A manufacturer's spectral certificate to demonstrate the accuracy shall be submitted to the Supervising Officer for approval prior to delivery. Each lamp shall be individually identified by part number and serial number.

The power per unit length of the UV lamp shall be limited to minimising risk of quartz sleeve shattering due to solarisation.

Warranty for the performance of the UV lamps shall be provided. The rated life of the UV lamp shall be a minimum of 4,000 hours, including the case when intermittent on/off occurs within the same day.

18.1.6.5 CONTROL AND MONITORING PROVISION

18.1.6.5.1 A system control panel shall be provided to provide on, off & modulating control, change-over control, and functions monitoring & status displays of the system components and to generate alarm signals & displays.

18.1.6.5.2 The system control panel shall be manufactured from stainless steel grade 316 and installed with cooling fan, louvre and replaceable filter for ventilation purpose.

18.1.6.5.3 The system control panel shall be protected to IP 55. Provision shall be made to ensure that power supplies to the control circuitry will cut off automatically when the panel door is being opened.

18.1.6.5.4 All internal wirings inside the system control panel shall be properly harnessed and the UV arc tube shall be powered via a constant wattage transformer.

18.1.6.5.5 The system control panel shall be provided with a microprocessor driven control module offering: -

(a) data logging of UV dosed, UV lamp operating hour, UV lamp intensity up to 12 months;

(b) a menu-driven interface;

(c) Local/Remote operation;

(d) digital display screen with real time display of performance parameters which shall include, but not be limited to the followings: -

- power on;
- UV intensity in either % or mW/cm^2;
- UV dose in mJ/cm^2;
- fluid flow rate inside the UV chamber in m^3/hr;
- UV arc tube ready; and
- automatic wiper system status and alarm;

(e) membrane key pad for system configuration; and

(f) capability of downloading with RS232 interface.

18.1.6.5.6 The system control panel shall be incorporated with an earth leakage detector, which shall provide fail-safe protection for system operators working on the equipment.

SUB-SECTION 18.1.7

CONTROL SYSTEM

18.1.7.1 GENERAL

18.1.7.1.1 Scope of Work

The scope of work shall include, but not be limited to the design, supply, delivery, Installations, testing & commissioning and maintenance during the Maintenance Period of the control system including all the associated hardware, software, accessories, instrumentation and all the ancillary equipment & devices as specified in the Particular Specification and Drawings and as necessary for the satisfactory operation and maintenance of the water circulation, filtration and disinfection plants and systems.

The interconnecting wirings among various control panels, equipment, pumps, valves, meters, and devices installed under this Contract shall be supplied, installed and terminated. Manual override to automatic control shall be provided on local control panels of all equipment and pumps, unless such is not desirable for reason of safe operation.

The control points under the control system shall include but not be limited to the points indicated in the Control Point Schedule in the Appendix to this Sub-section. Any additional points that are needed to provide the desired functions as specified, and include these points in the Installations shall be advised to the Supervising Officer.

18.1.7.1.2 Functions

The control system shall serve to enable the entire water circulation, filtration and disinfection installations to function as specified in the Particular Specification, Drawings, and this General Specification unless otherwise indicated. The functions of each equipment, pump, valve, meter and device of the Installations shall include its start, stop, modulating operation wherever appropriate, and indications of start, stop and fault. The functions shall also include the sequenced start, stop and modulating operation of each equipment, pump, valve, meter and device whenever such sequence is required for the proper operation of the entire Installations; and the sequence shall, other than for a single equipment, pump, valve, meter, and device, include the operation of all other equipment, pumps, valves, meters, devices affected by the operation of the said equipment, pump, valve, meter and device.

The exact numbers of I/O points for the control system to provide the operation & maintenance functions of the entire fountain installation shall be designed and determined. The functions will be indicated in the Particular Specification or shown on Drawings.

Control facilities shall be provided to maintain the required surface water levels through control of valves and pumps.

20% additional I/O points and wiring to facilitate the I/O in the control system for future extension shall be allowed.

18.1.7.1.3 Operation Voltage

The control system shall be operated on single-phase mains voltage or on extra low voltage such as 12 V or 24 V. Where a particular manufacturer's system is offered and accepted, the Installations shall be installed to comply with that manufacturer's recommended technical details and methods of Installations.

18.1.7.1.4 Sensors and Controllers

(a) The sensors shall be placed in transparent chambers, one chamber for each sensor, at various locations as shown on the Drawings and the flow rate shall be adjusted to meet with manufacturer's recommendation. For chamber installed on the return water pipe and sampling lines, y-type strainer shall be provided. The sensors shall detect and sense the return water of the fountain in the sampling lines, in return water, after mixing chambers, after reaction tanks and before discharge to fountain. Allow for all necessary equipment, piping and accessories to provide the control and indication functions including running of pipes and/or wiring to the sensors.

(b) All indication on controller shall be of LED type. Dial reading gauge is not acceptable. Measurement of chlorine and ozone level shall be made by redox potential philosophy or chemical means. Sensors shall be able to measure the chemical concentration as ppm. Running life of all sensors shall be of at least 1 year with no maintenance.

(c) Indicator meters for fountain water quality shall be suitable for analogue input.

(d) The pH sensors and controllers shall be set at settings specified in this specification, with measurable range adjustable from 2-12. The residual free chlorine sensors and controllers shall be set at settings specified in this specification, with measurable range adjustable from 0.0-10.0 ppm, 0.0-5.0 ppm and 0.0-2.0 ppm with selection. The ozone sensors and controllers shall be able to be set at 0.4 ppm after reaction tank and 0.1 ppm before discharge to fountain with measurable range adjustable from 0.0-3.0 ppm. All sensors and indication on controllers shall be able to give measurement down to 2 places after decimal point i.e. 0.01.

(e) Extra output signals shall be provided to transit the temperature signals and chemical levels such as residual chlorine and ozone concentration and pH value to the supervisory control panel if such panel is specified.

(f) Sensors shall also be included to measure ozone concentration in gas after ozone generator.

(g) Elements sensing liquid temperature in pipework shall be: -

(i) provided with means for withdrawal for calibration, servicing, etc., without the need for draining the system;

(ii) positioned so that the active part of the element is wholly within the liquid;

(iii) positioned so that the element is not less than 10 pipe diameters downstream from a point of mixing, unless otherwise recommended by the manufacturer;

(iv) positioned so that sufficient length of flexible conduit can be allowed to permit complete withdrawal of the element; and

(v) positioned downstream from the valve, after the pumps, for the control of mixed flow temperature using mixing valves.

(h) Elements sensing liquid flow in pipework shall be positioned so that: -

(i) the element is mounted in a section of pipe where there is a straight run of at least 5 diameters on each side of the flow switch;

(ii) the element is mounted so that the terminals or wire leads are easily accessible for wiring; and

(iii) the element shall not be subjected to water hammering. If a fast-closing valve is located downstream of the element, a suitable water hammer arrester shall be used.

(i) Sensing elements shall in all cases be installed in accordance with the manufacturer's latest recommendations and instructions.

(j) For sensors exposed to view, the precise location shall be approved by the Supervising Officer.

(k) All sensors shall be arranged to give convenient access for servicing.

(l) Suitable support and easy access facilities shall be equipped for all sensors, monitoring and measuring equipment. Suitable protection guard against damage shall be provided for equipment exposed to public contact. Temperature setting scales shall be clearly marked in °C.

18.1.7.1.5 Control Panels

Pump control panels shall be provided beside the group of pumps, for start & stop control and indication of fault. Push buttons shall be provided for start & stop, and LED lamps shall be provided for indications.

Panels to house the controllers for monitoring the water quality, alarms for detection of gas leakage, and control accessories for controlling of fountain water level shall be provided. The panel material shall be stainless steel to Grade 316.

18.1.7.2 LEVELS OF CONTROL

18.1.7.2.1 General

There are 3 different levels of control, and the level to be adopted shall be as specified in the Particular Specification. The 3 levels of control are as follows: -

Level 1- Basically manual control;

Level 2- Centralised control; and

Level 3- Computer assisted centralised control.

18.1.7.2.2 Basically Manual Control

(a) All water circulation, filtration and disinfection equipment shall be complete with local control panels for manual start/stop and control. The electrical and, if applicable mechanical, interlocks for maintaining the required sequence of operation of all the equipment, pumps, valves and devices shall be facilitated for proper starting, stopping, controlling, safety-alarming of water circulation, filtration and disinfection in accordance to the fountain performance requirements specified in the Particular Specification and the requirements for relevant equipment, valves and devices stipulated in this General Specification.

(b) Start & stop of equipment and pumps shall be facilitated on the corresponding local control panels. Push buttons shall be used, unless other means are required as recommended by the manufacturer or necessitated due to operational or safety needs. Electrical interlocks to ensure smooth start-up, stop and safe operation shall be provided.

(c) Remote fault indications shall be provided for all equipment, including disinfection systems and pumps. Remote fault indications shall be provided for all faults and alarms, as indicated in the Control Point Schedule in the Appendix to this Sub-section. The remote fault indications shall be at designated locations approved by the Supervising Officer. A panel shall be provided to house the indications. The panel shall be of stainless steel construction of 1.6 mm thick with side hinged opening with key lock. Coordination with other relevant parties shall be carried out on detailed arrangement to make neat and tidy Installations to the Supervising Officer's approval. Details of the layout and construction of the panel shall be submitted to the Supervising Officer for approval prior to fabrication and Installations. Buzzer alarms and visual indications shall be provided. Buzzer alarm for a fault shall be able to be muted by silencing switches while the visual indication remains on until the fault signals are rectified and the system is reset.

18.1.7.2.3 Centralised Control

(a) Level 2 control includes the manual controls in Level 1 and a central supervisory control. Wherever so indicated in the Particular Specification or Drawings, supervisory control panel shall be supplied and installed in a designated location. The supervisory control panel, which incorporates the functions of the panel to house fault indications stipulated in 18.1.7.2.2, shall be able to fully communicate with the local control panels for individual equipment. The supervisory control panel shall have all major indications, controls, and alarm functions. The supervisory control panel shall house all visual and audible indications and controls for the proper functioning of the water circulation, filtration and disinfection systems, controllers for monitoring the water quality, and alarm system for detection of gas leakage. Electrical interlocks to ensure smooth start-up, stop and safe operation shall be provided.

(b) The centralised control shall involve an automatic control system (ACS), which controls and monitors the proper, effective and efficient operation of the water water circulation, filtration and disinfection equipment & devices. The ACS shall also control and monitor the operation of the heating equipment and associated pumps & accessories. The ACS shall incorporate the I/O

provisions and functions indicated in the Control Point Schedule in the Appendix to this Sub-section.

(i) The ACS shall comprise of an electronic programmable logic controller (PLC) with built-in real time clock for scheduling. The PLC controller shall be located inside the supervisory control panel. The appropriate ACS shall be so designed to meet the requirements and operational needs of pool operation & management. The ACS shall have adequate capacity for scheduling all the operation needs per the Particular Specification.

(ii) The main function of the ACS is for on/off controls, monitoring of operation status and alarms generation of the water circulation, filtration and disinfection equipment & devices. Comprehensive system controls and monitoring functions of individual equipment shall be carried out by the system controller of individual equipment. The ACS shall be so designed to achieve a reliable control in performing the control and monitoring functions set in the design criteria and shall be of micro-processor based electronic or direct digital control type.

(iii) All fountain equipment and devices specified shall be able to be turned on and off in accordance with the time schedules pre-set in the built-in programme of the ACS including any holiday and special schedules so required by the users. A monitoring and alarm system shall be incorporated in the PLC in giving audio and visual status and alarm of faults for each equipment and device.

(c) The controllers serving different equipment shall be able to fully communicate with each other via the ACS to provide the functions as specified for the entire fountain installation. The ACS shall be able to perform, but not be limited to, the following functions: -

- high speed logic control;
- full capability to handle PID loops as well as other control logic;
- real time multi-tasking and multi-programming functions;
- safety interlocking;
- analog alarm function;
- powerful floating-point calculation functions;
- connection to industrial Ethernet (redundant network);
- redundant I/O channel medium;
- full set electrical I/O modules, analog I/O modules and relative intelligent modules;
- clock instructions;

- analogue I/O shall support 4-20 mA;
- expandable to accept spare I/O; and
- operate from a voltage source of 220 V A.C. 50 Hz with sufficient output to support the requirement of the PLC plus the specified spare capacity.

(d) For easy programming, user-friendly I/O devices shall be provided for the setting and re-setting of the water quality and operation schedules of fountain.

(e) To prevent malfunctioning of the real time clock and losing of memory, 7-day back-up battery with power healthy indicator and alarm shall be provided.

(f) Indicators of water quality including pH level and free chlorine level shall be provided.

(g) The supervisory control panel shall be of stainless steel construction of 1.6 mm thick with side hinged opening with key lock. Coordination with other relevant parties shall be carried out on detail arrangement to make a neat and tidy Installations to the Supervising Officer's approval. Buzzer alarms and visual indications shall be provided. Buzzer alarm for faults shall be able to be muted by silencing switches while the visual indication remains on until the fault signals are rectified and the system is reset. A mimic diagram with the entire system and piping schematic shall be engraved on the panel. Graphic of all fountains, main piping, equipment, pumps, main valves, flow meters, enthalpy meters, thermometers, fountain water quality indicators shall be shown on the mimic. LED lamps showing ON, OFF, malfunction, alarm, etc. for all equipment, pumps, motorised valves shall be provided on the mimic. Indication of duty/standby for relevant equipment and pumps shall be provided. Details of the layout and construction of the panel shall be submitted to the Supervising Officer for approval prior to fabrication and installations.

(h) Unregulated power supplies shall be filtered. Shielded cable shall be used when it is necessary to install D.C. signal leads in the same control wiring conduit.

(i) The detailed design of the control system shall be submitted to the Supervising Officer for approval before ordering and fabrication.

18.1.7.2.4 Computer Assisted Centralised Control

Level 3 control includes the Level 2 control and ACS, with the man-machine interface of the supervisory control panel carried out by a personal computer with LCD screen, keyboard and printer. Central

interface with the control system shall be via the keyboard and graphic buttons or scales on computer graphics. On-screen graphics of system schematics shall be provided, including all fountains, main piping, equipment, pumps, main valves, flow meters, thermometers, water quality indicators, etc. ON, OFF, malfunction, alarm, duty/standby status, equipment healthy status, power supply healthy status, etc. for all equipment, pumps, motorised valves, etc. shall be provided.

The computer configuration shall be as specified in Clause 8.2.5.4 of this General Specification.

18.1.7.3 REMOTE MONITORING

For systems with Level 3 control, the control system shall be able to be accessed remotely via internet on computers, mobile phones, tablets, etc. for remotely monitoring. Related internet service shall be provided for three years and handover to maintenance team after three years. The remote access shall be protected by two levels of passwords. The user with 1st level password can monitor the system status. The user with 2nd level password can monitor the system status and revise the time schedule and control set points. Parameters to be monitored and controlled shall be those in the Control Point Schedule in the Appendix to this Sub-section. In addition, message shall be sent the designated mobile phones whenever there is equipment fault or the water quality cannot fulfil the required standard.

18.1.7.4 INTERFACING WITH CCMS

For systems with Level 3 control, the control system shall be connected to the CCMS on the site via IP Local Area Network or BACNet. All parameters as specified in the Control Point Schedule in the Appendix to this Sub-section shall be fully accessible by the CCMS. All necessary information shall be provided to the contractor responsible for the CCMS installation works to enable the connection.

18.1.7.5 EQUIPMENT PERFORMANCE MONITORING AND DATABASE FOR CONTINUOUS COMMISSIONING

The control system shall monitor the perforce of equipment such as pumps. When the performance of the equipment deviates from the design value or its equipment performance (such as pump performance curve) by 20%, alarm message shall be issued.

Whenever vibration monitoring is specified for an equipment in particular specification or any drawing, vibration sensors shall be installed at the locations near bearings of pumps. Vibration analyser shall be installed to collect and analyse the signal from vibration sensor. Equipment status as good, satisfactory, unsatisfactory and damaging shall be analysed according to ISO 10816 or manufacturer's recommendation based on the measured vibration data. Equipment status shall be sent to CCMS for monitoring.

When status of unsatisfactory is detected, alarm shall be trigged in CCMS. When status of damaging is detected, the equipment shall be stopped immediately.

All parameters as specified in the following control point schedule shall be stored on the computer for 3 year with the interval of 15 minutes for continuous commissioning.

Control Point Schedule

description	analogue input (AI)		digital input (DI)		Analogue output (AO)		digital output (DO)		purpose	sensing/ control device	equipment/ device being controlled
	points	Mode & Remark	points	Mode & Remark	Points	Mode & Remark	points	Mode & Remark			
water level			2				2		monitor & control water level	level sensor	nil
make up water			2				2		monitor & control make up water	level sensor	nil
valves for water level and make up water			2				2	from water level and make up water	monitor & control make up water	nil	valves, depending on design
Balance tank water level			4	hi, mid, low levels, overflow			2		control motorised valves and other controls	level sensors	valves, depending on design
strainers status			1	dirty			1 *	* only for auto-backwash	monitor block/clean status	differential pressure sensor	backwash if auto strainer
main circulation pump			3	on/off fault status			2	ON/OFF control	monitor & control pump on/off/fault	contactors/ relays	pump
pump flow switch			2	Standby / duty pump operation					monitor and control pump	flow switch	nil
flocculation			1	if turbidity meter used					flocculation	turbidity meter	injection pump
alum tank level			1	low level alarm					monitor alum level	level sensor	injection pump
alum dosing pump			3	On / off/ fault status			1	stops alum dosing pump when low level or water is not turbid	on/off control dosing pump	contactors/ relays	injection pump
backwash sand filter			1	differential pressure across sand filter			depend on valves quantity	Open /close respective valves with timer	open/close respective valves for backwash	differential pressure sensor	valves and air compressor
compressor for back wash			3	on/off/fault status			1	start/stop compressor with timer	control compressor for back washing	contactors/ relays	on/off compressor

description	analogue input (AI)		digital input (DI)		Analogue output (AO)		digital output (DO)		purpose	sensing/ control device	equipment/ device being controlled
	points	Mode & Remark	points	Mode & Remark	Points	Mode & Remark	points	Mode & Remark			
ozone booster pump			3	on/off/fault status			1	booster pump can operate only if main pump is running	monitor & control pump	contactors/ relays	booster pump
Ozone generator	3	O_3 quantity; no. of generators in operation; cooling air/water temperature condition, etc.	5	on/off/fault; cooling air/water temperature too high; no suction; air dew point temperature too high, etc.	1	control O_3 output	1	on/off control, and shut-off generator in case of O_3 leakage	monitor & control O_3 generator status and control O_3 output	ORP controller (mV); other status by contactors/ relays	ozone generator
oxidising reduction potential meter (ORP)	1	measure ions in water							monitor oxidising level (mV) for O_3 concentration indication	ORP controller	Ozone generator
ozone monitor			1	detect any ozone in water			2	stop main pump & O_3 generator and sound alarm	monitor ozone level in water	ozone monitor	pump & O_3 generator
flow meter	1	measure water flowrate in main pipe							measure water flowrate in main pipe	flow meter	nil
pH and residual chlorine measurement	2	pH and residual Cl level							monitor & control pH & residual Cl	pH/Cl controller	NaOCl, HCL or NaOH dosing pumps with timer-set alarm
salt water level in brine saturator			1	DI for low level of salt water level					monitor salt water level	level sensor	electrochlorinator and brine pump, with timer-set alarm
water softener			2	ON/OFF status if available					monitor water softener operation	contactors/ relays	nil
brine pump			2	ON/OFF status			1	cut off pump in case of low salt water level; when NaOCl tank is full	monitor & control brine pump	contactors/ relays	brine pump
Electro-chlorinator			3	ON/OFF; fault status			1	cut off electro-chlorinator in case of brine pump stop; when H_2 content >1%	monitor NaOCl system operation on/off/fault	contactors/ relays	electrochlorinator and brine pump

description	analogue input (AI)		digital input (DI)		Analogue output (AO)		digital output (DO)		purpose	sensing/ control device	equipment/ device being controlled
	points	Mode & Remark	points	Mode & Remark	Points	Mode & Remark	points	Mode & Remark			
NaOCl dosing pump			3	ON/OFF; Fault status			1	cut pump in case of tank low level; when residual Cl reach its preset value.	On/off control dosing pump	contactors/ relays	NaOCl dosing pump
HCL level			1	Low level alarm					monitor HCL level	level sensor	nil
HCl dosing pump			3	ON/OFF; Fault status			1	cut pump in case of tank low level; when pH reach its preset value.	On/off control dosing pump	contactors/ relays	dosing pump
NaOH level			1	Low level alarm					monitor NaOH level	level sensor	nil
NaOH dosing pump			3	ON/OFF; Fault status			1	stop pump when NaOH level low; when pH reach its preset value	on/off control dosing pump	contactors/ relays	dosing pump
ozone leakage detector			3	3 levels leakage alarm depend on manufacturer product. To cut ozonator when leaking					monitor plant room if any ozone leakage	O_3 leakage detector	stops O_3 generator and sounds alarm
hydrogen detector			1	give alarm when H_2 level >1%; to cut electro chlorinator					monitor NaOCl tank room if H_2 present>1%	H_2 detector	stops electrochlorine generator and sounds alarm
hydrogen blower			2	Operating / stop					monitor blower on/off & control el- plant	differential pressure switch	electrochlorinator
NaOCl tank level			3	high level to cut off brine pump; low level to give alarm; further low level to cut dosing pump					monitor level & control electro-chlorinator & dosing pump	level sensors	electrochlorinator and dosing pump
backwash carbon tank			1	DI for differential pressure across carbon filter					open/close respective valves	differential pressure Switch	valves on/off
Pump Energy Consumption									Monitor pump energy consumption	Power analyser	

description	analogue input (AI)		digital input (DI)		Analogue output (AO)		digital output (DO)		purpose	sensing/ control device	equipment/ device being controlled
	points	Mode & Remark	points	Mode & Remark	Points	Mode & Remark	points	Mode & Remark			
Water Pressure	1								Monitor pump pressure	Pressure sensor	Pump
Pump Vibration Frequency and overall velocity	2								Monitor pump vibration	Vibration sensor and vibration analyser	
Water colour	1								Monitor water colour	water colorimeter	

SUB-SECTION 18.1.8

ANCILLARY INSTALLATIONS

18.1.8.1 UNDERWATER LIGHTING INSTALLATIONS

18.1.8.1.1 Underwater lighting system shall comprise water proof and vandal proof light fittings, two-core submersible cables, watertight junction boxes with neoprene gaskets, conduit and accessories, separated extra-low voltage (SELV) power source with safety isolating transformer, rectifier and all necessary accessories, RCBOs, etc. as indicated on the Drawings and in compliance with BS 7671:2018+A1:2020. LED light fittings shall be used for underwater lighting

18.1.8.1.2 The submersible light fittings shall be made of cast bronze or equivalent and complete with LED lamp bulbs (with two-core submersible cables). It shall be of IP 68, BS EN 60529:1992+A2:2013 and suitable for operation at the water depth as indicated on the Drawings. The whole light fitting shall be easily demountable in water for bringing up the fitting to deck surface for lamp replacement. A flexible water tight conduit shall be provided connecting the light fitting with power supply system

18.1.8.1.3 The colour lens or fittings shall be made of cast tampered glass, convex and heat resistance. The lens shall be mounted on neoprene gaskets. The whole frame of the light fitting shall be smooth with no sharp corner. It shall be installed in recessed position.

18.1.8.1.4 Nominal output voltage of the SELV power source shall suit the LED lamp bulbs. The safety isolating transformer of the SELV power source shall be double-insulated, single phase, rated at appropriate kVA, housed in a metal enclosure. The primary winding and the secondary winding shall be so constructed that there is no possibility of any connection between the windings. The safety isolating transformers shall comply with IEC-61558-2-6 and tested by a recognised independent body. Each underwater light shall be connected by a single two-core submersible cable and supplied by a single SELV power source. The source for SELV (i.e. safety isolating transformer) is installed outside Zones 0 and Zone 1 in compliance with Code 26M(6)(a) of Code of Practice for the Electricity (Wiring) Regulations.

18.1.8.1.5 Exposed-conductive-parts of the SELV circuits shall not be connected to Earth, or to protective conductor or exposed-conductive-parts of another circuit. Circuit protective conductor connected to metallic enclosure(s) enclosing the safety isolating transformer shall be brought back to main earth terminal. The primary winding of safety isolating transformer and the circuit connected to it shall be protected by RCBO. In case of any short circuit fault, the RCBO shall operate to trip the supply. No earth connection between the primary and secondary sides of the safety isolating transformer shall be made made. The earthing conductor of each underwater lighting, if any, shall not be connected to the primary side of the safety isolating transformer. The lowest insulation resistance measured between the primary and secondary sides of the safety isolating transformer shall not be less than 1 Mohm.

18.1.8.1.6 A 24-hour programmed timer switch shall be provided and serve to control the "ON" and "OFF" operation of the underwater lighting system. Also, an overriding facility shall be provided.

18.1.8.2 JET NOZZLE

18.1.8.2.1 Jet nozzle shall be of stainless steel, ABS or copolymer PP constructed and shall be capable to withstand working pressure of the fountain. Jet nozzle shall be selected to match with the appearance of fountain, and be positioned in a neat and tidy manner with no sharp corners.

18.1.8.2.2 Unless otherwise specified, jet nozzle shall be integrated with submersible 24V D.C. variable speed controlled pump to form a standard modular set and to deliver water jet pattern with the desirable water height. The intensity of flow shall be fully adjustable.

18.1.8.2.3 Jet nozzle shall be complete with socket end or threads for pipe connection.

18.1.8.3 WATER TESTING EQUIPMENT

Where stated in the Particular Specification, water testing equipment shall be provided to determine the chlorine residual and pH value of the fountain. The equipment shall be of portable type and suitable for field testing.

For residual free chlorine testing, plain Diethyl-p-phenylenediamine tablets and colour disc shall be provided. For pH value testing, phenol red solution and colour disc covering range of 6.8 - 8.4 shall be provided. The equipment shall be contained in a robust portable case suitable for carrying out field tests. At least 2 sets of testing equipment shall be provided.

18.1.8.4 ELECTRICAL INSTALLATIONS

18.1.8.4.1 General

(a) Unless otherwise specified, all low voltage electrical equipment necessary for the complete installations under the Contract shall be provided and installed. All necessary wiring from the points of power supply provided by others as indicated on the Drawings shall be carried out.

(b) All electrical work shall be carried out by registered electrical workers. Submit Work Completion Certificate in compliance with the Electricity Ordinance, Laws of Hong Kong.

(c) The accuracy of all installations, shop drawings and wiring diagram and for the correct internal wiring of all pre-wired equipment supplied under the Contract shall be verified.

(d) Unless otherwise specified, all electrical equipment, wiring and installation work shall comply with the relevant parts of this General Specification, Code of Practice for the Electricity (Wiring) Regulations issued by EMSD, BS 7671:2018+A1:2020, the Supply Rules of the electricity supply authority, and the respective recommended installation practices and standards of the equipment manufacturers. The Installations shall be to the satisfaction of the Supervising Officer.

(e) The supply voltage shall be 380 V three phase or 220 V single phase, 50 Hz, unless otherwise specified.

(f) The Clauses in this Sub-section related with control and metering shall be read in conjunction with the relevant parts of this General Specification on control and metering.

18.1.8.4.2 Cable Termination

The final termination of the power cables for main supply to the motor control cubicle and liaison with other relevant parties on sequence of works shall be included under the Works. All electrical Installations for equipment provided under the Works, commencing from the motor control cubicle, shall be supplied and installed, including cabling, switches, wiring, earth bonding, etc.

18.1.8.4.3 Equipment Sizing

All equipment and installations shall be sized with continuous ratings at the designed duties with minimum acceptable temperature rise.

18.1.8.4.4 Wiring in Conduit/Trunking

The electrical wiring shall be installed in trunking and conduit system and all conduits shall be concealed. Whenever possible, all wiring shall be grouped and laced together in a neat and tidy manner. Surface conduits/trunkings are acceptable only in plant rooms. All conduits for dangerous good stores, sodium mixed oxidant generation and storage rooms, ozone generator room and hydrochloric acid shall be concealed and shall be of galvanised steel metal conduits. Power and Control wiring shall be in separate conduits. All electrical Installations in rooms classified as Dangerous Goods Store shall comply with FSD requirements, whether shown on the Drawings or not.

18.1.8.4.5 Conduit

Both surface and concealed conduit system shall be galvanised steel conduits as specified in the relevant parts of this General Specification. Submit conduit run drawings for the electrical and control work to the

Supervising Officer for approval before installations. All concealed conduit work shall be done in good time prior to concreting work in the corresponding area, and tie up with the overall programme. Check the building programme and ensure that all concealed conduit are installed prior to concreting.

18.1.8.4.6 Circuit Identification

For control and auxiliary circuit wiring in particular, different colours shall be provided to distinguish the various circuits. In any circumstances, all wires shall have at both ends a coded ferrule permanently marked with suitable characters and codes for identification purpose. Each connection shall terminate at an approved type of terminal block, which shall also be suitably labelled.

18.1.8.4.7 Wiring to Moving Parts

Wiring from the fixed part of the circuits within control panels, starter panels, etc. to the movable parts, such as hinged front plates of the panels, shall be grouped together in a proper manner and be enclosed in flexible PVC tubing strong enough for mechanical protection, and yet flexible enough that the hinged plates can be opened and closed with ease. The wiring from the fixed part to the movable part shall also be long enough to allow the hinged front covers to swing through at least 180 degrees from their normally closed positions.

18.1.8.4.8 Earthing

Proper earthing shall be provided for exposed conductive parts of all his equipment and equipotential bonding for all extraneous conductive parts thereof, as described in the relevant parts of this General Specification, the Code of Practice for the Electricity (Wiring) Regulations and so called for by the as BS 7671:2018+A1:2020, to the main earthing system of the electrical system. All metal parts of equipment provided within the fountain zone have to be bonded to the fountain earthing grid system. All bonding wires shall be supplied and installed for connection to earth termination points near the equipment or within the zone to be bonded. Allow for and co-ordinate on exact location of termination points.

18.1.8.4.9 Conductive Moving Parts

All conductive moving parts such as hinged front doors of panels, battery and charger cabinets, etc. shall be properly and sufficiently earthed by suitably sized flexible insulated cables to the fixed conductive parts of the panels which are in turn electrically earthed as necessary.

18.1.8.4.10 Electrical Motor

(a) Adequate access to the motors and their associated facilities shall be allowed such that the necessary periodical testing, cleaning and maintenance can be carried out. The motors shall not be installed in a position where surrounding plant or building work may obstruct in meeting such requirements.

(b) Each electric motor, electric air heater battery or other electrical device which is controlled from the main control panel and is so situated that the panel is at a distance and/or out of sight from the equipment. shall be provided with a local "stop-lock" control circuit switch (where there is a separate control circuit), plus a local main power supply circuit isolator in all such cases.

(c) Exception for armoured cables, all other cables appearing above floor level shall be enclosed in approved trunking, solid or flexible conduit, with approved provision for movement of the motor. The terminal boxes for cable connection shall be suitably arranged to make a neat joint with the conduits or cables.

(d) The anti-condensation heater shall be controlled such that the heater shall be de-energised when the starter is switched on and vice versa. Heaters shall be wired from the motor control panel.

(e) Pulleys shall be correctly aligned and any holding down bolts or fixings shall be positioned to ensure correct alignment.

(f) Slide rails shall be provided for all motors driving through belts. Purpose-made adjusting devices shall be provided to adjust the belt tension and to secure the motors.

(g) The protective guards shall be rigidly constructed. It shall not be possible to remove any guard without the aid of a tool.

(h) Motor arranged for automatic restart shall have a label of durable material permanently fixed to it and in a prominent position clearly inscribed with the legend: -

DANGER: THIS MOTOR IS AUTOMATICALLY CONTROLLED AND MAY START WITHOUT WARNING. ISOLATE BEFORE INSPECTION.

A Chinese translation of the above shall also be provided on the same label.

18.1.8.4.11 Low Voltage Motor Switchgear, Starter and Control Panel

(a) General

Motor switchgear, starters and controls shall be supplied and installed to perform the operation and control of the fountain circulation, filtration and disinfection equipment. The starters and controls shall be housed in wall-mounted local motor control panels, or floor-standing motor control switchboard as required. The control panels or switchboard shall incorporate all control devices, timers, accessories and wiring necessary for proper operation.

(b) Local Motor Control Panel

The local motor control panel shall be of wall-mounted type, unless otherwise specified, to house the motor starter and switchgear.

(c) Motor Control Switchboard

(i) Where stated in the Particular Specification, motor control switchboard (hereafter called the “Switchboard”) shall be provided. The Switchboard shall be a free-standing floor-mounted low voltage switchboard to group centrally the motor starters, controls and switchgear for the water circulation, filtration and disinfection equipment, etc.

(ii) The Switchboard shall be installed on a raised concrete "housekeeping" base provided by others. Precautions shall be taken to prevent damage or deterioration of panels during transit and to afford physical protection on site prior to final acceptance.

(iii) Unless otherwise specified in this Specification or the Particular Specification, the Switchboard shall comply with the requirements as stipulated in the relevant parts of this General Specification.

(iv) Automatic power factor correction capacitor

Capacitor bank shall be wall or floor mounting cubicle-type, built up from static primary capacitor unit. The capacitor bank and associated equipment shall not be installed inside the switchboard. If it is not practical due to physical constraint or other justified reasons, the equipment shall be installed in a separate compartment segregated from the rest of the switchboard.

18.1.8.4.12 High Voltage Installations

All the high voltage electrical installation work shall be carried out by a Registered Electrical Contractor and Worker for Grade H electrical work as required by the Electricity Ordinance, (Cap. 406). After the completion of the electrical installation works, it shall be inspected, tested and certified by a Registered Electrical Worker to confirm that the requirements of the Electricity (Wiring) Regulations have been met. The Registered Electrical Worker and Registered Electrical Contractor shall sign the Work Completion Certificate for the individual high voltage electrical installations and submit to the Supervising Officer before the electrical installations is energised.

18.1.8.5 AUDIO SYSTEM

18.1.8.5.1 General

Audio system shall consist of amplifier, speaker, microphone, control and monitoring panel, digital audio player and all necessary accessories as required for the installation. The audio system shall be integrated with jet nozzles and lighting system to achieve performance requirement.

The audio system shall comply with "General Specification for Public Address Systems" issued by Electrical and Mechanical Services Department.

18.1.8.5.2 Measuring Criteria

Unless otherwise specified, measuring criteria for the whole audio system shall comply with "General Specification for Public Address Systems" issued by Electrical and Mechanical Services Department.

18.1.8.5.3 Amplifier

Amplifier shall be mixing type for combining speech and music. The amplifier shall have adequate continuous power output to meet the requirement of the configuration. The unit shall be capable of delivering the rated output watts with less than 0.05% harmonic distortion in the design bandwidth. The amplifier shall have a broadband frequency response of 20 Hz to 20 KHz. The output voltage and impedance shall meet with the system requirements.

Amplifier shall be protected against over loads and output shorts and a special thermal overload on the heat sink. Output wattage shall be as shown in the schedule of work or as required to meet the needs of the audio system. Amplifier shall be mounted in suitable wall mounted / floor standing enclosures.

18.1.8.5.4 Speaker

Speaker shall be outdoor weather proof especially designed for broadcasting high quality music and voice communications and approved by an appropriate authority for use in such situations.

Speaker shall be of high efficiency yielding maximum output at minimum power across 200 – 12000 Hz frequency ranges. Speaker shall have a line-matching transformer for direct connection to amplifiers with multiple taps. Speaker shall be mounted in a rugged metal housing with vandal resistant grille if specified.

The speaker shall be protected to IP 55.

18.1.8.5.5 Microphone

While specified, microphone shall be provided for the audio system. Microphone shall be of dynamic type provided with built-in blast and pop protection, built-in on-off switch and microphone holder.

18.1.8.5.6 Control and Monitoring Panel

As a minimum requirement, control and monitoring panel shall be provided with the following facilities: -

(i) monitor speaker with volume control;
(ii) system power on/off switch;
(iii) VU meter;
(iv) channel selector switch; and
(v) line voltage selector switch for monitoring 70V or 100V outputs.

18.1.8.5.7 Digital Audio Player

Digital audio player shall have playback capability for CD, DVD, MP3 and other digital audio files as specified.

As a minimum requirement, digital audio player shall be provided with the following facilities:-

(i) power on / off switch with indicator;
(ii) headphone jack with volume control;
(iii) output level control;
(iv) digital information display;
(v) direct track selection buttons;
(vi) random and disc / track repeat playback;
(vii) remote control unit;
(viii) 24-bit DAC convertor or better; and
(ix) Optical digital outputs and RCA analog outputs.

18.1.8.6 COMPRESSED AIR SUPPLY AND BACKWASHING SYSTEM

The compressors shall be air-cooled rotary air compressor with pressure lubrication system and direct couple motor. The compressor shall provide compressed air for scouring the filter beds of sand filter prior to backwashing. The compressor shall deliver sufficient quantity of oil free compressed air scouring 1 filter bed at a time in each system. Number of compressors shall be as shown on the Drawings or Equipment Schedule. The compressor shall be fitted with delivery air pressure gauge, oil pressure gauge, suction filter and silencer, air-oil separator, oil heater and ancillary control accessories. The compressor motor shall be selected for non-overloading characteristic. The compressor shall be designed for quiet operation and if noise level exceeds the EPD's requirements, an acoustic enclosure shall be provided for housing each compressor.

The air compressor for the sand filter tank shall be sized to give 50 m/h per unit filter area of air flow through filter during backwashing of each filter.

The compressed air supply and backwashing system shall comprise of 2 air compressors, one duty and one standby. All interconnecting pipeworks and fittings, valves including commissioning valves, shut-off valves, flow switches, flexible connections, etc. to all filters, controls and interlocks, required for proper backwashing as specified shall be provided no matter shown on Drawings or not.

Backwashing system with necessary valves and drains to meet the system requirements shall be supplied and installed. The backwash operation of the sand filter shall be designed for both manual and automatic operation. The Installations shall allow for the filter backwashing activity to be carried out while the water treatment system is in operation, i.e. one filter shall be put out of operation in the system. The carbon filter shall not be backwashed by ozone-containing water. A by-pass pipe from the sand filter discharge shall be provided for backwashing of carbon filter.

Backwashing water velocity of sand filter shall be in accordance with manufacturer's recommendation on different sand grain size and depth. The water velocity chosen shall be effective in cleaning the filter in duration of 7 minutes for sand filter excluding the air scouring time.

The air pressure safety valve on the air compressor shall be safety checked and sealed by a competent person. Certificate shall be issued by the competent person certifying that the operation of the safety valve are checked and sealed properly.

Motor, coupling and compressor shall be mounted on a common base plate supported on vibration isolation mountings.

A local control panel adjacent to the air compressor shall be provided such that the plant attendant can manually perform the air scouring operation. All control buttons shall be operated on 12 V/24 V D.C.

18.1.8.7 LIFTING FACILITIES

All the equipment in the plant rooms shall be checked and ensured to be well arranged and can be easily accessed for maintenance and operation.

If there is any equipment that cannot be easily removed for maintenance, eyebolts, lifting I-beams, chain hoists, access openings and other lifting facilities for use during servicing and maintenance of the installed equipment shall be proposed for approval by the Supervising Officer, which are builder's works requirements to be carried out in the Building Part of this Contract. Sufficient maintenance lifting facilities shall be allowed on Drawings in the builder's works requirements for proper servicing and maintenance of all equipment so that they can be incorporated in the Building Part of this Contract at early stage of project. Access openings, maintenance and lifting facilities shall be provided with no additional cost if additional numbers of them are found required during acceptance of the installations by the Supervising Officer.

Electric driven lifting chain hoists for handling of salt bags for the sodium hypochlorite generation system and the mixed oxidant generation system shall be supplied and installed.

Electric driven lifting chain hoists for handling of large pump motors shall be supplied and installed.

The lifting height of the hoists shall suit the site condition, loading limit of I-beams and eyebolts and weight of the equipment/chemicals. They will provide normal operating purpose such as maintenance, delivery and relocation of materials and equipment. I-beams and eyebolts will be provided in the Building Part of this Contract.

Chain hoists shall be selected and ordered so that they can be mounted on the I-beam installed. Details of hoists shall be submitted to Supervising Officer for approval before ordering.

The load chain shall be of malleable quality, electrically welded, pitched and of calibrated steel complying with BS EN 818-1:1996+A1:2008 and BS EN 818-7:2002+A1:2008 and proof tested to twice the safe working load specified for the hoist. Test certificate shall be submitted to the Supervising Officer.

The hooks shall comply fully with BS EN 1677-5:2001+A1:2008. They shall be able to rotate upon ball or roller bearings for ease of swivelling, and provided with a catch to prevent displacement of wire rope from the hook.

All moving parts of the hoist shall be greased or oiled after installations. Ball or roller bearings shall be packed with appropriate grease to the approval of the Supervising Officer.

Construction of the stoppers of the I-beams shall be ensured to be suitable to stop the trolley motion outside the working range.

A qualified surveyor shall be arranged to carry out the formal test under load conditions.

The hoist shall be tested to a proof load of at least 125% of safe working load on site in the presence of the Supervising Officer or his Representative.

All the lifting requirements and access openings shall be submitted as builder's work drawings to be approved by the Supervising Officer.

18.1.8.8 SUPPORTING CHEMICAL TREATMENT

Chemical treatment, other than disinfection purpose, of the fountain water shall comprise of dosing of aluminium sulphate (alum) to the raw water to form floc and dosing of hydrochloric acid (HCL) solution to correct alkalinity imparted to water by disinfectants and soda ash (NaOH) to correct the acidity. Centralised preparation and storage tanks shall be provided which shall be designed with a capacity to store for 16 to 24 hours of continuous operation for at least 4 days.

Each chemical dosing system shall have 2 tanks, each can be operated independently while the other is in service. Both tanks are connected and would be used together under normal situation.

The chemical tanks of dosing systems shall be used as combined preparation and storage type and shall be made from reinforced fibreglass or high-density polyethylene, or equal and approved. Each tank shall be complete with outlets, valves, overflows to drains and accessories. Level indication such as level glass tube shall also be provided for all tanks. For alum dosing system, stainless steel with rubber lining is also acceptable and each tank shall be complete with stainless steel dissolving tray and electric stirrers.

Pipings from make up tank shall be supplied and installed to provide water supply for the chemical tanks where required for the normal operation of the system.

Individual chemical metering pumps shall be provided to inject the chemical solutions into the water circuit. The chemical dosing pumps shall be plastic diaphragm variable output type complete with totally enclosed fractional horsepower motor. The pumps shall also have facilities for manually adjusted stroke length from 30% to 100% and stroke rates. Starters for the chemical pumps shall be of the direct on line push button type with no volt release and magnetic overload protection. Each group of pumps for corresponding fountain shall have 2 duty pumps and 1 standby pump, both having same characteristics, with selector switch enabling the choosing of any one of the pumps as the lead, lag or standby pump. Electrical supply and control facilities shall be such that all pumps can operate simultaneously under manual mode.

For alum system, 1 of the duty pump shall operate continuously when the carbon filters are in operation. The maximum dosing rate shall be 2.5 ppm of alum in main flow of water with 1 duty pump or as indicated in the Particular Specification. Initially, the stroke length shall be set to give 1 ppm of alum in main flow of water. The second duty pump is used to raise the alum level manually if required.

All level electrodes used for chemical dosing system shall be of corrosion resistant type suitable for submersing in the chemicals being used or measured.

Details of all equipment, pumps, tanks, controls and calculation shall be submitted to the Supervising Officer for approval before ordering.

All equipment and devices installed in Dangerous Goods stores shall comply with FSD's requirements. All electrical equipment used shall be of flammable proof and explosion proof type where required by FSD.

Clear and concise notices and instructions on the operation procedures for the chemical dosing system shall be posted besides the equipment of the systems. Warning notices shall also be posted to warn operators in handling the chemicals. The notices and instructions shall be made from permanent materials with easily reading characters in red, in both English and Chinese.

2 sets of safety plastic gloves, face mask, goggle, footwear and 1 set of plastic protective clothing shall be provided for handling of chemicals in each of the alum room and HCL room.

SECTION 18.2

SPECIFIC INSPECTION, TESTING AND COMMISSIONING, TRAINING, ATTENDANCE, OPERATION AND MAINTENANCE REQUIREMENTS

SUB-SECTION 18.2.1

SPECIFIC REQUIREMENTS DURING CONSTRUCTION PERIOD

18.2.1.1 GENERAL

On top of the requirements stipulated in relevant Parts of this General Specification, the Installations and Works during construction period shall also comply with the specific requirements in this Sub-section.

Testing and commissioning of the Installations shall also refer to the equipment manufacturer's recommendations and specifications.

18.2.1.2 TESTING AND COMMISSIONING SPECIALIST

The entire testing and commissioning procedure shall be undertaken by competent specialist staff of the contractor responsible for the Works or by a competent independent commissioning specialist engaged by the contractor responsible for the Works with the approval of the Supervising Officer.

Where specified in the Particular Specification, the competent independent specialist shall be engaged and for the approval by the Supervising Officer to conduct testing and commissioning work.

18.2.1.3 SAFETY, FUNCTIONAL AND PERFORMANCE TESTS

18.2.1.3.1 Electrical Tests

(a) Electrical Tests on Motor Control Switchboard

(i) The tests shall be carried out before and after connection of power supply. The tests shall follow the requirements as stipulated in the relevant parts of this General Specification for L.V. Cubicle Switchboard.

(ii) The tests to be carried out for the high voltage motor control switchboard shall strictly follow the tests as recommended by the equipment manufacturer.

(b) Electrical Tests on Motors

(i) Required Tests

- check motor nameplate voltage;
- check motor rotation and speed, prior to connection of the driven equipment;
- ascertain maximum kW absorbed by pump at the most demanding point of the pressure/volume characteristic curve at the specified pump speed;
- check the earth continuity loop resistance for every motor starter;
- check the insulation to earth resistance for every motor starter taken with 500 V insulation resistance tester;
- test the full load current taken by all motors on each phase;
- test the tripping time of starter overloads set to 10% above the motor nameplate rating;
- test the function of each control unit in accordance with the specification (e.g. selector switches correctly wired, high or low circuit cut-out operates, level switches correctly operating);
- check motor temperature in accordance with BS EN 60034-1:2014 as applicable; and
- check starting current of each motor.

(ii) Type Tests

Type tests and abbreviated tests shall meet the requirements of IEC 60072-1:1991, IEC 60072-2:1990 and IEC 60072-3:1994. The Supervising Officer has the discretion to agree or accept type-test results for performance in place of individual unit tests but these will not be accepted in place of practical on site, pressure, insulation, resistance tests which shall still be carried out on individual units.

(iii) Contractor's Responsibility

Approval of test certificates shall not absolve the contractor carrying out the Works from providing motors capable of driving the various items of plant under the conditions of loading stated in the contract.

18.2.1.3.2 Filling Water Systems And Venting

(a) Testing of Tanks

All water tanks shall, after erection, be filled with water and shall remain filled for at least 24 hours during which all joints shall be carefully examined. Any defect shall be rectified immediately and the test repeated.

(b) Flushing of Water Systems

Before finally charging, the water systems shall be thoroughly flushed and all strainers, filters, etc. cleaned or replaced.

(c) General Procedure

The water systems shall be properly charged with water (which shall be treated where specified). The filling process shall be from the bottom of the system upwards. Careful examination shall be conducted to the state of valves and air vents before and during filling to avoid air locks and excessive spillage.

When the whole system is filled, the source shall be disconnected, permanent supply shall be opened and the tank levels shall be adjusted.

18.2.1.3.3 Hydraulic Testing For Water Distribution Pipework Systems

(a) General

All water distribution pipework systems shall be hydraulically tested in sections as installation work progresses and before thermal insulation if any is applied.

(b) Test Pressure

The hydraulic test pressure shall be one and a half times the total working pressure.

(c) Precautions

Before hydraulic tests are carried out, all safety valves, gauges, etc. shall be effectively isolated or removed. This safety equipment shall be effectively tested at their design working pressure during commissioning of the installations.

(d) Method of Testing

For a satisfactory and acceptable test, the pressure shall be maintained for a period of 24 hours or as otherwise stated in the Particular Specification, without loss of pressure after all weak joints, defective fittings and pipes disclosed by the initial application of the test are rectified. During the final testing period the Supervising Officer or his Representative shall be invited to witness the tests. All sections of the work under test shall be accessible for inspection and selected welds shall be hammer tested.

(e) Hydraulic Test Certificates

Certificates of all hydraulic tests made on Site shall be forwarded to the Supervising Officer for approval and such approval shall be obtained before any thermal insulation if any is applied. A separate and duplicated set of installations/shop drawings shall be provided for the purpose of keeping accurate record of site tests. 1 copy will be kept by the Supervising Officer or his Representative on Site.

(f) Details on Test Certificate

A blank test certificate form shall be submitted for Supervising Officer's approval prior to carrying out the actual test on Site.

All test certificates shall be signed by authorised site representative and by the Supervising Officer or his Representative who has witnessed the test. All test certificates shall contain the following particulars: -

(i) date of test;

(ii) apparatus or section under test;

(iii) makers number (if any);

(iv) nature, duration and conditions of test;

(v) result of test;

(vi) name of Contractor's representative (in block letter) in charge of test; and

(vii) name of Supervising Officer or his Representative who witness the test.

18.2.1.3.4 Testing And Commissioning For Ozone Generation System

(a) Ozone Generating Module

(i) check the cleanliness of the dielectric glass tube;

(ii) check the cleanliness of the electrode;

(iii) check the cleanliness of the stainless steel liner tube;

(iv) check the O-ring for spacer, glass tube & liner tube;

(v) check ozone generating module leakage; and

(vi) check any leakage of pipework.

(b) Drying System

(i) check the solenoid valve diaphragm;

(ii) check the function of the air blower;

(iii) check the cleanliness of the air filter; and

(iv) check the proper adjustment of the cam timer and micro-switch.

(c) Air Supply System

(i) check the proper adjustment of the air flow rate; and

(ii) functional test for the air flow switch.

(d) Cooling Water System

(i) check the proper adjustment of the water flow rate;

(ii) check the solenoid valve diaphragm; and

(iii) check the proper adjustment of the water flow temperatures.

(e) Dew Point Monitoring

(i) check the proper adjustment of the dew point monitor p.c. board; and

(ii) check the cleanliness of the dew point sensor.

(f) Pipework & Accessories

(i) check the leakage of any pipework;

(ii) check all the strainers; and

(iii) check all the valves.

(g) Electrical Equipment

(i) check the tightness of the main power switch;

(ii) check the tightness of all wire terminals;

(iii) check the function of all the indication lamps;

(iv) check the tightness of the wiring of motorised variable transformer;

(v) check the tightness of the high tension transformers; and

(vi) check the function of all safety devices.

(h) Testing

check the proper function of the whole system.

(i) Control Panel

(i) general check for the panel;

(ii) check & test the power supply;

(iii) check & test the section control circuits;

(iv) check the tightness of the wiring terminals;

(v) check & test the induction lamps;

(vi) check the function of the cooling fans;

(vii) check the cleanliness of the panel;

(viii) check the control fuse or MCB;

(ix) check the function of the emergency stop;

(x) check the function of the meters; and

(xi) functional test for the panel.

18.2.1.3.5 Testing And Commissioning For Ultra-Violet Disinfection System

(a) General

(i) ensure the chamber is free from damage;

(ii) check that the cabinet is located satisfactory with respect to operation and safety;

(iii) remove all quartz ware and check for damage; and

(iv) earth continuity checks on system components.

(b) UV Chamber

(i) with the system in operation, ensure that water passes through the chamber

(ii) check the water system for leaks;

(iii) check that the water is flowing in the right direction;

(iv) check that bleed valves are fitted correctly; and

(v) record voltage and current when UV lamp is at full power.

(c) Automatic Wiper System

(i) check that the wipe cycle programme is in accordance with the specified requirements;

(ii) check that the limit switches are in the correct linear position;

(iii) check that the limit switches are correctly wired;

(iv) check that the motor is correctly wired;

(v) check that the wiper flap is the correct distance from the monitor probe tip;

(vi) check that all safety guards are in place; and

(vii) when in operation ensure all wiper features respond correctly.

(d) Control & Monitoring

(i) check that all interconnecting wiring is satisfactory;

(ii) check that the temperature thermostat/sensor is correctly wired and positioned;

(iii) check that system settings are correct; and

(iv) carry out functional check on Control Cabinet and ensure it performs satisfactorily.

18.2.1.3.6 Testing And Commissioning For Mixed Oxidant Disinfection System

Commission and test the system shall be done in compliance with the manufacturer's recommendation.

The testing and commissioning procedure are to be submitted to the Supervising Officer prior to the commencement of commissioning and testing.

Provide all necessary tools, equipment and labour for testing and commissioning of the system.

Measurements such as production rate of mixed oxidant with average concentration shall be taken.

SUB-SECTION 18.2.2

SPECIFIC REQUIREMENTS DURING MAINTENANCE PERIOD

18.2.2.1 GENERAL

On top of the requirements stipulated in relevant Parts of this General Specification, the Installations and Works during Maintenance Period shall also comply with the specific requirements in this Sub-section.

Operation, servicing and maintenance of the Installations, if specified, shall also refer to the equipment manufacturer's recommendations and specifications.

18.2.2.2 TRAINING REQUIREMENT

2 training courses shall be provided for the Employer's staff on the working principles, operation and maintenance of the whole water circulation, filtration and disinfection system and other auxiliary systems. One training course will be aimed for operational staff and/or maintenance staff which covers detailed operational procedures and steps and precautions. Training notes/manuals are required in both English and Chinese. The second training course will be aimed for management staff and/or non-technical staff which covers brief description of the system and precautions e.g. response during alarm. At least 5 seats shall be given to the Employer's staff for each training course. Training Venue shall be on site or provided by the Employer.

All queries raised by the operational staff during initial stage of operation shall be answered. A qualified engineer shall be sent to site to inspect and to answer any query raised by the operational and maintenance staff if they cannot be dealt with or solved over telephone.

18.2.2.3 COMPETENT TECHNICIAN TEAM

During the Maintenance Period, a team of competent technicians shall be provided to station on site for a period of 1 month, who will carry out daily operation of the whole water circulation, filtration and disinfection system, maintenance, testing and commissioning of the installations. At the same time, the team shall give thorough instruction and demonstration to the fountain operation staff on the operation and maintenance of the Installations. All activities shall be recorded in the log book.

18.2.2.4 REPLACEMENT OF SPARE PARTS

At the expiry of Maintenance Period, all consumable parts shall be replaced. Parts with operation life longer than the Maintenance Period need not be replaced.

ANNEX I – ABBREVIATIONS

A/C	Air-conditioning
AAB	Automatic Air Balancing
AABC	Associated Air Balance Council U.S.
A.C.	Alternating Current
ACB	Air Circuit Breaker
ACMV	Air Conditioning, Refrigeration and Mechanical Ventilation
ACRA	The Hong Kong Air-conditioning & Refrigeration Association Ltd.
ACS	Automatic Control System
AGC	Automatic Gain Control
AHF	Active Harmonic Filter
AHU	Air Handling Unit
AISI	American Iron and Steel Institute
AMR	Automatic Meter Reading
ANSI	American National Standards Institute
AO	Analogue Output
API	American Petroleum Institute
ArchSD	Architectural Services Department, the Government of the Hong Kong Special Administration Region
ARI	Air-conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
ASTA	The Association of Short Circuit Testing Authorities
ASTM	American Society for Testing and Materials
AVC	Advanced Video Coding
AWB	Automatic Water Balancing

Az	Azimuth
B&ES	Building and Engineering Services Association
BAC	Building Automation and Control
BASEC	British Approvals Service for Cables
BASEEFA	British Approval Services for Electrical Equipment in Flammable Atmospheres
BD	Buildings Department, the Government of the Hong Kong Special Administrative Region
BEC	Code of Practice for Energy Efficiency of Building Services Installation issued by EMSD
BESA	Building Engineering Services Association
BGC	Centrica Plc/BG Plc of United Kingdom (previously known as British Gas Corporation of United Kingdom)
BMS	Building Management System
BR	Broadcast Reception
BS	British Standards, including British Standard Specifications and British Standard Code of Practice, published by the British Standards Institution
BS EN	European Standard adopted as British Standard
BSB	The Building Services Branch of the Architectural Services Department, the Government of the Hong Kong Special Administrative Region
C.T.	Current Transformer
C/N	Carrier to Noise
CAD	Computer Aided Design
CAV	Constant Air Volume
CCD	Charge Coupled Device
CCMS	Central Control and Monitoring System
CCTV	Closed Circuit Television
CEN	European Standards prepared by European Committee for Electrotechnical Standardisation or European Committee for Electrotechnical Commission Publication

CFC	Chlorofluorocarbon
CGA	Canadian Gas Association
CFR	Code of Federal Regulation (Department of Transportation, USA)
CHO	Chilled Water Optimisation
CHW	Chilled Water
CIBSE	The Chartered Institution of Building Services Engineers
CIF	Common Intermediate Format
CLM	Computerised Lighting Management
CMOS	Complementary Metal Oxide Semiconductor
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COP	Code of Practice
COS	Change-of-state
CPC	Circuit Protection Conductor
CRI	Colour Rendering Index
CSA	Cross-sectional area of a conductor
CSWP	CAD Standard for Works Projects
CVT	Constant Voltage Transformer
D.C.	Direct Current
DBO	Distribution Boards Intended to Be Operated By Ordinary Persons
DCE	Data Circuit-terminating Equipment
DDC	Direct Digital Controllers
DDC/O	Direct Digital Controllers/Outstations
DEVB	Development Bureau, the Government of the Hong Kong Special Administrative Region
DIDW	Double Inlet Double Width

DIN	German Industry Standard
DO	Digital Output
DOL	Direct-On-Line Starters
DOP	Di-Octal Phthalate
DSD	Drainage Services Department, the Government of the Hong Kong Special Administrative Region
DTE	Data Terminal Equipment
DVD	Digital Video/Versatile Disc
DVR	Digital Video Recorder
E&M	Electrical & Mechanical
EE_TC	Testing and Commissioning Procedure for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region issued by the Architectural Services Department of latest version before the date of the first notice of tender invitation
EIA	Electronics Industries Association
EIMCSP	The Energy Institute Model Code of Safe Practice
EJMA	Expansion Joint Manufacturers Association
El	Elevation
EMC	Electro-magnetic Compatibility
EMSD	Electrical and Mechanical Services Department, the Government of the Hong Kong Special Administrative Region
EN	European Standards implemented by the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC)
EPA	Environmental Protection Agency
EPD	Environmental Protection Department, the Government of the Hong Kong Special Administrative Region
EPDM	Ethylene Propylene Diene Monomer (M-class)
EPR	Ethylene Propylene Rubber
ETD	Embedded Temperature Detectors

FCC	Federal Communications Commission
FCU	Fan Coil Unit
FDA	Food and Drug Administration, USA
FM	Frequency Modulation
Fm	Factory Mutual
FOC	Fire Offices' Committee, UK
FRC	Fire Resistance Construction
FRP	Fibreglass Reinforced Polyester
FRR	Fire Resistance Rating as defined in the current Code of Practice for Fire Safety in Buildings and its subsequent corrigenda/amendments issued by the Buildings Department, the Government of the Hong Kong Special Administrative Region
FS_TC	Testing and Commissioning Procedure for Fire Service Installation in Government Buildings of the Hong Kong Special Administration Region issued by the Architectural Services Department of latest version before the date of the first notice of tender invitation
FSD	Fire Services Department, the Government of the Hong Kong Special Administrative Region
FSDCoP	Codes of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment, current edition published by the Fire Services Department, the Government of the Hong Kong Special Administrative Region
FWCT	Fresh Water Cooling Towers
GA	General Acceptance
GB	China national standards (Guobiao Standards) administrated by the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ)
G.I.	Galvanised Iron
GasSO	Gas Standards Office of the EMSD
GRP	Glass Reinforced Plastics
GWIN	Government Wide IoT Infrastructure
H.T.	High Tension

H.V.	High Voltage
HBC	High Breaking Capacity
HCFC	Hydrochlorofluorocarbon
HCHO	Formaldehyde
HCS	Hydrous Calcium Silicate
HDMI	High Definition Multimedia Interface
HEPA	High Efficiency Particulate Arrestance
HFC	Hydrofluorocarbon
HID	High Intensity Discharge
HKAS	The Hong Kong Accreditation Service
HKIE	The Hong Kong Institution of Engineers
HKSAR	Hong Kong Special Administrative Region
HOKLAS	The Hong Kong Laboratory Accreditation Scheme
I/O	Input/Output
IAQ	Indoor Air Quality
ID	Identification
IDMT	Inverse Definite Minimum Time
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IET	The Institution of Engineering and Technology, previously the Institution of Electrical Engineers, U.K.
IF	Intermediate Frequency. A middle range frequency generated after downconversion in a satellite receiver
IGBTS	Insulated Gated Bipolar Transistors
IIAR	International Institute of Ammonia Refrigeration
IM	Intermodulation
IMO	International Maritime Organisation

IOT / IoT	Internet of Things
IP	Index of Protection
IP Camera	Internet Protocol Camera
ISAPI	Internet Server Application Programming Interface
ISO	International Organization for Standardization
ISO SQL	International Organization for Standardization, Database Language SQL
ITU-R	International Telecommunication Union – Radiocommunication Sector
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
JIS	Japanese Industrial Standards
KE	Catering Equipment
KEMA	N.V. tot Keurig van Elekrotechnische Materialmen in Arnhem, the Netherlands
kWh	Kilowatt-hours
L.T.	Low Tension
L.V.	Low Voltage
LAN	Local Area Network
LCD	Liquid Crystal Display
LCSD	Leisure & Cultural Services Department, the Government of the Hong Kong Special Administrative Region
LD	Labour Department, the Government of the Hong Kong Special Administrative Region
LED	Light Emitting Diode
LNA/LNB	Low Noise Amplifier/Low Noise Block Down Converter
Lon Talk	Echelon Corporation Lon talk® Protocol
LP	Licensed Plumber
LPC	Loss Prevention Council, UK
LPCB	Loss Prevention Certification Board, UK

LPG	Liquefied Petroleum Gas as defined under the Gas Safety Ordinance (Cap.51)
LPG_TC	Testing and Commissioning Procedure for Liquefied Petroleum Gas Installation in Government Buildings of the Hong Kong Special Administrative Region issued by the Architectural Services Department
LPHW	Low Pressure Hot Water
LSOH	Low Smoke Zero Halogen
LVSB	Low Voltage Cubicle Switchboard
MCB	Miniature Circuit Breaker
MCC	Motor Control Centre
MCCB	Moulded Case Circuit Breakers
MCR	Maximum Continuous Rating
MI	Mineral-insulated
MiC	Modular Integrated Construction
MICS	Mineral Insulated Copper Sheathed
MPEG	Moving Picture Experts Group
MPP	Metallised Polypropylene
NAIMA	North American Insulation Manufacturers Association
NaOCl	Sodium Hypochlorite
NaOH	Sodium Hydroxide
NC	Noise Criteria
NEMA	National Electrical Manufacturers Association
NES	Naval Engineering Specification
NFPA	National Fire Protection Association
NO_2	Nitrogen Dioxide
NPSH	Net Positive Suction Head
NSF	National Sanitary Foundation, USA
NTSC	National Television System Committee

NVR	Network Video Recorder
O&M	Operation and Maintenance
O_3	Ozone
OAP	Outdoor Air Pre-conditioners
OD	Outside Diameter
ODBC	Open Database Connectivity
OFCA	Office of the Communications Authority, the Government of the Hong Kong Special Administrative Region
OGCIO	Office of the Government Chief Information Officer
ONVIF	Open Network Video Interface Forum
OPSO	Over Pressure Shut Off
ORP	Oxidation–reduction Potential
OSHA	Occupational Safety and Health Administration
P.C.D.	Pitch Circle Diameter
PA	Public Address
PAL	Phase Alternating Line
PAS	Publicly Available Specification published by the British Standards Institution
PAU	Primary Air Handling Unit
PBFE	Performance based fire engineering (or performance based fire safety engineering or performance based fire protection engineering) studies, approaches, analyses, assessment, applications and/or similar works adopting fire engineering principles
PC	Personal Computer
PCB	Polychlorinated Biphenyl
PCP	Polychloroprene
P.C.D.	Pitch Circle Diameter
PE	Polyethylene

PFAC	Pulverised Fuel Ash Cement
PID	Proportional Integral Derivative
PIR	Passive Infrared
PLC	Programmable Logic Controller
PN	Practice Notes for Authorised Persons, Registered Structural Engineers and Registered Geotechnical Engineers issued by Buildings Department
PNxx	Pressure Rating xx BAR at 23°C
PoE	Power on Ethernet
POT	Portable Operator Terminal
PSTN	Public Switched Telephone Network
PTFE	Polytetrafluoroethylene
PTTA	Partially Type-Tested Assemblies
PVC	Polyvinyl Chloride
PWM	Pulse Width Modulation
QPSK	Quarternary Phase Shift Keying
r.m.s.	Root Mean Square
RAD	Rapid Application Development
RAID	Redundant Array of Independent Disks
RAM	Random Access Memory
RCBO	Residual Current Operated Circuit Breakers with Integral Overcurrent Protection
RCD	Residual Current Device
RF	Radio Frequency

RFSI	Related Fire Service Installations shall include all fire service installations in a building or project that are carried out by others and not included in the Installations, but they are required to be inspected and accepted by the FSD on completion. Related Fire Service Installations shall include, but not limited to, water supplies, supply tanks, ring main systems, street hydrants, interfacing signals between fire service system and various electrical and mechanical systems, emergency generator, emergency lighting, exit sign, pressurisation of staircases system, smoke extraction system, and fixed automatically operated approved appliances.
RFSP	Related Fire Service Provisions shall include all building components, fixtures, installations and provisions, but excluding Fire Service Installations, for fulfilling the fire safety requirements of a building or project, and they are required to be inspected and accepted by the FSD on completion. Related Fire Service Provisions shall include, but not limited to, fireman lifts, emergency vehicular access, fire dampers, fire doors, fire shutters, fire seals, fire insulation, fire fighting and rescue stairways, materials for separation of compartments, passive fire protection, ventilation system, exhaust system for gas flooding system, electrical installation, cubicle switchboard installation, telephone wiring, provisions for dangerous goods stores, labels and signs, etc.
RH	Relative Humidity
Rn	Radon
RPE	Registered Professional Engineer under Engineers Registration Ordinance
RSP	Respirable Suspended Particulates
RTC	Real Time Clock
RTD	Resistance Temperature Detector
S/N	Signal to Noise
SCCU	Statutory Compliance Checking Unit established within ArchSD
SCR	Silicon Controlled Rectifier
SELV	Separated Extra Low Voltage
SF6	Sulphur Hexafluoride
SI	International System of Units
SMACNA	Sheet Metal and Air-conditioning Contractors' National Association, USA
SMATV	The Satellite Master Antenna Television

SO	Supervising Officer
SRC	Sulphate Resisting Cement
STP	Standard Temperature and Pressure
STSVR	Static Tap Switcher Voltage Regulator
T&C	Testing and Commissioning
TBC	Total Bacteria Count
TEFC	Totally Enclosed Fan Cooled
THD	Total Harmonic Distortion
TIA	Telecommunication Industry Association
TL	Transmission Loss
TM	Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites
TMF	Temporary Mains Fresh Water for flushing
TPF	Total Power Factor
TTA	Type Tested Assembly
TV	Television
TVOC	Total Volatile Organic Compounds
UHF	Ultra High Frequency
UKLPGA	Liquefied Petroleum Gas Association of United Kingdom (previously known as Liquefied Petroleum Gas Industry Technical Association)
UL	Underwriters Laboratories
ULSD	Ultra Low Sulphur Diesel
UPS	Uninterrupted Power Supply
UPSO	Under Pressure Shut Off
UPVC	Unplasticised Polyvinyl Chloride
USB	Universal Serial Bus
UTP	Unshielded Twisted Pair

UV	Ultraviolet
V/F	Voltage/Frequency
VAV	Variable Air Volume
VDE	Verband Deutscher Elektrotechniker
VDRI	Voltage Dip Ride-through Inverter
VGA	Video Graphics Array
VHF	Very High Frequency
VOC	Volatile Organic Compound
VRF	Variable Refrigerant Flow
VRV	Variable Refrigerant Flow
VSD	Variable Speed Drive
VVVF	Variable Voltage Variable Frequency Speed Controller
WA	Water Authority, the Government of the Hong Kong Special Administrative Region
WHO	World Health Organization
WLAN	Wireless Local Area Network
WRAS	Water Regulations Advisory Scheme of United Kingdom (UK)
WSD	Water Supplies Department, the Government of the Hong Kong Special Administrative Region
XLPE	Cross-Linked Polyethylene
XLPE/SWA/PVC	Cross-linked Polyethylene Insulated, PVC-Sheathed, Galvanised Steel Wire Armoured and PVC covered