GENERAL SPECIFICATION
FOR
AIR-CONDITIONING, REFRIGERATION, VENTILATION
AND
CENTRAL MONITORING & CONTROL SYSTEM
INSTALLATION
IN
GOVERNMENT BUILDINGS
OF
THE HONG KONG SPECIAL ADMINISTRATIVE REGION
2001 EDITION
(VOLUME I)

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SECTION A1
SCOPE OF SPECIFICATION

A1.1 INSTALLATION TO COMPLY WITH THIS GENERAL SPECIFICATION

This General Specification details the intrinsic properties (including materials and workmanship) required of an air conditioning, refrigeration, ventilation, central monitoring and control system installation carried out for or on behalf of the Architectural Services Department, the Government of The Hong Kong Special Administrative Region.

A1.2 INSTALLATION TO COMPLY WITH THE PARTICULAR SPECIFICATION & DRAWINGS

The air conditioning, refrigeration, ventilation, central monitoring and control system installation shall comply in every respect with this General Specification unless otherwise specified in the current in force Legislation and other Subsidiary Legislation, Particular Specifications and/or Contract documents relating to a particular job or modified by written instruction of the Architect. In case of conflict, the order of authority shall follow the requirement as specified in Sub-section A2.3 of this General Specification.

A1.3 SCOPE OF THE WORK

The scope of any work carried out in accordance with this General Specification and the Particular Specification and Drawings relating to any project shall include for all the labour and materials necessary to form a complete installation including tests, adjustments, commissioning and maintenance as prescribed or as necessary. It shall include not only the major items of plant and equipment shown or specified but also include all the incidental sundry components necessary together with the cost of labour for installing such components for the complete execution of the works and for the proper and functional operation of the installation, whether or not these sundry components are stated in detail in the Contract Documents. It shall also include co-operation with other Contractors involved on the Contract Site in respect of co-ordination, programming, scheduling and sequence of installation of the works in all circumstances where stipulated in the Contract Documents or proven as necessary in practice.

A1.4 DEFINITIONS, INTERPRETATION & ABBREVIATIONS

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

“A/C” Air Conditioning
“ACB” Air Circuit Breaker
“ACMV” Air Conditioning and Mechanical Ventilation
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>“DDC/O”</td>
<td>Direct Digital Controllers/Outstations</td>
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<tr>
<td>“DDC”</td>
<td>Direct Digital Controllers</td>
</tr>
<tr>
<td>“DIDW”</td>
<td>Double Inlet Double Width</td>
</tr>
<tr>
<td>“DIN”</td>
<td>German Industry Standard</td>
</tr>
<tr>
<td>“DOL”</td>
<td>Direct-On-Line Starters</td>
</tr>
<tr>
<td>“DOP”</td>
<td>Dioctylphthalate</td>
</tr>
<tr>
<td>“DTE”</td>
<td>Data Terminal Equipment</td>
</tr>
<tr>
<td>“E&amp;M”</td>
<td>Electrical &amp; Mechanical</td>
</tr>
<tr>
<td>“EIA”</td>
<td>Electronics Industries Association</td>
</tr>
<tr>
<td>“EJMA”</td>
<td>Expansion Joint Manufacturers Association</td>
</tr>
<tr>
<td>“EMC”</td>
<td>Electro-magnetic Compatibility</td>
</tr>
<tr>
<td>“EMSD”</td>
<td>The Electrical and Mechanical Services Department, the Government of the Hong Kong Special Administrative Region</td>
</tr>
<tr>
<td>“EPDM”</td>
<td>Ethylene-propylene-diene elastomer</td>
</tr>
<tr>
<td>“ETD”</td>
<td>Embedded Temperature Detectors</td>
</tr>
<tr>
<td>“FCC”</td>
<td>Federal Communications Commission</td>
</tr>
<tr>
<td>“FCU”</td>
<td>Fan Coil Unit</td>
</tr>
<tr>
<td>“FDA”</td>
<td>Food and Drug Authority, USA</td>
</tr>
<tr>
<td>“FRC”</td>
<td>Fire Resistance Construction</td>
</tr>
<tr>
<td>“FRP”</td>
<td>Fibreglass reinforced polyester</td>
</tr>
<tr>
<td>“FSD”</td>
<td>The Fire Services Department, the Government of The Hong Kong Special Administrative Region</td>
</tr>
<tr>
<td>“G.I.”</td>
<td>Galvanised Iron</td>
</tr>
<tr>
<td>“Government”</td>
<td>The Government of The Hong Kong Special Administrative Region</td>
</tr>
<tr>
<td>“GRP”</td>
<td>Glass Reinforced Plastics</td>
</tr>
<tr>
<td>“GSA”</td>
<td>General Services Administration</td>
</tr>
<tr>
<td>“H.V.”</td>
<td>High Voltage</td>
</tr>
<tr>
<td>“HBC”</td>
<td>High Breaking Capacity</td>
</tr>
<tr>
<td>“HCF”</td>
<td>Hydrofluorocarbon</td>
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<tr>
<td>“HCFC”</td>
<td>Hydrochlorofluorocarbon</td>
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</tbody>
</table>
“HCS”  Hydrous Calcium Silicate
“HEPA”  High Efficiency Particulate Air
“HKIE”  The Hong Kong Institution of Engineers
“HKSAR”  The Hong Kong Special Administrative Region
“HVCA”  Heating and Ventilation Contractor Association, U.K.
“I/O”  Input / Output
“IAQ”  Indoor Air Quality
“IEC”  International Electrotechnical Commission
“IEE”  The Institution of Electrical Engineers, U.K.
“IEEE”  Institute of Electrical and Electronics Engineers
“IGBTS”  Insulated Gated Bipolar Transistors
“IIAR”  International Institute of Ammonia Refrigeration
“IMO”  International Maritime Organisation
“IP”  Index of Protection
“ISO SQL”  International Organisation for Standardization, Database Language SQL
“ISO”  International Organisation for Standardization Publications.
“KEMA”  N.V. tot Keuring van Elekrotechnische Materialen in Arnhem, the Netherlands
“LAN”  Local Area Network
“LCD”  Liquid Crystal Display
“LED”  Light Emitting Diode
“LSOH”  Low Smoke Zero Halogen
“Lontalk”  Enchelon Corporation Lontalk® Protocol
“LPHW”  Low Pressure Hot Water
“L.V.”  Low Voltage
“MCC”  Motor Control Centre
“MCR”  Maximum Continuous Rating
“MICS”  Mineral Insulated Copper Sheathed
“NAIMA”  North American Insulation Manufacturers Association
“NaOCl”  Sodium Hypochlorite
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>“NaOH”</td>
<td>Sodium hydroxide</td>
</tr>
<tr>
<td>“NC”</td>
<td>Noise Criteria</td>
</tr>
<tr>
<td>“NEMA”</td>
<td>National Electrical Manufacturers Association</td>
</tr>
<tr>
<td>“NES”</td>
<td>Naval Engineering Specification</td>
</tr>
<tr>
<td>“NFPA”</td>
<td>National Fire Protection Association</td>
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<tr>
<td>“NPSH”</td>
<td>Net Positive Suction Head</td>
</tr>
<tr>
<td>“OD”</td>
<td>Outside Diameter</td>
</tr>
<tr>
<td>“ODBC”</td>
<td>Open Database Connectivity</td>
</tr>
<tr>
<td>“Or equivalent standards”</td>
<td>Means internationally recognised standards acceptable to the Architect 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 Architect.</td>
</tr>
<tr>
<td>“O&amp;M”</td>
<td>Operation and Maintenance</td>
</tr>
<tr>
<td>“ORP”</td>
<td>Oxidation –reduction Potential</td>
</tr>
<tr>
<td>“OSHA”</td>
<td>Occupational Safety and Health Administration</td>
</tr>
<tr>
<td>“Particular Specification”</td>
<td>The Specifications referred to in the Contract for a Particular Project</td>
</tr>
<tr>
<td>“PAU”</td>
<td>Primary Air Intake Unit</td>
</tr>
<tr>
<td>“PCP”</td>
<td>Polychloroprene</td>
</tr>
<tr>
<td>“PFAC”</td>
<td>Pulverised Fuel Ash Cement</td>
</tr>
<tr>
<td>“PID”</td>
<td>Proportional Integral Derivative</td>
</tr>
<tr>
<td>“PLC”</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>“PN”</td>
<td>Practice Note</td>
</tr>
<tr>
<td>“POT”</td>
<td>Portable Operator Terminal</td>
</tr>
<tr>
<td>“PSTN”</td>
<td>Public Switched Telephone Network</td>
</tr>
<tr>
<td>“PTFE”</td>
<td>Polyfluoroethylene</td>
</tr>
<tr>
<td>“PTTA”</td>
<td>Partially Type-Tested Assemblies</td>
</tr>
<tr>
<td>“PVC”</td>
<td>Polyvinyl Chloride</td>
</tr>
<tr>
<td>“PWM”</td>
<td>Pulse Width Modulation</td>
</tr>
<tr>
<td>“r.m.s.”</td>
<td>Root Mean Square</td>
</tr>
<tr>
<td>“RAD”</td>
<td>Rapid Application Department</td>
</tr>
</tbody>
</table>
“RAM” Random Access Memory

“RH” Relative Humidity

“RTC” Real Time Clock

“RTD” Resistance Temperature Detector

“SCR” Silicon Controlled Rectifier

“SF₆” Sulphur Hexafluoride

“SMACNA” Sheet Metal and Air Conditioning Contractor’s National Association

“SRC” Sulphate Resisting Cement

“Standard/Guided Drawings” The drawings for reference purpose prepared by the BSB to show detailed arrangements of the common standard installations

“TBC” Total Bacteria Count

“TEFC” Totally Enclosed Fan Cooled

“TIA” Telecommunication Industries Association

“TL” Transmission Loss

“UL” Underwriters Laboratories

“UPS” Uninterrupted Power Supply

“uPVC” Unplasticised Polyvinyl Chloride

“UV” Ultra-violet

“V/F” Voltage/Frequency

“VDE” Verband Deutscher Elektrotechniker

“VAV” Variable Air Volume

“VOC” Volatile Organic Compound

“VRV” Variable Refrigerant Volume

“VSD” Variable Speed Drive

“WSD” The Water Supplies Department, the Government of the Hong Kong Special Administrative Region

“XLPE/SWA/PVC” Cross linked polyethylene insulated, PVC-sheathed, galvanised steel wire and PVC covered

“XLPE” Cross-Lined Polyethylene
SECTION A2
STATUTORY OBLIGATIONS AND OTHER REGULATIONS

A2.1 INSTALLATION TO COMPLY WITH OBLIGATIONS AND REGULATIONS

The air conditioning, refrigeration, ventilation, central monitoring and control system installation shall comply with this General Specification, and with the following statutory obligations and other regulations currently in force in the HKSAR:

A2.1.1 The Building (Ventilating System) Regulation under Buildings Ordinance (Hong Kong).

A2.1.2 The current requirements of Fire Services Department, The Government of The Hong Kong Special Administrative Region, as defined in the latest edition of the Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment plus all relevant current Fire Services Department circulars.

A2.1.3 The Noise Control Ordinance.

A2.1.4 Electricity Ordinance, Chapter 406, and other subsidiary legislation made under the Ordinance.

A2.1.5 Occupational Safety and Health Ordinance.

A2.1.6 Air Pollution Control Ordinance.

A2.1.7 Ozone Layer Protection Ordinance.

A2.1.8 Water Pollution Control Ordinance.

A2.1.9 The General Specification for Electrical Installation in Government Buildings of The Hong Kong Special Administrative Region issued by Building Services Branch of Architectural Services Department. (hereinafter means Electrical General Specification)

A2.1.10 The Codes of Practice issued by the following international institutions:
- American National Standard Institute
- Air-conditioning and Refrigeration Institute
- American Society of Mechanical Engineers
- American Society of Testing and Materials
- Committee for European Normalisation
- The Institute of Electrical and Electronic Engineers
- International Organisation for Standardisation
- Japanese International Standard
- National Fire Protection Association
A2.1.11 The Supply Rules and other requirements issued by the relevant local electricity supplier and water authority.

A2.1.12 Code of Practice for Energy Efficiency of Electrical Installations issued by the Electrical and Mechanical Services Department.

A2.1.13 Code of Practice for Energy Efficiency of Air Conditioning Installations issued by the Electrical and Mechanical Services Department.

A2.1.14 Code of Practice for the Electricity (Wiring) Regulations issued by the Electrical & Mechanical Services Department.

A2.2 SAFETY REQUIREMENTS

The air conditioning, refrigeration, ventilation, central monitoring and control installation shall comply with all regulations on safety aspects issued by the Works Bureau, the Labour Department of Hong Kong Special Administrative Region and other authorities from time to time. These include but are not limited to the following:

A2.2.1 Public Works Programme Construction Site Safety Manual

A2.2.2 Factories and Industrial Undertakings (Electricity) Ordinance, its subsidiary Regulations and its Codes of Practice

A2.2.3 Fire Services Ordinance

A2.2.4 Electricity Ordinance

A2.2.5 Dangerous Goods Ordinance

A2.2.6 Waste Disposal Ordinance

A2.2.7 Boilers and Pressure Vessels Ordinance

A2.2.8 Gas Safety Ordinance

A2.2.9 Occupational Safety and Health Ordinance

A2.3 CASE OF CONFLICT

In case of conflict between the technical requirements of this General Specification and any other requirements, the following order of priority shall apply:

A2.3.1 All currently in force Legislation and other Subsidiary Legislation.

A2.3.2 The Particular Specification and/or the Contract documents for a particular project.
A2.3.3  This General Specification.

A2.3.4  The relevant Codes of Practice and Technical Standards.

**A2.4  INTERNATIONAL SYSTEM OF UNITS**

All installations shall use the International System of Units (SI).
SECTION A3
GENERAL REQUIREMENTS ON MATERIAL, EQUIPMENT, WORKMANSHIP & QUALITY

A3.1 MATERIAL AND EQUIPMENT

A3.1.1 Material 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 international Institutes and Standards and as specified in this General Specification. This requirement shall be deemed to include all amendments to these standards and codes up to the date of tendering.

A3.1.2 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.

A3.1.3 Equipment Catalogues and Manufacturer’s Specifications

Equipment catalogue and Manufacturer's Specification related to proposed items of equipment shall be specific and shall include all information necessary for the Architect to ascertain that the equipment complies with this General Specification and/or the Particular Specification and Drawings. Data and sales catalogue of a general nature are not acceptable. Unless agreed to by the Architect in writing, all data and catalogues submitted must be in English and in pure SI units i.e. mm, m, kPa, m/s, Hz, kW, l/s etc.

Contractor's shall submitted catalogues and Manufacturer's specification of the proposed equipment for the examination and approval of the Architect in writing before any equipment is ordered.

A3.1.4 Equipment Deviations

Subsequent to the award of the Contract, and only in exceptional circumstances where it is demonstrated in writing by the Contractor that the original equipment offered cannot be obtained, the Architect may consider and accept, in writing, alternative equipment and materials proposed by the Contractor provided always that these are fully in compliance with the relevant Specifications and Drawings and do not impose any additional contractual or financial liabilities onto the Employer. The Contractor shall bear in mind that submission of alternatives usually causes delay because of additional time required by the
Architect to process further approval. The consequences of such delay shall be born by the Contractor.

Subject as always to the Architect's approval, where the Contractor proposes to use items of equipment other than those specified and dimensionally different from the Contract Drawings, the installation of which items requires any redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical, electrical or architectural layout, then drawings showing the layout of the proposed equipment and any redesign involved shall be prepared by the Contractor at the Contractor’s own expenses and be submitted to the Architect for approval.

Where the equipment deviation involves significant changes to the building, e.g. a larger plant room, this will unlikely be agreed unless the enlargement presents no significant problem and the Contractor is prepared to pay for the building alterations involved.

Where such approved deviation necessitates a different quantity and arrangement of ductwork, piping, structural supports, insulation, controls, motors, starters, electrical wiring and conduits, and any other additional materials together with all necessary accessories from that originally specified or indicated in the Contract Drawings, the Contractor shall supply and install such ductwork, piping, structural supports, insulation, controls, motors, starters, electrical wiring and conduits, and any other additional materials together with all necessary accessories required by the system at no additional cost to the Employer. The contractor shall also be responsible for all other expenses by other contractors in view of the change. Any deduction of cost due to the change shall be deducted form the contract.

The responsibility and detailed arrangement for abortive work and cost different for alternative equipment and material shall be in accordance with the Preliminaries of the Contract.

A3.1.5 Manufacturers’ Technical Support in Hong Kong

All equipment listed in the Equipment Schedule shall be supplied through authorised sole 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 to the Contractor. Unless otherwise specified in the Particular Specifications, equipment supplied directly by the manufacturers which do not have local agencies or offices will not be accepted.

A3.1.6 Materials Delivery Protection and Security on Site

For the purpose of accurate interim payment certification, all material delivered to site must be accurately listed and recorded in the site record books maintained by the Project Building Services Inspector (PBSI).
Once material and equipment delivered to site and paid for in interim payment, these material and equipment shall be the Employer’s property and shall not be removed from site except:-

Where materials are to be removed from the site by the Contractor, the reasons and details shall be notified to the PBSI for recording in the site record book. No material shall be removed without the PBSI’s approval and knowledge.

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. In this case the Contractor shall comply with the Building Contractor’s arrangements.

A3.1.7 Protection

Unless the responsibility is clearly defined in the Contract that the protection on site for delivered equipment, material and installation is solely by other Contractors, the Contractor shall be responsible for the safe custody of all materials and the equipment as stored or installed by him until finally inspected, tested and accepted. Also unless otherwise specified, the Contractor shall protect all work against theft, fire, damage or inclement weather and carefully store in a safe and secure place all material and equipment received on site but not yet installed.

All cases of theft must immediately be reported to the Police with full details of materials stolen. The site BSI and/or Clerk of Works (COW), Building Contractor and the Architect shall also be similarly informed.

In the case of fire, a similar report must be made to the nearest Fire Services Station, site BSI, and/or COW, Building Contractor and Project Architect.

Where necessary the Contractor shall provide steel container type lockable storage or other equally secure enclosures placed within a securely fenced-in compound where the latter is to be provided by the Building Contractor on the site.

If rooms are required to secure the storage of sensitive and/or expensive items, the Contractor shall ensure that the Building Contractor will provide clean, decorated, finished and lockable secure accommodation before their installation. If the Building Contractor fails to concede to such request, the Contractor shall report the shortcomings of the accommodation to the Architect for his contractual action.

A3.1.8 Samples to be Approved

The Contractor shall submit sample boards for approval within four weeks of award of the Contract. If four weeks are practically insufficient, the Contractor may request the Architect in writing for an extension of time. The board shall contain samples of all
‘compact’ sized materials and accessories to be used in the work. Written approval of all samples and technical details shall be obtained from the Architect 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.

A label in English (and also in Chinese if the Contractor wishes) bearing the name of Manufacturer, type of material or accessories to be used, is to be attached adjacent to each item. The sample board shall be displayed in the Employer's Site Office during the whole Contract Period.

Additionally, the Contractor shall supply sufficient samples of materials for those not listed in the Equipment Schedule or stated in the Particular Specification. Where required and stated in the Particular Specification, the samples will be subjected to destruction test.

A3.1.9 Selection of Equipment

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

Where items of equipment are interconnected to form an integral part of the complete air conditioning installation, their characteristics of performance and capacities shall be so matched as to give safe, reliable, efficient and economical operation of the complete air conditioning installation.

A3.1.10 Service Conditions

The following service conditions shall apply

(a) Climate : Hong Kong (tropical)

(b) Ambient temperature:
   Peak -5°C to +40°C (continuously 4 hours)
   Average 0°C to +35°C (over 24 hours)

(c) Altitude : up to 2000 m above sea level

(d) Relative humidity : 99% maximum

A3.1.11 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%.
A3.2 WORKMANSHIP

A3.2.1 Safety On Site

Work shall be carried out in such a manner as to comply with all the regulations, ordinances, etc., as listed in Sub-section A2.2 of this General Specification together with any amendments made thereto.

A3.2.2 Tradesmen and Supervision

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 Architect.

The Contractor shall employ for the control and supervision of all work, one or more qualified and competent Supervising Engineers. The qualified and competent Supervising Engineer shall have minimum 5 years on site experience for similar type of installation works. In case of minor nature of installation, the Contractor may propose to under the duties of the Supervising Engineer by the on site foreman as specified below. Approval by the Architect shall be obtained prior to any installation work.

The Contractor shall also employ a full time competent foreman on site for each trade. All trade foremen shall be registered tradesmen of the relevant trade.

The Contractor shall immediately replace any Supervising Engineer or trade foreman whose experience, skill or competency is, in the opinion of the Architect, found to be inadequate for the particular work.

A3.2.3 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 Architect has 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 an interval time of one year unless otherwise as required in the Contract for a particular project.

A3.2.4 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 this General Specification, Particular Specification and drawings of the project.
The installation shall be in compliance with the statutory requirements as specified in Section A2 of 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 Air Conditioning installation.

A3.3 LABEL AND NOTICE

A.3.3.1 Labels and Related Instruction

In order to make cross reference to the Operation, Maintenance, Service Manuals and Schematic Drawings etc., the Contractor shall provide labels for marking all valves, pipework, fuses, terminals, lamps, switches, handles, keys, instruments, gauges, control and other equipment, etc. and elsewhere to facilitate maintenance or as directed by the Architect with engraved multi-layer formica or similar material. Wording shall be submitted to the Architect for approval before manufacture.

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

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 utilising brass round head bolts and nuts or woodscrews. Adhesives or self tapping screws are not acceptable.

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.

All English lettering used on labels shall be 'Halvetica Bold' capitals (except where indicating metric units or as otherwise directed) with black letters on white labels for normal purposes. Where special colours or details are required these shall be as specified or directed.

All labels and instructions shall be in English complete with translation in Chinese characters. Heights for the English lettering shall be as follows with that for Chinese characters to match:-

(a) Pipelines, valves, motor valves, fans, doors, etc 8 mm
(b) Greasing instructions for motors, fan bearings, etc 6 mm
(c) Thermostats, sensors, thermometers, pressure gauges, general instructions, etc. 3 mm

For electrical panels or other items, lettering shall be :

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

For electrical/pneumatic components the letter heights shall be as follows :-

(d) Identifying equipment in cabinets 3 mm
(e) Door cabinets 8 mm
(f) Switches & indicators on panel faces 3 mm

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

A3.3.2 Coded Labels

Where appropriate, items such as valves, damper’s 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 Architect before implementation.

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

A3.3.3 Warning Notice

Warning notices shall be provided as required by the Electricity Ordinance and the Code of Practice for the Electricity (Wiring) Regulations. 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 red lettering not less than 5 mm high to be fixed on every container or enclosure of equipment for operating at voltages exceeding “Low voltage”.

(b) 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.
A3.4 GUARD AND RAILING FOR MOVING OR ROTATING PARTS OF EQUIPMENT

All moving or rotating parts of equipment shall be provided with an approved guard and railing complying with the Factories & Industrial Undertakings (Guarding an Operation of Machinery) Regulations, published by the Labour Department, 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.

A3.4.1 Temporary Guards

During the execution of work, the Contractor shall ensure that all moving parts are adequately guarded by temporary guards.

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, but in case they are not provided, the Contractor shall immediately report the matter to the Architect.

A3.4.2 Permanent Guards on Plant

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

A3.5 OTHERS

A3.5.1 Space for Plant

The Contractor shall ensure that all plants, material and equipment supplied by him can be accommodated and installed within the spaces as generally shown on the Contract Drawings with adequate access and space for maintenance of all items supplied.

The Contractor shall also ensure that access to plant is adequate to allow for its removal and/or ultimate replacement. Where this is considered not possible or necessary the Architect shall be consulted for alternative arrangements.

A3.5.2 Foundations, Holes and Openings
Any necessary openings, or holes through the building structure, or partition walls together with all concrete bases, supports, enclosing ductworks, etc. required by the Contractor (including those already indicated on the Contract Drawings) will be carried out by the Building Contractor under the terms of the Building Contract at no extra cost to the Contractor (except where extra work is required to meet the Contractor’s own requirement as described under Sub-section A3.1.4). The Contractor shall submit to the Architect for approval, full details of such requirements in adequate time, so that due consideration may be given before the Building Contractor commences work in the area concerned.

Following approval by the Architect, the Contractor shall be responsible for marking out the exact position and size of all such work and/or providing in sufficient time detailed information in drawing form to the Building Contractor, such that the Building Contractor may carry out this work in accordance with the Builder's Work Drawings provided by the Contractor.

The Contractor shall be liable for all expenses and contractual delay claims incurred in failing to comply with the foregoing requirements.

A3.5.3 Cutting-away and Making Good

All ‘cutting-away’ and ‘making-good’ as required to facilitate the Contractor’s works will be carried out by the Building Contractor, except for those minor provisions required for the fixing of screws, rawplugs, redhead bolts, etc. which shall be carried out by the Contractor.

The Contractor shall minimize the amount of cutting-away and making good necessary by giving timely and accurate instructions for the leaving of holes, etc. The Contractor shall at the necessary times in the course of the Contract Works mark out on the site or supply drawings to the Building Contractor for the latter’s attention to all cutting-away and preparing of ways. The Contractor shall ensure that the work is carried out strictly in accordance with the requirements or otherwise, the cost of all work and material in the event of negligence in allowing any unnecessary or incorrect cutting-away and making-good will be the Contractor’s responsibility.

A3.5.4 Water Proofing

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

Unless otherwise specified or instructed, the Contractor shall provide all necessary sleeves, puddle flanges, caulkimg and flashing as appropriate to make these penetrations absolutely watertight.

A3.5.5 Quality Assurance Standards
All materials and equipment shall be manufactured by factories with acceptable quality assurance procedures. Factories having ISO 9001 or ISO 9002 certification are deemed to have acceptable quality assurance procedures. Other similar quality assurance standards may be accepted by the Architect on their individual merits. Details of such other quality assurance standards shall be submitted with the Equipment Schedule.
A4.1 SCOPE OF REQUIREMENT

This Section covers the current contractual practices for Contract/Sub-contract/Quotation let by the Architectural Services Department for an air conditioning, refrigeration, ventilation, central monitoring and control installation and shall be read in conjunction with the documents of the Contract for a particular project.

The word “installation” means not only the major items of plant and apparatus conveyed by this General Specification and the Contract, but also all the incidental sundry components necessary for the complete execution of the work and for the proper operation of the installation, with their labour charges, regardless whether these sundry components are mentioned in detail in the tender documents issued in connection with the Contract.

A4.2 STANDARDS AND STANDARD DETAILS

The standards and standard details refer to the abbreviations, symbols and drawings prepared by BSB to show details of the common standard installations. The Contractor shall refer to these standards whenever such are mentioned or specified in the Drawings or the Particular Specification. The same standards and standard details shall also be used in the Contractor's "as-fitted" drawings etc., whenever applicable. The Contractor shall approach the Architect for obtaining such details if necessary.

A4.3 SURVEYS AND MEASUREMENTS

The Contractor shall relate all horizontal and vertical measurements 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 work.

All works shall be installed to these established lines and levels and the Contractor shall verify all measurements on site and check the correctness thereof as related to the work.

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. The Contractor shall co-ordinate with the Building Contractor to obtain all necessary datum and reference grids prior to their surveys and measurements.

A4.4 ACCEPTANCE OF INSTALLATION/SHOP DRAWINGS, TECHNICAL LITERATURE AND MATERIAL SAMPLES

Where delays because of late drawing submissions by the Contractor and/or the effect of re-submissions (and particularly multi-resubmissions), the
Contractor may be held responsible for any financial losses incurred and to the extent that the adverse effects can be demonstrated to have been incurred by the Contractor for having failed to produce acceptable drawings in reasonable and good time unless the delay is due to late comments/approval by the Architect. The time allowed for comments and resubmission shall be in accordance with the General Conditions of the Contracts and Special Conditions of Contracts.

The above conditions can also apply to submission and acceptance of other items such as technical literature and material samples.

**A4.5 CO-OPERATION, CO-ORDINATION AND WORK SEQUENCING WITH OTHER TRADES**

The Contractor shall co-operate and where necessary co-ordinate the work and programme with all other trades, Contractors and as specify in the Contract Documents. Unless otherwise stated in the Contract, the Contractor shall be responsible for co-ordinating the work with others and for timely and satisfactory completion of the Contract.

Any significant problems beyond the Contractor’s control shall promptly be reported to the Architect for advice and/or decision.

No extra claim for delay either financially or by extension of the Contract Period will be allowed if the Contractor fails to properly and adequately co-coordinate and programme the work at all times.

**A4.6 DRAWINGS PROVIDED BY THE CONTRACTOR**

**A4.6.1 Installation and Shop Drawings**

Unless otherwise indicated or instructed, the Contractor shall, in the stated or in adequate time before each section of the work proceeds, prepare, and submit for acceptance by the Architect, detailed installation and/or shop drawings (which may also be referred to as working drawings) to demonstrate how they propose to install the works both in ‘Detail’ and ‘Form’ to facilitate the practical installation. These drawings shall be fully dimensioned and shall be based on the basic intentions of the ‘Contract Drawings’ but shall not be simply a copy of them.

Installation and shop drawings in this context shall mean the drawings of items to be constructed by the Contractor at a workshop away from the site.

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 Architect.

Contractor’s ‘Installation Drawings’ and/or ‘Shop Drawings’ shall be prepared to such scales that will clearly show all necessary details.
The drawings shall be prepared to the same sheet sizes and scales as used for the ultimate ‘As-Installed’ record drawings.

‘Installation Drawings’ and/or ‘Shop Drawings’ shall generally include, but not limited to, the following:-

(a) Symbols and notations same as and compatible with the Employer’s own Contract Drawing standard.
(b) Complete layout/assemblies including all necessary minor items and accessories.
(c) Positions of all fixings, hangers and supports.
(d) Clearances 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.
(e) 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.
(f) Outline of insulation and clearances to allow for application thereof.
(g) Outline of valve and similar insulation boxes and the clearances to allow for the removal thereof.
(h) Lifting points and weights of each item. Note: These may be shown on separate drawings, if necessary, to avoid confusion.

A4.6.2 Manufacturer’s Shop Drawings

The term ‘Manufacturer’s Shop Drawing’ means any drawing of items or plants to be manufactured by a specialist manufacturing supplier away from the Contract Site.

Immediate after placing of any order or at any event within four weeks unless otherwise agreed in writing by the Architect, the Contractor shall forward to the Architect for comment and, where necessary, approval two copies of ‘Manufacturer’s Shop Drawings’ indicating detailed construction, principal dimensions and weights, clearances for withdrawals and/or cleaning, etc. No work shall be proceeded on or off the site unless these shop drawings have been approved in writing by the Architect.

A4.6.3 Ductwork Fabrication and Installation Drawings

The Contractor shall, prior to the commencement of any ductwork manufacture, submit to the Architect for technical appraisal and approval the fabrication ‘Shop Drawings’ and ‘Installation
Drawings’ of the ductwork demonstrating the proposed final details of the manufacturing and erection methods of the ductwork.

Generally, the drawings shall be drawn to a scale of not less than 1:50 but subject to the Architect'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; angles 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 equalizing ductwork bends, splitters and any other air flow control devices such as dampers, control mechanisms, acoustic treatment measures, flexible joints, air diffusion devices proposed complete with inlet or extracted airflow volumes and velocities.

A4.6.4 Air Handling Plant Shop Drawings

Air handling unit plant shop 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 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 by the Contractor or others. All such known positions and/or clearances shall be dimensioned wherever possible.

A4.6.5 Pipework Installation Drawings

Prior to the commencement of any manufacture, fabrication, or installation, the Contractor shall submit to the Architect for technical appraisal installation drawings for the pipework installation. Generally, the drawings shall be drawn to a scale of not less than 1:50. Subject to the Architect’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 motorized 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.

A4.6.6 Control and Wiring Diagrams Drawings

The Contractor shall prepare and submit schematic diagrams showing the control layout with each item clearly identified with all interlocking and related facilities.

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 Contractor’s own installed services and those installed by others. For those services installed by others, the Contractor shall be responsible for obtaining sufficient details of relevant information from them in order to complete the drawings.

A4.6.7 Switchgear, Starter, Control/Instrumentation/Motor Control Drawings

Shop/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.

A4.6.8 Checking Drawings of Other Trades

The Contractor shall follow the design intent of the Contract Drawings in planning and carrying out the work and shall cross check with other trades in order to verify the line, level, space and sequence in which the work is to be installed.

If directed by the Architect, the Contractor shall, without extra charge, make reasonable adjustments to the proposed installation drawing layouts as are necessary to prevent conflicts with the work of other trades or for the proper sequence of and execution of work. 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 Architect wherever such a requirement is justified.

A4.6.9 As fitted Drawings for Testing & Commissioning Work and Major Plant Rooms

Seven calendar days prior to commencement of any commissioning procedures on any section of the installation, the Contractor shall provide two (or more if required) preliminary copies of ‘As fitted’ drawings complete with all details such as design air and water flow rates to be used for commissioning purposes. Any amendments noted on these drawings during the commissioning and test stage shall subsequently be transferred to the original ‘As fitted’ drawings once the amendments have been accepted by the Architect.

The Contractor shall provide and install in the relevant major plant room glass-framed, non-fading prints of the following :-

(a) 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.

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

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.
A4.7 SPECIAL PLANT ROOMS CO-ORDINATION WORK

Unless otherwise stated in the Contract Documents, in the case of a plant room where the Contractor’s equipment constitutes the major item involved (i.e. as in the case of an air conditioning plant room), the Contractor shall allow in the tender for taking effective responsibility for the co-ordination of other services/building details within these specific areas. Furthermore the Contractor shall carry out this responsibility in 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 Contractor shall, on behalf of the Architect also allow for the cross checking of other Contractors’ plant room installation drawings before work thereon proceeds.

A4.8 SPARE PARTS AND SPECIAL TOOLS

For plant and/or equipment included in the tender, the Contractor shall provide 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.

Unless otherwise specified, within four months of signing the Contract, or in such period of time as has been agreed by the Architect in writing, the Contractor shall submit in respect of the proposed plant and/or equipment a list of the manufacturer’s recommended spare parts that are likely to prove necessary to service the plant and/or equipment during the first year’s operation and parts required immediately following the completion of the Contract Maintenance Period.

The spare parts submission shall include diagrams or catalogue details of the parts concerned and bona fide manufacturer’s published price lists. The Contractor may add the net shipping costs for each item plus a 15% margin to cover overheads and profit. Where appropriate, the prevailing exchange rate must be stated. The Contractor should note that an unacceptable or inadequate response to this requirement may result in their installation not being accepted.

Unless specified in detail, the criteria by which the Contractor shall judge the need for spare parts to be included in the Schedule 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 3 years or less from its installation and/or commencement of operation excluding the Contract Testing and Commissioning Periods.

The schedule shall include at least the following items where they are part of the installation concerned :-

(a) Springs, valves, valve rings, valve plates, etc.
(b) Bearings or bearing bushes
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 free maintenance period and/or defects liability shall be replaced by the Contractor at no cost to the Employer before the Maintenance Certificate is issued. The above items shall not be exhaustive. The Contractor shall be responsible for the replacement of other parts and components for normal operation of the installation.

Additionally the Contractor shall submit within the same period a priced schedule for the supply of any special tools necessary for servicing and maintenance of any part of the installation.

Instructions for purchase of any special tool shall be issued separately but the basis for charging shall be similar to that for the Contractor’s equipment manufacturer’s recommended spare parts.

The purchase of the needed spare parts and tools shall be secured by Architest’s Instruction for which a provisional sum shall be provided in the Contract.

The exact types and quantities shall be determined by the Architect based on the Contractor’s best advice and at the most appropriate time during the Contract Period when requirements can be most realistically assessed taking account of the installation as installed or still being installed.

A4.9 SUBMISSION OF TESTING & COMMISSIONING PROCEDURE

Upon completion of the installation but prior to acceptance, the Contractor shall submit to the Architect in good time a schedule showing the appropriate testing and commissioning procedures to be carried out. The schedule shall be agreed by the Architect before any testing and commissioning work is carried out.

Detailed requirements for testing and commissioning shall be in accordance with the relevant Sections of this General Specification.
A5.1 GENERAL

The specifications stated in this section shall be the cleanliness standard of outdoor air to be introduced into the building, the requirements on the indoor air quality objectives suitable for different types and uses of buildings and for different levels of comfort and health for the occupants, the treatment and conditioning processes of air, the equipment/materials for treatment and conditioning, the testing and commissioning of the system, the methodologies of assessing indoor air quality, the licensing/registration requirement, the training requirements of qualified IAQ workers, the operation and maintenance relating IAQ issues, and the housekeeping and energy efficiency relating to IAQ issues.

This General Specification shall apply to all buildings or totally enclosed areas provided with air-conditioning and mechanical ventilation installations (ACMV) for human comfort.

The specification shall be used in conjunction with acceptable guidelines for ventilation such as the latest version of the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) Standard 62-1999, “Ventilation for Acceptable Indoor Air Quality”. The requirements of the specification shall in any case fulfil the latest requirements as published by Environmental Protection Department.

The specifications shall not in any way provide exemption from existing legal obligations relating to indoor air quality. Legal provisions on ventilation and certain other factors affecting indoor air quality in buildings are contained in the following Regulations:

- Building (Planning) Regulations, under the Building Ordinance, CAP 123
- Ventilation for Scheduled Premises
- By-laws, under the Public Health and Municipal Services Ordinance, CAP 132
- Places of Public Entertainment Regulations, CAP 172
- Air Pollution Control Ordinance, CAP 311
- Smoking (Public Health) (Amendment) Ordinance, CAP 371
- Consumer Goods Safety Ordinance, CAP 456
- Ozone Layer Protection Ordinance, CAP 403
- Pesticides Ordinance, CAP 133
- Occupational Safety & Health Ordinance, CAP 509

The overall quality of indoor air is influenced by thermal acceptability and air contaminants. The thermal acceptability includes temperature, humidity and air movement. The air contaminants include airborne particles (Respirable Suspended Particulates), volatile organic compounds (VOC), tobacco smoke, asbestos, formaldehyde, radon, combustion gases, ozone, respiratory products and body odours, and micro-organisms.
A building fitted with air-conditioning and mechanical ventilation (ACMV) system shall be provided with a natural or mechanical ventilation system to introduce and distribute outdoor air with acceptable quality. For these buildings, the factors which determine the adequacy and quality of the air supplied by the ACMV system are:

- The quality of outdoor air
- The outdoor air intake rate
- The performance of air filters and cleaners
- Siting of ventilation equipment
- The recirculation rate
- Thickness and thermal value of insulation
- Effectiveness of air distribution systems
- Variable air volume system controls on minimum fresh air intake rate
- Ventilation controls
- Humid climatic conditions
- The ventilation rate of pollution-emitting activities
- Ventilation rates

The list shown above is not exhaustive and the Contractor shall assess the site condition and compile a check list for ventilation for submission to the Architect for endorsement.

The level of emission and design parameters of indoor air quality shall meet the requirements as generally described in Sub-sections A5.3 and A5.4. The painting and painting works for air-duct and finishes shall comply with IAQ relevant requirements and standards.

IAQ control and sensor requirements shall be as detailed under Section A6: Energy Efficiency and Energy Conservation; Section B4: Installation Methodology of Automatic Control and Section C4: Material and Equipment specification of Automatic Control.

To prevent the ingress of containment from outside, a net positive pressure should be maintained inside the building. The exact requirement of pressurization shall be in accordance 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.

Unless otherwise stated in the Particular Specification and/or drawings, for single chiller system, at least one condensing circuit shall incorporate heat reclaim function. For multi-chillers, at least one chiller shall perform as heat pump. For only heat pumps arrangement, the heat pumps shall have both heating and chilling functions. For VRV units alone, the VRV units shall cover both heating and chilling functions.

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.

A5.2 OUTDOOR AIR QUALITY

The Contractor shall select air cleaning and air treatment equipment for the control of IAQ based on the outdoor air quality as indicated in Table A5.2. Prior to commissioning and testing of the installation as specified in the Particular Specification, the outdoor quality shall be verified again by the Contractor. In case of discrepancy, the Contractor shall submit proposal for approval to rectify the outdoor air conditions in meeting the minimum standard as shown in Table A5.2.

Table A5.2 Outdoor Air Quality Objectives
(Maximum Acceptable Concentration Level)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Concentration in micron gram/m³ (i) (vii)</th>
<th>Average Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 hr (ii)</td>
</tr>
<tr>
<td>Sulphur Dioxide</td>
<td>800</td>
<td>350</td>
</tr>
<tr>
<td>Total Suspended Particulate</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>Respirable Suspended Particulate (PM₁₀)(v)</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>Nitrogen Dioxide</td>
<td>300</td>
<td>150</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>30,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Photochemical Oxidants (as ozone) (vi)</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(i) Measured at 298K (25ºC) and 101.325 kPa (one atmosphere).
(ii) Not to be exceeded more than three times a year.
(iii) Not to be exceeded more than once per year.
(iv) Arithmetic means.
(v) Respirable suspended particulates means particles suspended in air with a nominal aerodynamic diameter of 10 micron meter or less.
(vi) Photochemical oxidants are determined by measurement of ozone only.
(vii) Formula for conversion from micron gram/m³ to ppm for gases is as follows:

\[
\text{ppm} = \frac{(\mu g)/m^3 \times 24.45}{1000 \times MW}
\]

where \( MW \) = molecular weight of gas

The outdoor air intakes shall be located where the air induced shall be cleanest taking into account any sources of contaminants which are close to or upwind of the intake. No rectification work is required if outdoor air data measured is below concentration level shown in Table A5.2.
A5.3 DESIGN PARAMETERS OF INDOOR AIR QUALITY

The indoor air quality objectives and levels of achievement shall be in following the latest requirement as published by Environmental Protection Department or other recognised Authority as specified in the particular specification.

For general information, the common indoor VOCs and pollutant sources are shown in Table A5.3.

Table A5.3 Common Indoor VOCs and their Pollutant Sources

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Indoor Pollutant Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formaldehyde</td>
<td>Germicide, pressed-wood products, urea-formaldehyde foam insulation (UFFI), hardwood plywood, adhesives, particle-board, laminates, paints, plastics, carpeting, upholstered furniture coverings, gypsum board, joint compounds, ceiling tiles and panels, non-latex caulk compounds, acid-cured wood coatings, wood panelling, plastic/melamine panelling, vinyl floor tiles, parquet flooring.</td>
</tr>
<tr>
<td>Benzene</td>
<td>ETS, solvents, paints, stains, varnishes, fax machines, computer terminals, and printers, joint compounds, latex caulk, water-based adhesives, wood panelling, carpets, floor tile adhesives, spot/textile cleaners, Styrofoam, plastics, synthetic fibres.</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>Solvents, refrigerant, aerosols, fire extinguishers, grease solvents.</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>Solvents, dry-cleaned fabrics, upholstered furniture covers, printing inks, paints, lacquers, varnishes, adhesives, fax machines, computer terminals and printers, typewriter correction fluid, paint removers, spot removers.</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>Dry-cleaned fabrics, upholstered furniture coverings, spot/textile cleaners, fax machines, computer terminal and printers.</td>
</tr>
<tr>
<td>Chloroform</td>
<td>Solvents, dyes, pesticides, fax machines, computer terminals and printers, upholstered furniture cushions, chlorinated water.</td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>Dry cleaning agent, degreaser, insecticides, carpeting.</td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
<td>Insecticide.</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>Deodorant, mold and mildew control, air fresheners/deodorisers, toilet bowl and waste can deodorisers, mothballs and mothflakes.</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>Styrene-related products, synthetic polymers, solvents, fax machines computer terminals and printers, polyurethane, furniture polish, joint compounds, latex and non-latex caulkling compounds, floor tile adhesives, carpet tile adhesives, lacquered hardwood parquet flooring.</td>
</tr>
<tr>
<td>Pollutant</td>
<td>Indoor Pollutant Sources</td>
</tr>
<tr>
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</tr>
<tr>
<td>Toluene</td>
<td>Solvent, perfumes, detergents, dyes, water-based adhesives, edge-sealing, moulding tape, wallpaper, joint compounds, calcium silica sheet, vinyl-coated wallpaper, caulking compounds, paint, carpeting, pressed-wood furnishings, vinyl floor tiles, paints (latex and solvent-based), carpet adhesives, grease solvents.</td>
</tr>
<tr>
<td>Xylene</td>
<td>Solvents, dyes, insecticides, polyester fibres, adhesives, joint compound, wallpaper, caulking compounds, varnish, resin and enamel varnish, carpeting, wet-process photocopying, press-wood products, gypsum board, water-based adhesives, grease solvents, paints, carpet adhesives, vinyl floor tiles, polyurethane coatings.</td>
</tr>
</tbody>
</table>

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.

A5.4 INSTALLATION – PART B: TREATMENT AND CONDITIONING PROCESS

Air cleaning is usually most effective when used in conjunction with either source control or ventilation. Most air cleaning in large buildings is aimed primarily at preventing contaminant buildup in ACMV equipment and enhancing equipment efficiency. Air cleaning equipment intended to provide better indoor air quality for occupants must be properly selected and designed for the particular pollutants being treated.

<table>
<thead>
<tr>
<th>IAQ Parameters</th>
<th>Treatment and Conditioning Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>Dilution by outdoor air</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>Dilution by outdoor air</td>
</tr>
<tr>
<td>Respirable Suspended Particulate</td>
<td>Particulate Filtration Electrostatic Precipitation</td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>Electronic air cleaner</td>
</tr>
<tr>
<td>Ozone</td>
<td>Dilution/purging by outdoor air Activate carbon Filter</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>Electronic air cleaner</td>
</tr>
<tr>
<td>Total Volatile Organic Compound</td>
<td>Electronic air cleaner</td>
</tr>
<tr>
<td>Radon</td>
<td>Purging by outdoor air Activate carbon filter</td>
</tr>
<tr>
<td>Airborne Bacteria</td>
<td>Germicidal Ultraviolet Sterilizer</td>
</tr>
<tr>
<td>Room Temperature</td>
<td>Heating / cooling</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>Dehumidifier / Humidifier</td>
</tr>
</tbody>
</table>
Particulate Filtration

Particulate filtration removes the air-borne respirable suspended particulates. In order to achieve the required level of filtration, it is necessary to combine filters in different stages to achieve multi-stage filtration. There are usually three stages: the first stage or primary, the secondary, and the final stage in which high efficiency particulate air (HEPA) filters are used to capture fine particles smaller than 1.0 micron meter.

The primary filter is normally exposed to the full velocity of the air stream and is normally dry panel or a panel consisting of washable filter elements. The secondary stage which normally comprises roll or bag filters covers an extended surface area to reduce air velocity through the media to about 0.12 m/s. The final stage comprises HEPA filters which are normally pleated to increase surface area so as to reduce the air velocities through the media to about 0.03 m/s.

This multi-stage filtration is used not only because of the cleanliness of air required but it also prolongs the life of the filter unit of each stage hence reduces the maintenance cost of the filtration system.

Electrostatic Precipitation

Electrostatic precipitation uses the attraction of charged particles to oppositely charged surfaces to collect airborne particulates. In this process, the particles are charged by ionising the air with an electric field. The charged particles are then collected by a strong electric field generated between oppositely charged electrodes. Electrostatic precipitation provides relatively high efficiency filtration of small respirable particulates at low air pressure losses. Electrostatic precipitators may be installed in air distribution equipment or in specific usage areas.

Germicidal Ultraviolet Sterilizer

Germicidal, or short-wave ultraviolet has wavelength band between 200 nm and 300 nm. Germicidal ultraviolet is primarily intended for the destruction of bacteria and other micro-organisms, like mould and spores in the air or on exposed surfaces. The exposure of germicidal ultraviolet necessary to kill bacteria is proportional to exposure time and the intensity of ultraviolet. The inverse square law applies to the germicidal ultraviolet, that is, the killing power decreases as the distance from the lamps increases.

Electronic Air Cleaners

Electronic air cleaners work on the principle of ionisation created by an electromagnetic field known as corona discharge. In the ionisation process, neutral oxygen atoms or molecules are electrically charged and converted to negative and positive ions. The negative ions help to reduce or eliminate airborne micro-
organisms, organic smells and, volatile organic components. Electronic air cleaners can maintain purification efficiency of not less than 85% total bacteria count.

A5.4.5 Physical Adsorbers on Ozone and Radon

Adsorption is a surface phenomenon, similar in many ways to condensation. Pollutant gas molecules that strike a surface and remain bound to it for an appreciable time. The adsorbers are in granular or fibrous form to increase the gross surface exposed to an airstream. The surface of the adsorber is treated to develop pores of microscopic dimensions, which greatly increase the area available for molecular contacts. Typical adsorber media are treated activated aluminas and carbons.

Activated carbon adsorbs ozone readily, both reacting with it and catalyzing its conversion to oxygen.

Radon is a radioactive gas that decays by alpha-particle emission, eventually yielding individual atoms of polonium, bismuth, and lead. These atoms form extremely fine aerosol particles called radon daughters or radon progeny, which are also radioactive; they are especially toxic in that they lodge deep in the human lung where they emit cancer-producing alpha particles. Radon progeny, both attached to larger aerosol particles and unattached, can be captured by particulate air filters. Radon gas itself may be removed with activated carbon but in ACMV systems, this method costs too much for the benefit derived. Control of radon emission at the source and ventilation is the preferred method of radon control.

A5.5 EQUIPMENT/MATERIALS – PART C: TREATMENT AND CONDITIONING MEDIA

A5.5.1 Rotary Solid Desiccant Dehumidifiers

All technical requirements shall comply with the requirements stipulated in Sub-section A6.4 of this General Specification. The type of reactivation power shall be as specified in the Particular Specification. Liquid desiccant type dehumidifier shall be submitted for Architect’s approval.

A5.5.2 Desiccant Type Dehumidifier Air Handling Unit

(a) General

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 design as specified. 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.

(b) Rotor

Rotor shall be high efficiency silica gel or lithium chloride. 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, incombustible, non-toxic and washable. Rotor shall be suitable for non-stop operation and the service life is minimum 10 years. 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.

(c) Heat Pump System

Heat pump refrigeration system where specified shall be integrated into the dehumidifier AHU to pre-cool the process air and regenerate the rotor. The heat pump system 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 aluminum fins.

(d) Fan

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.

(e) Control

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.

A5.5.3 Electrostatic Precipitators

Average efficiency of the auto clean electrostatic filter shall not be less than 90% rated at ASHRAE 52.1-92. Auto clean electrostatic filter shall consist of a motorized 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 1m in direction of airflow. Each section of the galvanized 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, galvanized steel, drain pan and drain connections. Access doors shall be sealed against air leakage by continuous perimeter gaskets of closed cell neoprene.

Each ioniser-collector section shall be finished with the required number of one-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 cell to ensure complete drainage of wash water and excess adhesive, minimizing the possibility of short circuits when high voltage power is restored following completion of the wash cycle. Cells shall be designed so that high voltage input terminals and the high volt rated glass 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 the design of 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 designed 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, galvanized steel air distribution baffles and a motor-driven, mobile header assembly which uses grooved nylon wheels to traverse the entire width of the section on twin steel angle carrier rails. The mobile header assembly shall be connected to the inlet water solenoid valve and to the adhesive pump by means of non-snag, expanded PVC hose with a braided polyester exterior protective cover. Rotating washer rams, each equipped with adjustable, multi-directional, 360° 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 mobile
assembly. The filter adhesive shall be cold water soluble and non-flammable. The Contractor shall supply a rotary gear adhesive pump with bronze impeller and sufficient adhesive for reconditioning cycle.

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 drip and fan dry cycles. The washer control enclosure access door shall incorporate a status light to indicate when the reconditioning cycles is energized. An internal panel is to be equipped with a combination of LED status lights and a digital readout to indicate which part of the reconditioning cycle is in operation. The digital readout is to be visible through a window in the control cover.

The power shall be of solid state design, having 10-15 steps or more of output voltage adjustment, relays for remote indication of primary input and secondary output, 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 primary and secondary neon glow lamps to indicate status of the power supply and the solid state high voltage supply. The power pack shall also include safety provisions of a circuit breaker, a manual reset button, time delay safety type door interlock switches.

A5.5.4 Electronic Air Cleaners

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 independent laboratory 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 output voltage of the electronic air cleaner shall be in the range between 4,000 volts to 8,000 volts.

The electronic air cleaner shall not generate ozone in excess of the safety standards specified by the Occupational Safety and Health Administration (OSHA), USA and Food & Drug Authority (FDA), USA, or other recognized national standards.

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 so that it switches on/off with the fan of the blower. The electronic air cleaner shall be wired so that the units
may be unplugged and removed for regular servicing. The electrical wiring shall conform with the relevant safety standards.

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 design.

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 an earth clip connected 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.

The electronic air cleaner shall not generate ozone in excess of 0.01ppm.

A5.5.5 Germicidal Ultraviolet Air Sterilizer

Air sterilizer shall be of ductwork mount type. Each sterilizer shall consist of ultraviolet lamps, transformer with enclosure, lamp supporting rods and inspection glass window. Air sterilizer shall be operated on 220V/1ph/50Hz.

Air sterilizer shall have one pass bacteria removal efficiency at least 90%. The selection of UV air sterilizer shall be based on face air velocity, temperature and ductwork size. Detail selection methods shall be submitted to the Architect for approval.

The UV lamps shall be manufactured of special short-wave transmitting glass or quartz. The UV lamps shall emit UV at the 200nm to 300nm mercury spectral line, known as germicidal, or shortwave ultraviolet. Each lamp shall not consume power more than 40W but emit pure UVC irradiation not less than 120 micron meter/cm² measured at 1 metre from source after 100 hours burning at 25 °C. The total UV light intensity shall be not less than 360 micron W/cm² per 1.0 m³/s airflow measured at 1.0m from source.

The UV sterilizer lamps shall be positioned perpendicular to the air flow at velocity less than 5.0 m/s to allow maximum exposure. Access door with safety current-cut switch shall be provided to access the UV lamps. Suitable inspection window shall be provided on the equipment. Baffle type filters on the ductwork
openings shall be provided in case that direct UV light may be emitted out of the ductwork openings. Safety labels shall be provided on the ductwork access panel. Additional water-tight metal enclosure shall be provided to house the transformer enclosure if there is a chance of water spraying into the equipment.

The operating life of the UV lamps shall be at least 10,000 hours. The operation of the UV air sterilizer shall be interlocked with the blower/air handling unit such that the UV air sterilizer is operated when the blower/air handling unit is operated. The sterilizer shall be switched off with an indicator light on when the maintenance access is opened.

UV air sterilizer shall not generate ozone. Notwithstanding, the ozone level inside the plant area shall be less than 0.05ppm. Background ozone level shall be in compliance with ASHRAE, OSHA standards.

Safety precautions shall be taken in the installation and maintenance of the air sterilizer to prevent the leakage of UV light. When the UV exposure level exceeds 0.2 micron W/cm² over 8 hours, baffle filters shall be installed for those air discharge louvre to reduce UV light intensity level.

Remote control panel shall consist of circuit breaker, auto-off-manual switch, hour run meter, ampere meter, pilot lamp and fine-wire fuse.

On-site performance test shall be conducted to verify:

- The total bacteria count (TBC) removal efficiency
- Background UV intensity
- Ozone level

Pressure sensors shall be located at both upstream and downstream across filter section for PAU/AHU. When comparing the pressure differential of the upstream and downstream with reference to a reference value, the controller shall send either one of the following signals to the control panel :-

- Filter normal
- Filter leakage and alarm signal
- Filter clog and alarm signal

A5.5.6 Water Scrubbers

(a) General

(i) Horizontal cross flow fibreglass reinforced polyester (FRP) foul air water scrubber system shall be supplied and installed for central air treatment of odour, gas, liquid and solid contaminants prior discharge to outside of the building.
(ii) The water scrubber systems shall be outdoor type tailor-made and designed by a single recognised scrubber specialist as a complete package to suit the available space and in accordance with the specified performance and requirements in the Particular Specification. Every major components such as the fan, recycle pumps, scrubber section c/w packing, mist eliminator and nozzle shall be compatible 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, pipeworks, fan and ductwork connections.

(iii) Scrubber section shall be of horizontal draw-through cross-flow packed tower bed type with mist eliminator at the last section of the scrubber. Each complete scrubbing system shall comprise a scrubber section with recycle pumps, 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 Architect.

(iv) All material and components adopted in the scrubbing system shall be suitable for operation with selected chemicals including sodium hypochlorite, sodium hydroxide and the resulting by-products of scrubbing.

(v) Those items specified to be constructed of fibreglass reinforced polyester (FRP) resin shall conform to relevant BS or ASTM standards and shall be stabilised against ultraviolet degradation. This shall apply to the scrubbers and fan. The resin shall be Duracor 6000-6 series or products having equivalent functions or performance and approved.

(vi) All internal wetted bolts and fasteners, and all external bolts and fasteners including anchor bolts and flange bolts shall be high grade American Iron Steel Institute 316 stainless steel or products having equivalent functions or performance.

(vii) Scrubber section 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.

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The pumps shall be direct coupled to TEFC motor, self-priming, horizontal end suction, corrosion resistant and centrifugal type. Accessories such as pressure gauges, stop and vent cocks shall be provided for each pump. The flow rate shall be determined by the Contractor to suit the performance specification with adequate flow rate and pump heads to cater for the piping and scrubber paint friction losses.

The pump casing, impeller shall be of rigid PVC and the impeller shaft shall be of stainless steel approved by the Architect.

(b) Construction

(i) The mist eliminator section shall be replaceable, corrosion resistant packing, mesh type or other approved type fabricated of fibreglass reinforced polyester or products having equivalent functions or performance and approved. The eliminator section shall be in modular form of adequate surface area and strength to withstand the handling air flow area and pressure.

(ii) The scrubbing liquid distribution system shall be the spray type or other approved type, sized for the flow rate to suit the design of the scrubber system to meet specified performance. Material of construction shall be fibreglass reinforced polyester.

(c) Control

(i) The water scrubber system shall be capable of both automatic or manual operation. In “auto” mode, the central exhaust fan shall be started or stopped automatically. The scrubber exhaust fan shall be inter-locked with the recycle pumps’ operation such that it will not be operative unless the pumps are operating. The 2-way motorized valve and flow regulating valve at water feed-in pipe shall be provided and interlocked with the fan.

(ii) Chemical feed pumps shall dose proportionately to maintain the desired concentration of the scrubbing liquid. NaOH shall be controlled with pH analyzer to maintain a pH value of 8 to 9 while NaOCl shall be controlled with oxidation-reduction-potential (ORP) analyzer to maintain a ORP value of 300 to 400 mV or to
values recommended by the manufacturer in order to comply the performance specification.

(iii) 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 during low water level condition.

(iv) 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.

(v) 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.

(vi) In “manual” mode, the fan and pumps shall be operated by means of start/stop buttons at the water scrubber control panel.

(vii) Local and remote control panels shall be provided for the water scrubber systems as specified in the Particular Specification. 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.

(viii) In “Local” mode, the fan and pumps shall be operated by means of start/stop buttons at the local control panel.

(ix) Provision shall be provided for roller shutter for refuse collection point, poultry scalding room and other areas as specified in Particular Specification to interlock the operation of the roller shutter with the scrubber operation.

(x) The remote panel for the water scrubber system shall be of constructions as specified in the Particular Specification or products having equivalent functions or performance as approved and weather-proof suitable for outdoor installation.
Motor driven fans shall be provided for each scrubber unit and shall be of sufficient capacity and horsepower, as indicated in the Particular Specification 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 ducting.

Fans shall be of high efficiency and low speed backward curved 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 an fibreglass reinforced polyester (FRP) laminate using Duracor 6000-6 series or products having equivalent functions or performance as approved.

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 oversized 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 two directions according with recognised international standards.

The fan base shall be made of corrosion material of sufficient strength or carbon steel treated with anti-corrosion coatings approved by the Architect. No metal parts including bearing supports shall be exposed to the corrosive air stream.

Fans shall come complete with motors, drives, belts, FRP motor and drive canopy, housing drains, access doors and flexible connectors for inlet and outlet.
(viii) 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 nameplate horsepower of the motor furnished.

(ix) Each electric motor shall be suitable for 380 volts, 3 phase, 50 Hertz continuous 24 hours operation.

(x) The motor enclosure shall be totally enclosed, fan cooled and suitable for outdoor application.

(xi) The motors shall be designed, constructed and tested in accordance with all the requirements of the applicable standards of the IEEE, NEMA and ANSI.

(xii) The fan static pressure to suit the ducting configuration and proposed equipment with calculations shall be submitted for Architect’s approval.

(xiii) Acoustic treatment, such as silencers and acoustic enclosure, shall be provided to ensure the noise break out to adjacent areas is at an acceptable level complied with the requirement of Environmental Protection Department.

(xiv) Silencers shall be of packless type or to be complete with adequate coating and shall be suitable for the chemical corrosive environment. The exhaust fan and driving motor shall be housed in an acoustic G.I. sheet enclosure as specified in the Particular Specification.

(e) Chemical Feed System

(i) Each scrubber system shall be provided with a complete chemical feed system for storing and feeding the chemicals required. All adequate provisions shall be provided for the storage, installation and operation of the chemical solutions in compliance with the Fire Services 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.

(ii) 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 Fire Services Department, typically of 250 litres.

(iii) Chemical metering pumps shall be solenoid-operated diaphragm pump for the type of weatherproof protection. The pumps shall be operated on 220V/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 light-metal alloy die. Solenoid shall be proof 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 stroke frequency, accessories shall include PVC dosing valve and foot valve.

(iv) pH and ORP Control

Each scrubber shall be provided with pH and ORP probes located such for analyzing the contents in the scrubber sump. Probes shall meet the following table:

Table A5.5.6 Technical Requirement of Measuring Probes

<table>
<thead>
<tr>
<th></th>
<th>pH Probe</th>
<th>ORP Probe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>0 to 14pH</td>
<td>0 to 990mV</td>
</tr>
<tr>
<td>Stability</td>
<td>0.03pH units per day, non-cumulative</td>
<td>0.5mV per 24 hours, non-cumulative</td>
</tr>
<tr>
<td>Temperature</td>
<td>0 to 60°C</td>
<td>0 to 60°C</td>
</tr>
<tr>
<td>Pressure Rating</td>
<td>4.8 kPa</td>
<td>4.8 kPa</td>
</tr>
<tr>
<td>Wetted Materials</td>
<td>Glass</td>
<td>Glass</td>
</tr>
<tr>
<td>Accuracy Sensitivity</td>
<td>0.1 pH unit</td>
<td>5 mV</td>
</tr>
</tbody>
</table>

A5.6 CONFORMITIES OF IAQ DESIGN OBJECTIVE AND COMPLIANCE

One or more software tools for predicting the performance of the IAQ equipment and system shall be proposed by the Contractor and submitted to the Architect for approval. The proposed tool shall demonstrate the conformities of IAQ objectives performed by the IAQ equipment and system.

Testing and commissioning of IAQ equipment and system shall be carried out for the conformities of IAQ design objective and to the satisfaction of the Architect or to meet the requirements as stated in the Particular Specification.

The details of T&C work are detailed in Sub-section A9.19 – IAQ Equipment and System Test under Section A9: Inspection, Commissioning and Testing. Upon satisfactory completion of all the tests, a certificate of IAQ compliance
level of building according to the format and detailed requirements as specified in the Particular Specification shall be issued to the Architect.

A5.7 IAQ ASSESSMENT AND METHODOLOGIES

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 end of the Maintenance Period, i.e.,

(a) First Assessment - After testing & commissioning
(b) Second Assessment - Six months after occupation of building or substantial completion
(c) Third Assessment - Two months before the end of Maintenance Period

IAQ compliance shall be proved by results of measurements. In addition, an end user satisfaction survey shall be conducted before end of the Maintenance Period.

The details of measurements, assessment and methodologies are described in Sub-section A9.19 – IAQ Equipment and System Test under Section A9: Inspection, Commissioning And Testing.

A5.8 OPERATION AND MAINTENANCE

A5.8.1 O & M Matters

In addition to the contractual requirements of training, operation and maintenance as described in Section A10: Operation And Maintenance Requirements for the ACMV installation, similar requirements for Indoor Air Quality installation as mentioned below shall be met.

A5.8.2 Training Requirements

Facilities familiarization and training programme shall be provided to ensure that the owner’s operation and maintenance staff acquire full knowledge and appreciation of all aspects of the design, operation, breakdown attendance, routine maintenance and diagnosis of installation, which have effects on the indoor air quality.

A training proposal shall be submitted to the Architect for approval at least three months prior to completion of the ACMV installation. Training shall include both aspects of operation and maintenance as well as trouble shooting procedures and the use of special tools.

A5.8.3 Operation and Maintenance Requirements
Full responsibility shall be held for the following, in addition to those required for O&M of ACMV installation mentioned elsewhere in the specification, within the Contract Maintenance Period:

(a) Instruction to Employer’s O&M Staff

Training shall be provided to Employer’s staff involved in operation and maintenance to understand the design intent, to operate and to maintain the IAQ system correctly, to achieve and maintain the designed IAQ parameters. An O&M manual shall be prepared by a qualified personnel.

(b) Attendance to Faults and Complaints

IAQ faults and complaints shall be attended and rectified for arising from defective work and materials. Report shall be submitted to the Architect for these incidents.

(c) Periodical IAQ Audit with Logs and Records

Periodical IAQ audit shall be carried out as specified to ascertain the status of the IAQ parameters and submit records/logs with details such as date, results of audit, measurements and name of person conducting the audit to the Architect.

(d) IAQ Assessment as Specified with Logs and Records

In addition to the IAQ assessment during testing and commissioning, IAQ assessment shall be carried out six months after building occupation and at the end of the Maintenance Period. IAQ compliance shall be proved by results of measurements. In addition, a satisfaction end user survey report shall be submitted to the Architect for endorsement. According to the agreed end user report, an end user satisfaction survey shall be conducted before the end of the Maintenance Period.

A5.8.4 Maintenance Concept

IAQ maintenance should be an on-going exercise consisting of periodic IAQ assessment, identification of IAQ problems and deficiencies as well as follow-up IAQ improvement scheme to bring the IAQ to the designed and acceptable standard. The following are general maintenance items that need to be carried out regularly during the Maintenance Period:

Service requirements shall include functional inspection, cleaning, adjustment, sample test and rectification. The detailed arrangement shall be :-

(a) Monthly Services:
(i) Outdoor air intake equipment including screens and louvres
(ii) Air pre-filters
(iii) Cooling coils
(iv) All trays and sumps
(v) Condensate drains and water traps
(vi) Water cooling towers
(vii) Water treatment system

(b) Quarterly Services:

(i) Air dampers,
(ii) All types of filters including HEPA filters, electrostatic filters, chemical filters, carbon filters
(iii) Oxygen generators
(iv) UV light chambers
(v) Check system performance

(c) Half-yearly Services:

(i) IAQ sensors such as thermostat, humidistat, pressurestat, CO₂ sensors, air movement sensors
(ii) Humidifiers, dehumidifiers
(iii) Inspect all components of the ventilation system for cleanliness and microbial growth, and clean them as necessary
(iv) Volume control dampers

(d) Annual Services (before the end of Maintenance Period):

(i) Inspect and clean as necessary accessible parts of ductwork and air grilles
(ii) Fans, fan wheels, fan blades, belt drives
(iii) AHUs, fan coil units, VAV boxes and terminal units
(iv) Supply and return air plenums
(v) Variable speed drive control for fans
(vi) Inspect aluminium foil, paints or other concrete sealing layers and wall surface which are meant to stop radon gas emission and touch up if applicable

A5.9 HOUSEKEEPING AND ENERGY EFFICIENCY RELATING TO IAQ ISSUE

Indoor air quality is affected by the quality of maintenance and the materials used and procedures in operating and maintaining the building components including the ACMV system. Contractors who are familiar with building systems in general and with the features of the building in particular are important resources in preventing and resolving indoor air quality problems in the Maintenance Period.

To best respond to indoor air quality concerns, the Contractor shall have good understanding on how the building activities affect indoor air quality. The
housekeeping procedures in relation to the following items shall be carried out:

A5.9.1 Equipment Operating Schedules

(a) Confirm that the timing of occupied and unoccupied cycles is compatible with actual occupied periods, and that the building is flushed by the ACMV system before occupants arrive in accordance to the ASHRAE 62-1999 guidance on lead and lag times.

(b) Maintain essential ventilation or suitable air treatment in areas with long unoccupied periods to prevent mould growth in hot humid climates.

(c) Check control and use free air cooling mode at mild season.

A5.9.2 Control of Odours and Contaminants

(a) Maintain appropriate pressure relationships between building usage areas.

(b) Avoid recirculating air from areas that are strong sources of contaminants (e.g. smoking lounges, chemical storage and printing areas).

(c) Ensure adequate local exhaust depending on different sites and as specified in the Particular Specification for activities that produce odours, dust, or contaminants, or confine those activities to locations that are maintained under negative pressure (relative to adjacent areas).

(d) Make sure paints, solvents and other chemicals not being stored in the ACMV plant rooms.

(e) Maintain regular maintenance depending on different sites and as specified in the Particular Specification on local filter traps and adsorbents.

(f) Carry out routine cleansing with dry steam only.

A5.9.3 Ventilation Quantities

(a) Compare outdoor air quantities to the building design goal and the IAQ targets, and make adjustments as necessary and the adjustments should be carried out without compromising the IAQ objectives.

(b) Compare ventilation rates to ASHRAE 62-1999 and make adjustments as necessary and the adjustments should be carried out without compromising the IAQ objectives.
A5.9.4 ACMV Equipment Maintenance Schedules

(a) Inspect all equipment regularly as per manufacturers’ recommended maintenance schedule to ensure that they are in good condition and are operating as designed (i.e. as close to the design setpoints for controls as possible).

(b) Provide scrupulous maintenance on components that are exposed to water, e.g. drainage pans, coils, cooling towers, humidifiers, etc. to prevent microbiological growth and the entry of undesired microbiological organisms chemicals into the indoor airstream.

A5.9.5 ACMV Inspection

(a) Prepare checklists for thorough inspection of the ACMV equipment in the building to avoid missing items such as small exhaust fans may operate independently from the rest of the ACMV system and are often ignored during inspections.

(b) Maintain proper records on alteration/addition/removal of the ACMV installation for reference on IAQ impact due to changes in function, capacity, or operating schedule.

(c) Maintain proper records on occupant complaints on ACMV services for easy comparison if IAQ problems arise.

A5.9.6 Building Maintenance Schedule

(a) Schedule maintenance activities that interfere with ACMV operation or produce odours and emissions (e.g. painting, false ceiling or roofing operations) so that they are executed when the building is unoccupied.

(b) Inform occupants when such activities are scheduled and, if possible, use ventilation to ensure that ductwork and odours are confined to the work area.

A5.9.7 Preventive Maintenance

Provide adequate preventive maintenance and prompt attention to repairs of the ACMV equipment in order to maintain the ACMV systems in suitable control conditions so as to deliver good indoor air quality.

(a) General elements of preventive maintenance plan shall include:

(i) Periodic inspections, cleaning, and service as warranted
(ii) Adjustment and calibration of control system components
(iii) Maintenance equipment and replacement parts that are of good quality and properly selected for intended function

(b) Critical ACMV system components that require preventive maintenance in order to maintain comfort and deliver adequate ventilation air shall include:

- Outdoor air intake opening
- Damper control
- Air filters
- Drip pans
- Cooling and heating coils
- Fan belts
- Humidification equipment and controls
- Distribution system
- Exhaust fans

Provide adequate training to the maintenance staff to ensure that they have adequate understanding of the overall system design, its intended function, and its limitations.

A5.10 TRAINING AND LICENSING REQUIREMENTS

Training and licensing are required for IAQ workers carrying out IAQ installation, testing and commissioning, assessment and measurement, operation and maintenance or personnel supervising these works.

Recognized training includes training and certificates from the following:

- Relevant professional or academic institutions
- Vocational Training Council
- Equipment supplier
- Other training organizations recognized and accepted by the Architect

Installation, testing, commissioning, assessment, measurement, operation and maintenance shall be carried out by IAQ licensed personnel who must have recognized training or adequate experience accepted by the Architect.

A5.11 CERTIFICATION AND REGISTRATION

IAQ assessment shall be carried out upon completion of ACMV installation, six months after occupation of the building or substantial completion and at the end of the Maintenance Period. After each assessment, a report will be issued by the Contractor recording the measurement made and the readings taken from the IAQ parameters as specified in the Particular Specification. Before expiry of Maintenance Period, in addition, the Contractor shall also carry out an IAQ satisfaction survey to ascertain the situation of the IAQ in
the building and the feedback of the occupants. Quantity of survey and report on satisfaction survey shall be submitted to the Architect for approval.

For each of the three assessments, 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 (IAQ compliance or not) and the readings obtained shall be reported. The report forms shall be submitted and approved by the Architect one month before the measurement and assessment are proceeded. These Forms shall be endorsed by the responsible personnel of the Contractor, who must be a qualified personnel under any one of the following categories. Endorsed Forms (verifying IAQ compliance) shall be submitted to the Architect who will then verify that the installation complies with the relevant IAQ requirements.

Recognized qualified personnel for assessing and verifying IAQ compliance shall be:

A5.11.1 Registered Professional Engineer in building services or mechanical discipline under the Engineers Registration Ordinance (Cap. 409) or

A5.11.2 Person with other approved and recognized qualification and/or experience as accepted by the Architect.

After verification of IAQ compliance, a Certificate of Compliance and guidelines for maintaining IAQ level shall be issued to the Employer.
A6.1 GENERAL

All equipment provided by the Contractor for the air conditioning and ventilation installation shall conform to the energy efficiency and energy conservation requirement as stipulated in this General Specification and the Codes of Practice for Energy Efficiency of Air Conditioning Installations and for Electrical Installations issued by Electrical and Mechanical Services Department.

In case of any non-compliance, the Contractor shall submit full justification with technical data supporting the deviation from the requirements as specified in this General Specification and the Codes of Practice for Energy Efficiency of Air Conditioning Installations and Electrical Installations issued by Electrical and Mechanical Services Department.

The Contractor shall also refer to other Sections of this General Specification for the energy saving provisions.

A6.2 MINIMUM COEFFICIENT OF PERFORMANCE (COP) OF MAJOR AIR CONDITIONING AND VENTILATION EQUIPMENT

All major air conditioning and ventilation equipment shall have the minimum COP for both cooling and heating meeting the requirement as stipulated in this General Specification and the Codes of Practice for Energy Efficiency of Air Conditioning Installations and Electrical Installations issued by Electrical and Mechanical Services Department.

The Contractor shall submit documents and calculation showing the minimum COP for both cooling and heating of the following major air conditioning and ventilation equipment:-

- Air-cooled unitary air conditioner
- Water-cooled unitary air conditioner
- Air-cooled water chiller or heat pump with reciprocating compressor
- Air-cooled water chiller or heat pump with centrifugal compressor
- Air-cooled water chiller or heat pump with screw or scroll compressor
- Water-cooled water chiller or heat pump with reciprocating compressor
- Water-cooled water chiller or heat pump with centrifugal compressor
- Water-cooled water chiller or heat pump with screw or scroll compressor
- Total energy heat pumps utilising both cooling and heating output
- VRV with simultaneous cooling and heating
The Contractor shall note that the system energy shall be the main sources of energy in achieving the HKSAR’s IAQ Objectives as specified under Section A5 of this General Specification. Energy discharged to the environment shall be kept to minimum. Energy reclaim from the heat dissipating condenser and from the air conditioning exhaust shall be incorporated wherever practical. Electric reheat or re-heating using hot water boilers without recapturing the wasted energy shall not be accepted. The Contractor shall refer to the Contract Drawings and Particular Specification for exact requirements and details. The Contractor shall also check with the major equipment manufacturers and submit proposal in relating to the wasted energy recapture as specified in the Contract Drawings and Particular Specification to the Architect for consideration.

A6.3 MINIMUM EFFICIENCY OF FANS, PUMPS AND MOTORS

The minimum energy efficiency of all electrical driven motors shall comply to the requirements as specified in Section C7 of this General Specification.

The minimum efficiency of pumps and fans shall comply to the requirement as specified in Sections C3 and C13 of this General Specification.

The Contractor shall note that the minimum efficiency specified in this General Specification shall be the absolute minimum requirement. All enhanced or higher quality of products shall be offered if available.

A6.4 DEHUMIDIFIER

All dehumidifiers specified in the Particular Specification shall comply to the minimum energy efficiency as specified in this General Specification unless otherwise specified in the Particular Specification. The fresh air pre-conditioner system employing wasted energy recovery equipment shall conform to the followings :-

A6.4.1 Specification of Desiccant Type Fresh Air Pre-conditioner

(a) General

The pre-conditioner shall comprise a 3Å molecular sieve Potassium Aluminosilicate coated total energy wheel, an exhaust fan, a fresh 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.

(b) Casing

(i) The casing shall be constructed from 1 mm (Gauge 20) galvanized 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.

(ii) 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.

(iii) Four sets of 230 mm diameter flanged collars shall be provided for the connection of fresh air, supply air, return air and exhaust ductworks.

(iv) A control panel shall be provided in the casing, together with termination blocks, for the connection of electricity supply.

(c) Fan and Motor

(i) The fresh air and exhaust air fans shall be single inlet, single width, forward curve centrifugal fans. The blades shall be designed for maximum efficiency and quiet operation. 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.

(ii) The motor shall be standard NEMA frame with open drip-proof enclosure and shall be suitable for 220V, single phase, 50 Hz electricity supply.

(iii) The motor shall have the minimum efficiency complying to Section C7 of this General Specification.

(d) Total Heat Recovery Wheel

(i) 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.

(ii) 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.

(iii) 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.
(iv) 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.

(v) 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 ASHRAE 84-78P and ARI1060 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.

(vi) 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.

(vii) The media shall be designed to induce laminar flow under all conditions inside the flutes and to enable the flutes to be self-cleaning (e.g. purging).

(viii) The wheel shall be independently tested; shall conform with the requirements of NFPA-90A and shall have a flame spread less than 25 and a smoke developed less than 50 when both rated in accordance with ASTM E84.

(ix) The cross leakage of wheel shall not be greater than 5% of total air flow.

(e) Filter

(i) The filter shall be of washable type and about 25 mm in thickness.

(ii) The filter shall be listed by Underwriters laboratories as Class 2 and the filter efficiency shall be 30% to ASHRAE 52-76 standard.

(f) Purge Sector
(i) A purge sector shall be provided in the wheel so that the exhaust air shall not be carried over to the supply air.

A6.4.2 Specification of Paper Plate Type Fresh Air Pre-conditioner

(a) The paper plate type fresh air pre-conditioner shall be the product from a manufacturer holding the quality assurance standards of ISO 9001/9002 or products having equivalent functions or performance.

(b) The pre-conditioner shall comprise supply air fan, exhaust air fan and resin net (washable) filter. Each pre-conditioner shall comprise an non flammable heat exchange element as the media for the enthalpy exchange between outdoor air intake and exhaust air. The pre-conditioner shall be designed for cross flow type with a high durability and reliability, a high performance and low pressure loss type.

(c) The pre-conditioner shall transfer both sensible and latent heat with same effectiveness and shall not support bacteria growth.

(e) 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.

(f) The pre-conditioner shall have 3-steps air flow rate changeover.

(g) 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.

(h) The casing shall be made of galvanized 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 the Sections B11 and C11 of this General Specification.

(i) The energy efficiency of the motor of the pre-conditioner shall comply to the requirements as specified in Section C7 of this General Specification.
All sensing device for monitoring the air quality shall comply with Sub-section C4.4.6 of this General Specification.

**A6.6 MOTION DETECTING SENSING DEVICE**

In case of motion detecting system controlling the air conditioning supply to the conditioned space is specified, the motion detection sensor shall meet the following requirements:

**A6.6.1** Movement detectors shall be of passive infrared microwave verified type which shall detect movement by passive infrared technology and also by microwave technology. Reaction of A/C control system shall only be activated if both the passive infrared and microwave components of the sensor have been activated within a specified time.

**A6.6.2** For the passive infrared component, the detectors shall keep constant monitoring of the ‘thermal pattern’ of the controlled area. Any change of the infrared energy within the controlled area shall trigger the control of the passive infrared component. The infrared beam shall not penetrate glass, thin wall or plastics.

**A6.6.3** The microwave component shall keep constant monitoring of the controlled 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 controlled area or volume.

**A6.6.4** The range of detection shall be adjustable from 6m to 20m, the pattern of detection shall be 90° adjustable ±45° horizontally and -7° vertically. The velocity of the target to be detected shall be 0.15 – 3 m per second.

**A6.6.5** The sensitivity of the passive infrared component shall be 2°C at a target velocity of 0.6 m per second.

**A6.6.6** The electronic circuit of the detectors shall be protected against high level radio frequency interference, and shall be insensitive to thermal and optical source of interference.

**A6.6.7** LED signals indicating trouble shall be lit upon

(a) Excessive temperature

(b) Fall in input voltage below the correct performance of the detector is assured

(c) Interruption of microwave operation, e.g. due to masking or failure of the microwave component

**A6.6.8** A LED shall be provided to indicate on/off status of the walk test mode.
A6.6.9 The electronic circuit of the detectors shall be protected against high level radio frequency interference.

A6.6.10 The detector shall be one piece and shall be housed in a tamper-proof housing with tampering switches. Alarm signal shall be sent to Intelligent Local Controller when the housing is tampered.

### A6.7 DEVICES FOR ENTHALPY CONTROL OF FREE AIR COOLING

In case of free air cooling and enthalpy control is specified, the system shall meet the following requirements:

A6.7.1 The free air cooling control system shall be energised to monitor the system conditions when the supply air fan of air handling unit is turned on.

A6.7.2 The system shall have an exhaust air fan extracting return air under free air cooling operation.

A6.7.3 Motorised control exhaust air damper shall be installed at the exhaust air outlet and normally opened at preset position. This exhaust damper shall be interlocked with the exhaust air fan and fully opened under the free air cooling operation.

A6.7.4 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 and fully closed under the free air cooling operation.

A6.7.5 Motorised fresh air supply damper shall have minimum setting to provide the minimum fresh air supply to the system and shall be fully opened under the free air cooling operation.

A6.7.6 Temperature and humidity sensing devices shall be provided in the fresh air supply intake to monitor the fresh air conditions. These sensing devices shall provide all necessary information to the system controller which shall determine and operate the free air mode when conditions meet with the specified criteria.

A6.7.7 Temperature and humidity sensing devices shall also be installed in the downstream of the supply air fan to monitor the supply air conditions. The control system shall allow the top priority to these sensing devices to override the signal of free air cooling when the conditions of the supply air fails to meet with the specified condition.

A6.7.8 All sensing devices shall comply with the requirement as stipulated under Sub-section C4.4.6 of this General Specification.

A6.7.9 The details and final configuration of free air cooling system shall comply with the criteria specified under the Particular Specification.
A7.1 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.):-

A7.1.1 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;

A7.1.2 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,

(b) To sterilize the water to prevent biofouling and the growth of pathological bacteria such as Legionella Pneumophila;

A7.1.3 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 and subject to the approval of the Architect.

A7.2 FORM OF WATER TREATMENT

Where the types of treatment and plant are fully detailed in the Particular Specification, the Contractor shall install the plant and equipment as required.

Where no system or treatment is specifically detailed in the Particular Specification, the Contractor shall provide a basic system in accordance with Sub-sections A7.4, A7.5 or A7.7 as appropriate.

The Contractor shall submit drawings and technical information detailing the set-up of the proposed water treatment equipment, the type of chemicals used and the treatment proposal to the Architect 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.
The Contractor shall supply the necessary labour, testing equipment and chemicals for testing and commissioning, pre-cleaning and day-to-day water treatment of the systems within the Contract Period. In addition, the Contractor shall also allow for continuing the treatment for the whole of the 12 months Contract Maintenance Period until the Maintenance Certificate is issued.

During the above period, the Contractor shall employ the water treatment specialist to carry out at least one on-site water treatment service and water analysis for each month to prove that the performance of the treatment system is satisfactory and conforming with the approved treatment proposal. Reports of such tests, related treatment, consumption of chemicals etc. shall be forwarded to the Architect each month.

A7.3 **SEA WATER TREATMENT BY ELECTROCHLORINATOR**

Systems designed for the injection of sodium hypochlorite solution produced on-site by an electrochlorinator shall only be installed by the Contractor where required and fully detailed in the Particular Specification. Such 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 5 ppm maximum. 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 must 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 required to ensure continued treatment when one unit is 'off-line' for maintenance.

The 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 Fire Services Department’s statutory requirements.

An adequate electrical supply point will be made available to the equipment plant room by others. The electrical supply requirement and its connection to the electrochlorinator shall be carried out by the Contractor.
Where no other system is specified and unless otherwise instructed by the Architect, this method shall be included by the Contractor as the basic form of treatment for condenser cooling sea water applications.

### A7.4.1 Basic Requirements

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 specifications of 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 application by chemical metering pump with or without dilution.
- Being sufficiently bio-degradable such that they do not cause environmental difficulties for the marine life. In that respect they must be of a type acceptable and approved by the HKSAR Environmental Protection Department or relevant Government Authorities.

### A7.4.2 System Sizing and Design

The advice of approved water treatment specialist shall be sought on the dosages required, together with calculation, for a specified systems water volume.

In some cases where fixed sea water pumped quantities apply, metering pumps can be set for a particular input rate to achieve the appropriate dosage and duration. In such cases it is usually possible to pump biocide direct from its supply container.

Where variable pumping flows exist, then the metering pump/pumps concerned shall have the facility to automatically vary the amounts of chemicals pumped in to correspond in proportion with the actual sea water flow. This can be achieved by metering pumps which respond to the reading of a flowrate sensor.
inserted into the main sea water pipe. Variable pumping rates shall be required where a number of pumps are 'stage' controlled or where individual pumps are being 'speed' controlled.

Alternatively, sets of sea water pumps can be supplied with fixed biocide input from one metering pump per main sea water pump with inlet before the pump and as near as possible to the primary inlet sea water gate valve. Such metering pumps would be controlled from the individual pump circuit such that they only operate when their respective pump is operated.

Sets of pumps can also be supplied with a single source variable duty metering pump controlled from a flow metering device placed after the main header outlet. In such cases the chemical injection shall be distributed to all pump inlets via solenoid valves with each controlled to open when their respective main sea water pump is switched on.

A7.4.3 Flow Measurement and Control

The flow measuring device shall be of a low flow interference inserted velocity / static differential headed type as described more fully in Section C10.

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 not less than a length of 12 pipe diameters downstream from any bend or other 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.

A7.4.4 Biocide Storage

Apart from the necessity to periodically replenish the biocide supply, the installation shall otherwise be capable of catering for minimum 4 weeks unmanned automatic operation. Where the use of the biocide manufacturer’s container is considered by the Architect as inappropriate for the purpose, duplicate chemical tanks shall be provided to the following specification.

A7.4.5 Chemical Tanks

The Contractor shall supply and install two number made of chemical mixing tanks of ultra violet resistant round moulded fibre glass or polyethylene. Each tank shall not be less than 180 litre capacity.

The tanks shall be completed with cover of high rigidity fibre glass or polyethylene having suitable moulded recessed or other approved arrangements to support mountings of metering pump, agitator and liquid level controller switch.

The tanks shall be graduated in 10 litre steps.
The tanks shall be suitable for mixing the chemicals specified and though normally operated at approximately ambient plantroom temperatures, they shall nevertheless 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.

A7.4.6 Chemical Tube Connection to the Circulation System

Unless otherwise instructed by the Architect, the Contractor shall allow for drilling and tapping into the delivery pipe at points near to the sea water intake and installing a suitable sized PVC valve complete with connectors for attachment of the chemical tubes from the metering pumps.

A7.4.7 Make Up Water Supply to Chemical Tanks

Unless otherwise specified, this shall take the form of a 18 mm bib tap situated over each chemical tank. The Contractor shall provide a suitable supply to these bib taps with pipework securely fixed to the walls. A 25 mm mains valved supply will be provided by others within a 30 metres pipe run of the tanks. The Contractor shall also supply suitable lengths of chemical resistant flexible hose from bib taps to the tanks to facilitate the filling operation.

A7.4.8 Chemical Metering Pump

In conjunction with the chemical tanks, the Contractor shall provide panel or tank-top mounted high efficiency metering pumps one per tank 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 Architect. Chemical pump shall have on-off switch and protection fuse.

The pumps shall be suitable for 100 : 1 output range facilitated by means of independently variable stroke length and stroke frequency.

Pump housings shall be of corrosion resistant glass fibre reinforced polypropylene and all electrical/electronics 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.

The pump suctions shall be mounted into the tank using a 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.

A7.4.9 Chemical Tank Agitator

The Contractor shall supply and install into the provisions made on the chemical mixing tank cover one agitator assembly per mixing tank.

This shall consist of a fractional HP 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.

The motor casing and screws shall be manufactured in non ferrous metal.

A7.4.10 Chemical Tank Liquid Level Switch

In order to prevent the metering pump and agitator from running if the mixing tank becomes empty, the Contractor shall supply and install into each tank cover a suitable liquid level switch and control system. An 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.

The liquid level switch casing shall be manufactured from corrosion resistance material.

A7.4.11 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 by the Contractor from the supply point within the plant room to the water treatment equipment.

A7.5 COOLING TOWER/CONDENSER COOLING WATER TREATMENT BY CHEMICAL AGENTS

Where no other system is specified in the Particular Specification, this method shall be included for by the Contractor as the basic form of treatment for water recirculating between cooling tower and condenser applications. The minimum provisions shall be follows:

A7.5.1 Pre-cleaning and Flushing Out Operation
(a) The entire cooling tower/condenser cooling water system shall be flushed out using appropriate chemical dispersant, detergent and de-foamer 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.

(b) 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 Architect.

(c) 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 Architect's approval.

(d) The system water shall be completely drained as rapid as possible and the Contractor shall provide temporary 50 mm valved drain outlets on all points where the main pipework is 50 mm or over.

The Contractor shall ascertain that there is adequate drainage nearby to discharge to by large hose in order to ensure flooding of low level areas will not occur.

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 Contract Drawings. The system shall be refilled and flushed as necessary to achieve the required water quality level.

A7.5.2 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.

A7.5.3 Chemical Dosage System

The chemical dosage system shall be a fully automatic system comprising the following minimum equipment:
(i) Chemical metering pump as specified in Sub-section A7.4.8 and control panel constructed to IP 54 to BS EN 60529 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.

(ii) Chemical tanks as specified in Sub-section A7.4.5.

(iii) Chemical tank liquid level switch as specified in Sub-section A7.4.10.

A7.6 COOLING TOWER/CONDENSER COOLING WATER TREATMENT BY OZONE

This method of water treatment for fresh (well water) or sea water circulating between cooling tower and condenser shall only be installed by the Contractor where required and fully detailed in the Particular Specification. The minimum provisions shall be follows:

A7.6.1 Pre-cleaning and Flushing out Operation

As specified in Sub-section A7.5.1.

A7.6.2 Ozone Generation System for Cooling Water Treatment

The ozone generation system shall include all major ozone generating equipment, circulating pumps, interconnecting piping, pipe fittings, enclosure, wiring, accessories, control 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.

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 or 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 timer control incorporated. Multiple injection points shall be adopted for cooling systems with turnover rate not more than four times per hour.

Unless otherwise specified, the Contractor shall be fully responsible for 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. The ozone dosage rate shall not be less than 0.1 mg/litre 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 Architect for
approval before placing order and actual commencement of installation works.

Each 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 injector, solid particle separator, circulating pumps, pipings, pipe fittings, all necessary accessories, wiring, control and instrumentation. The modular enclosure shall be designed for ease of maintenance and safe operation with demountable panels, hinged doors, visual panels and adequate electrical segregation for the high voltage section.

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 Contract Drawings if specified in the Particular Specification and properly connected to the ozone generation system.

All components in contact with ozone produced shall be made of ozone resistant material designed for continuous and prolonged usage without deterioration or damage. 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.

Major 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 tanks 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 become 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 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:

(i) Voltage ratio and phase relationship test;
(ii) Induced over-voltage withstand test;
(iii) Insulation resistance test;
(iv) High voltage withstand test.

Minimum safety controls shall be provided as follows:

- 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);
- Isolation of power supply when panel doors or side panels are opened.

Unless otherwise specified, water-cooled type ozone generator shall be offered; air-cooled type modules shall only be offered for low capacity ozone generator unit or as specified in the Particular Specification. The cooling water shall be taken from the chilled water system of the building as indicated in the Contract 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.

(c) In-line Injector or Contactor
The in-line injector shall be venturi type complete 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.

(f) 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 Contract Maintenance Period.

(g) On Site Operational Training

Familiarisation of equipment and on-site training of the whole ozone water treatment system shall comply with the requirements in Sub-section A7.9 of this General Specification. In addition, a competent specialist of the ozone system shall hold the on-site training of the water treatment system.

**A7.7 CLOSE CIRCUIT CHILLED WATER OR LOW PRESSURE HOT WATER HEATING SYSTEMS TREATMENT BY CHEMICAL AGENTS**

Where no other system is specified in the Particular Specification, this method shall be included for by the Contractor as the basic form of water treatment for the close circuit chilled water or hot water heating system applications.

The minimum provisions shall be as follows:

A7.7.1 Pre-cleaning and Flushing Out Operations

As specified in Sub-section A7.5.1.
A7.7.2 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 should 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 Architect, have the following characteristics :-

- Suitable for the application, system operation conditions and fluid.
- Non-flammable.
- Low toxicity.

A7.7.3 Chemical Dosage Equipment

As specified in Sub-section A7.5.3.

A7.8 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 Contract 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 total dissolved solid and corrosion inhibitor level tester.

A7.9 TRAINING, OPERATION AND MAINTENANCE FACILITIES

No matter which type of water treatment system is offered, adequate on-site operational training and demonstration of the water treatment system shall be provided to the operation and maintenance staff prior to handover of the system or after completion of the installation. It shall include but not limit to the following:

A7.9.1 Familiarisation of equipment and system including function of each dosing chemical.

A7.9.2 Water treatment equipment set-up/adjustment.
A7.9.3 On-site training of water sampling and testing, equipment and system operation and maintenance procedures.

A7.9.4 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. The exact training requirement shall be submitted by the Contractor to the Architect for endorsement.

The Contractor shall provide prominent warning notices, goggles, gloves and necessary accessories for handling the chemicals.

Sufficient number of sampling points in the pipework or equipment for water analysis, routine inspection and testing shall be provided.

A7.10 PRE-TREATMENT FOR DUMPING OF CHEMICAL WASTES

All chemical waste for the water treatment shall be pre-treated in accordance with the latest requirements issued by Environmental Protection Department. The Contractor shall submit proposal including the treatment and dumping location of the chemical waste to the Architect for approval prior to the dumping exercise.
A8.1 GENERAL

All surfaces, other than those indicated to be left self finished such as stainless steel, anodized 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. All work shall be carried out by qualified tradesmen.

Water based paints with reduced volatile and preservative content or paints with reduced solvent content formulated for minimal Volatile Organic Compound (VOC) emissions complying with reputable international standards shall be used in occupied areas and renovated areas without good natural ventilation. In addition, all paints shall contain no mercury, lead, hexavalent chromium or cadmium compounds.

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 minimize VOC exposure.

All surfaces shall be painted and finished as specified in the Particular Specification to meet and match the aesthetic architectural design as required.

A8.2 COPPER PIPE AND FITTING

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.

A8.3 IDENTIFICATION OF PIPELINES

All pipework in the plant/machinery rooms shall be finished generally in accordance with ISO 3864. All pipework, where exposed on surfaces outside the plant/machinery room, shall be painted either as in the plant/machinery room or to match the surrounding surface with distinguishing surface with distinguishing colour code bands plus flow arrows in the specified colour scheme as directed by the Architect.

Pipes and pipelines shall be painted in colours either in accordance with ISO 3864 or as directed by the Architect complete 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, service appliances, bulkheads, wall penetrations and at any other places where identification is necessary as directed by the Architect.
Valves may be painted in the same colour as the associated pipework. However, if the pipeline is part of the fire services installation and has been coded only with the safety colour, the valves involved shall be fully painted 'safety-red'.

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.

A8.4 MACHINERY AND PIPEWORK

All machinery, unless otherwise specified, shall be finished in a colour as instructed by the Architect at the time of installation. The Contractor shall seek the Architect’s instructions 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.

A8.5 NUMBER OF PAINT COATS REQUIRED

All painted surfaces are to receive at least one primer coat and two coats of the finishing colour. Ferrous surfaces shall receive one primer coat of red zinc or zinc chromate, one under-coat and two finishing coats.

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.

A8.6 PIPES AND DUCTWORK

The final external treatment for insulated pipes and ductwork shall be as specified in Section C11 of this General Specification or as indicated in the Particular Specification or as directed on site by the Architect.

Pipes and ductwork concealed in false ceiling or ductwork not normally accessible need not be painted, unless otherwise specified in the Particular Specification but appropriate colour code identifications shall be applied.

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 Architect in 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 Architect but identified with appropriate colour code bands.
A8.7 PROTECTION OF PLANT, EQUIPMENT, PIPEWORK, ETC.

A8.7.1 Temporary Dehumidifiers and/or Air Conditioners

For temperature and/or humidity sensitive electrical or electronic control panels and equipment, the Contractor shall where necessary protect them against high humidity and/or temperature by operating portable or temporary dehumidifiers and/or air conditioners in the enclosures containing these equipment.

In order to protect these equipment against dust infiltration, the Contractor shall store them 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.

A8.7.2 Metal Surface

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 Contractor shall ensure that the standard of protection provided originally is re-applied at the earliest possible time.

A8.7.3 Rust and Foreign Matter

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.

A8.8 PROTECTIVE MEASURES AGAINST CORROSION

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.

For protection against system internal corrosion, chemical treatment of the internal water as described in Section A7 of this General Specification shall be applied. The provision of sacrificial anodes and bonding to eliminate electrolytic action shall also be applied wherever applicable.
A8.9 SCHEDULE OF COLOURS

Colour schedule as stated below are those of BS 4800 for ready mixed paints.

Table A8.9 – (1) Schedule of Colours

<table>
<thead>
<tr>
<th>Description of Services</th>
<th>Basic Colour</th>
<th>Colour Code Indication 100 mm approx.</th>
<th>Basic Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipework:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drinking</td>
<td>Green</td>
<td>Blue</td>
<td>Green</td>
</tr>
<tr>
<td>Cooling (Primary)</td>
<td>Green</td>
<td>White</td>
<td>Green</td>
</tr>
<tr>
<td>Boiler Feed</td>
<td>Green</td>
<td>Crimson</td>
<td>White</td>
</tr>
<tr>
<td>Condensate</td>
<td>Green</td>
<td>Crimson</td>
<td>Emerald Green</td>
</tr>
<tr>
<td>Chilled</td>
<td>Green</td>
<td>White</td>
<td>Emerald Green</td>
</tr>
<tr>
<td>Mains supply, Cold</td>
<td>Green</td>
<td>White</td>
<td>Blue</td>
</tr>
<tr>
<td>Mains supply, Hot</td>
<td>Green</td>
<td>White</td>
<td>Crimson</td>
</tr>
<tr>
<td>Sea, river Untreated</td>
<td></td>
<td></td>
<td>Green</td>
</tr>
<tr>
<td>Fire Fighting</td>
<td>Green</td>
<td>Safety Red</td>
<td>Green</td>
</tr>
<tr>
<td>Gases</td>
<td></td>
<td></td>
<td>Yellow ochre</td>
</tr>
<tr>
<td>In either gaseous or liquefied condition (exception)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compressed Air</td>
<td></td>
<td>Light blue</td>
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</tr>
<tr>
<td>Steam</td>
<td></td>
<td>Silver grey</td>
<td></td>
</tr>
<tr>
<td>Oil Lubricating</td>
<td>Brown</td>
<td>Emerald Green</td>
<td>Brown</td>
</tr>
<tr>
<td>Gas</td>
<td>Town</td>
<td>Yellow ochre</td>
<td>Emerald Green</td>
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<tr>
<td>Drainage</td>
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<td></td>
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<td>Acids &amp; Alkalines</td>
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<td>Violet</td>
<td></td>
</tr>
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<tr>
<td>Plant</td>
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<td>Opaline Green</td>
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<td>Electrical conduits &amp; Ductwork</td>
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</tr>
<tr>
<td>Ductwork</td>
<td></td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Fire Fighting</td>
<td></td>
<td>Safety red</td>
<td></td>
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<td>(1) Basic identification colours</td>
<td>BS 4800</td>
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<td>----------------------------------</td>
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<tr>
<td>Green</td>
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<tr>
<td>Silver grey</td>
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<td>Violet</td>
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<td>20E51</td>
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<tr>
<td>Black</td>
<td>00E53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orange</td>
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<table>
<thead>
<tr>
<th>(2) Safety Colour</th>
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<tr>
<td>Red</td>
<td>04E53</td>
</tr>
<tr>
<td>Yellow</td>
<td>08E51</td>
</tr>
<tr>
<td>Auxiliary blue</td>
<td>18E53</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(3) Code indication colour</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crimson</td>
<td>04D45</td>
</tr>
<tr>
<td>Emerald green</td>
<td>14E53</td>
</tr>
<tr>
<td>Yellow</td>
<td>10E53</td>
</tr>
</tbody>
</table>
A9.1 GENERAL

Throughout the execution of the installation, the Contractor shall be responsible for ensuring compliance with the Regulations included in Section A2 and shall notify the Architect of any infringement which directly or indirectly detracts from the safe and satisfactory operation of the installation(s) whether or not such infringement relates to the works covered in the Contract or to those associated with others.

A9.2 COMMISSIONING AND TESTING - DEFINITIONS

For the purpose of this General Specification the following definitions shall apply:

A9.2.1 Commissioning: the advancement of an installation from the stage of static completion to full working conditions and to meet the specified requirements. This will include setting into operation and regulation of the installation.

A9.2.2 Setting to work: the process of setting a static system into motion.

A9.2.3 Off-site Tests: tests carried out on items of equipment at manufacturer’s works or elsewhere to ensure compliance with the requirements of Specifications and/or relevant Standards or Codes of Practice (or other standards specified).

A9.2.4 Site Tests: tests on static plant and systems (e.g. inspection and testing of welds, hydraulic testing of pipework, etc.) to ensure correct and safe installation and operation.

A9.2.5 Regulation: the process of adjusting the rates of fluid flow and heat transfer in a distribution system within specified tolerances as stated in the relevant CIBSE Commissioning Code.

A9.2.6 Performance Testing: the measuring and recording of the performance of the commissioned installation.

A9.3 COMMISSIONING AND TESTING - GENERAL

A9.3.1 Any defects of workmanship, materials and performance, maladjustments or other irregularities which become apparent during commissioning or testing shall be rectified by the Contractor at no cost to the Employer and the relevant part of the commissioning or testing procedure shall be repeated at the Contractor’s expenses.
A9.3.2 The entire commissioning and testing procedure shall be undertaken by the Contractor’s own competent specialist staff or by a competent Independent Commissioning Specialist nominated by and acting for the Contractor and approved by the Architect.

A9.3.3 Where specified in the Particular Specification, the Contractor shall nominate a competent independent Specialist to conduct commissioning work.

A9.3.4 Where specified in the Particular Specification, the Contractor shall employ an approved specialist commissioning and testing firm who shall be named in the returned Tender Documents.

A9.3.5 At the appropriate time in the Contract, usually within the first three months, the Contractor shall furnish the Provisional Commissioning and Testing Programme, methods, procedures and formats of test records to the Architect. This shall be updated as the work progresses towards completion.

A9.3.6 Unless otherwise indicated, all electricity, main water and other fuels, such as town gas, necessary for the operation of the plant during preliminary runs and for full adjustments and commissioning tests will be provided at no cost by the Contractor unless otherwise specified in the Contract.

A9.3.7 If considered appropriate, the Contractor shall be required to carry out demonstration to dismantle those parts/components of the installation which are considered difficult/impossible for maintenance access. The Contractor shall be responsible for carrying out all necessary modification work at no extra charge to the Employer to alleviate the difficulties associated with dismantling or maintenance access.

A9.4 GENERAL COMMISSIONING REQUIREMENTS

A9.4.1 Systems shall be properly commissioned to demonstrate that all the equipment deliver the designed capacities and that air and water flow rates are balanced in accordance with the design.

Since the air systems are usually completed ahead of the hydraulic systems, commissioning of the air systems will commence earlier than the water systems.

Prior to any commissioning works, the Contractor shall check the completion of the air condition and ventilation associated builder’s work and the building services installations, to ensure that commissioning can be proceeded without obstruction.

(a) Checking Procedures on builder’s work:
(i) Plantrooms are completed and free of construction debris.

(ii) All plant room doors are fitted and lockable.

(iii) Permanent power supply of sufficient capacity is available and the Building Contractor is operating a security access procedure to all plant areas to prevent unauthorised switching of plant.

(The normal security access system is one of "Permit to Work" arrangement and procedure proposed by the Contractor in accordance with the latest guidelines on “Permit to Work” issued by the Labour Department.)

(iv) All builder’s work and building services installations in association with air conditioning systems are satisfactorily completed.

(v) All glazing works are completed and all windows closed.

(vi) All curtain walls and the building fabric are completed and reasonably water-tight.

(vii) All external doors, all stairs and lobbies, and toilet doors are completed and securable.

(viii) All ceiling works are completed, unless specifically agreed, with the exception of those access areas required to be left open for final adjustment and testing of high level building services equipment during the commissioning period.

All dust generating activities by other trades are finished and all areas are thoroughly cleaned and sealed to prevent ingress dust from getting into the ventilation and air conditioning systems during operation.

(ix) All builder’s work in association with pressurised and depressurised areas are completed.

(b) Checking procedures on Building Services Installation

The Contractor should ensure that:

(i) Air intake screens and louvres are unobstructed and clean.
(ii) Fan and other equipment chambers are clean and free of construction debris.

(iii) Floor gulleys and drainage traps are clear.

(iv) Fans are checked for impeller housing clearance and free of foreign objects.

(v) Heater batteries and cooler batteries are clean and fins combed.

(vi) Cooling coil condensate trays and humidifier drains are unblocked.

(vii) Dampers are clean.

(viii) Ducting and other airways are clean.

(ix) All electrical wiring circuits (power, lighting and controls) are completed, or will be completed at the correct stage during the commissioning period.

(x) All electrical panels are commissioned and clean.

(xi) Lighting systems are switched on.

(xii) Permanent power supply is available at the electrical panels, and all the connected equipment can be switched on.

(xiii) All equipment are checked for:

- Equipment rotation (fan kicked only)
- Lubrication
- Belt tension
- Motor fixings
- Duct flexible connector correctly aligned
- Keyway and setscrew tightness
- Clean condition
- Vibration isolation adjustment
- Correct operation of VAV control gear
- Correct overloads and amperages
- Investigate and locate all stop-start, disconnect and circuit interruption devices
- Inspect fan inlet and outlet to ensure satisfactory performance conditions are provided

(xiv) All outside air, return air and spill air dampers are operative.
(xv) All fire and volume control dampers are fitted and left in the fully open position.

(xvi) The supply air systems are blown through.

(xvii) All VAV and CAV terminals are installed, together with grilles and diffusers.

(xviii) All manual control valves are open or pre-set, as required.

(xix) All strainers are cleaned.

(xx) All water systems are flushed, vented and filled and chemical cleaning process is completed.

(xxi) Water treatment is completed.

(xxii) All filter media are installed.

(xxiii) Plantroom access is restricted to authorised personnel only.

(xxiv) All functional and safety devices are installed and operational.

A9.4.2 All aspects of the commissioning procedure shall follow the recommendations in the relevant CIBSE Commissioning Codes, including but not limited to:

(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 design performance.

(c) Energising and setting to work on all plants.

(d) Final regulation and demonstration that the installation delivers the correct rate of flow of fluids and air at the conditions specified in the Contract Documents.

A9.4.3 Progressive Commissioning

The Contractor shall not wait for completion of every part of the work but shall arrange for a progressive commissioning programme to achieve practical overall completion and have the whole work ready to be handed over by a date to suit the Building Contract completion date or any other agreed programme date.

A9.4.4 Specialist Commissioning
The Contractor shall be responsible for initially setting the plants to work and shall arrange for any Specialist Plant or Equipment such as CCMS to be commissioned and tested by the Specialist Equipment Manufacturer’s skilled Commissioning Engineer and/or technician.

A9.5 GENERAL TESTING REQUIREMENTS

A9.5.1 Cleaning

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

(a) Water System

The system (new or old) shall be flushed using an appropriate chemical dispersant of a 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 hours including a minimum of 12 hours with the pumped circulation in operation, unless otherwise recommended by the supplier with free technical support accepted by the Architect.

After chemical cleaning, the system shall be flushed and drained immediately. The Contractor or the chemical water treatment Specialist shall continue to take water samples at all system low points until the water samples indicate iron and chemical residues below the level of 1 ppm.

The success or failure of the above operation will depend on a high speed rate of draining down which is entirely related to the size of the drain points and ability of air to enter the system from the top.

For high speed draining down purposes the Contractor shall provide temporary 50 mm valved drain outlets on all points where the main pipework is 50 mm dia. or over.

The Contractor shall ascertain that there is adequate drainage nearby to discharge by large hose in order to ensure flooding of low level areas will not occur.
Subsequent to the flushing operations, the large drain down points shall be reduced to 15 mm valves or cocks or the sizes as indicated in the Contract Drawings.

(b) Air System

Ductwork systems shall be cleaned by purging using the supply air fan, or robot duct cleaning as recommended by the ductwork system cleaning Specialist. No fan shall be started until cleaning is commenced.

All submitted proposals for arrangements to ensure cleanliness of air and water systems shall follow the recommendations in the relevant CIBSE Commissioning Codes.

A9.5.2 Contractor to Inform Architect

The Architect shall be informed in good time of all site tests for plant, ducting and piping.

A9.5.3 Witness by Architect

The final tests shall be carried out in the presence of the Architect, or the Contractor representative, in accordance with the requirements of witness testing and commissioning as stipulated in the latest Building Services Branch Instructions. The Contractor shall give at least 72 hours notice, in writing, when any part or parts of the installation will be tested.

A9.5.4 Test Equipment and Labour

The Contractor shall allow for providing all skilled labour, testing gear (including pumps, tools, air and water flow instruments and thermometers, etc.) and attendants for all tests including those by Specialist employed under the Sub-contractor. The Contractor shall be solely responsible for the proper filling, emptying and flushing of the plants and pipes to be tested and shall make good any defects emerging from the tests, or made manifest under testing or re-testing, until the whole of the plant is free from defect and is in complete working order to the satisfaction of the Architect.

A9.5.5 Tests under Operating Conditions

The Contractor shall include the hydraulic and functional performance tests under operating conditions, on the whole installation to the entire satisfaction of the Architect.
A9.6 OFF-SITE TESTS

Where the specified Standards or Codes of Practice stipulate, 'type-tests' on items of equipment to demonstrate compliance shall be carried out at the Manufacturer’s works or elsewhere as appropriate. In all cases, 'type-tests' Certificates shall be submitted in duplicate to the Architect. Cases where appropriate, 'type-tests' Certificates will be accepted are as follows -

A9.6.1 Fans: 'type-tests' Certificates showing fan characteristic curves (ISO 5801), 'type-tests' Certificates for sound power levels (ISO 5136), fan dynamic balancing test Certificates complete with a method of statement from manufacturer on testing to Grade 2.5, 4 & 6.3 on appropriate fan types in accordance with ISO 1940.

A9.6.2 Pumps: 'type-tests' Certificates for head, discharge, speed and power input (ISO 2548, ISO 3555 and BS 599 as appropriate).

A9.6.3 Electric motors: 'type-tests' Certificates in accordance with BS 4999 Part 143 and/or IEC 60072.

A9.6.4 Low voltage starter switchgear and controlgear assembly: 'type-tests' Certificates for starter and control panels assembly as a whole in accordance with BS EN 60439-1.

A9.6.5 High voltage switchgear and motor control switchboard: 'type-tests' Certificates for high voltage switchgear and switchboard in accordance with IEC 60056.

A9.6.6 Other electrical equipment, such as air heaters (but excluding thermostatic control equipment): 'type-tests' Certificates in accordance with BS EN 60335, BS EN 60669-1, BS 5733 and BS 6220 as appropriate.

A9.6.7 Refrigeration plant: 'type-tests' Certificates for hydraulic and air pressure testing at works in accordance with BS 4434.

A9.7 SITE TESTS

A9.7.1 The Contractor shall carry out '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.

A9.7.2 On completion of cleaning operations described in Sub-sections A9.5.1 and A9.13, each water distribution system shall be recharged with clean water and then subjected to a hydraulic test as required by Sub-section A9.14.

Any items of equipment set to operate at or below the test pressure shall be isolated or removed prior to applying this test.
A9.7.3 All ductwork shall be tested for air leakage in accordance with Sub-section B2.10.

A9.8 INSPECTION AND TESTING DURING CONSTRUCTION PERIOD

A9.8.1 Periodic Site Tests

Site inspections of 'work in progress' will be made by the Architect or the representative from time to time. The contractor shall keep such inspection record for checking from time to time. Works to be permanently covered up shall be subjected to inspection and test before cover up. During the inspection, if the Architect discovers any work that has been covered up before inspection and testing, this work shall be uncovered for inspection and testing to the Architect’s satisfaction. The cost involved in uncovering the work, inspecting, testing and re-concealing the work together with any consequential losses shall be paid by the Contractor at no additional cost to the Employer.

A9.8.2 Tests at Factory

The Contractor shall note that the Architect may require to witness tests and inspections of locally and/or overseas manufactured equipment during construction at the manufacturer’s works. Where this requirement is indicated in the Contract Documents, the Contractor shall allow for making the necessary arrangements; including and indicating the Architect’s travel and subsistence expenses in the Bill of Quantities.

A9.8.3 Factory Test Certificates

Certificates of all hydraulic and other manufacturers' tests carried out at the Manufacturers' works shall be forwarded in duplicate to the Architect for approval. This approval shall normally be required before the materials or apparatus are dispatched from the Manufacturer’s works.

Where specified, the Contractor shall subject certain materials and equipment to be tested by the recognized institutions or laboratories and submit the type test certificates to the Architect for approval.

A9.9 PRESSURE TESTING FOR REFRIGERANT SYSTEMS

A9.9.1 Test Pressures

Refrigerant systems and circuits shall be pressure tested with nitrogen gas to test pressures as indicated below:-

Table A9.9.1 Testing Pressure
<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>High Side Test Pressure kPa</th>
<th>Low Side Test Pressure kPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>R 113</td>
<td>75</td>
<td>5</td>
</tr>
<tr>
<td>R 114</td>
<td>580</td>
<td>330</td>
</tr>
<tr>
<td>R 134a (Air Cooled)</td>
<td>2080</td>
<td>1190</td>
</tr>
<tr>
<td>R 134a (Water Cooled)</td>
<td>1270</td>
<td>880</td>
</tr>
<tr>
<td>R 502</td>
<td>3120</td>
<td>1930</td>
</tr>
<tr>
<td>R 717 (Air Cooled)</td>
<td>3230</td>
<td>1820</td>
</tr>
<tr>
<td>R 717 (Water Cooled)</td>
<td>1940</td>
<td>1340</td>
</tr>
</tbody>
</table>

In performing pressure tests for refrigerant systems and circuits containing blend refrigerants (e.g. R407C and R410A), manufacturer’s recommended procedures and test pressures shall be followed.

A9.9.2 Test Records

The method of recording the pressure tests shall be all as indicated in Sub-sections A9.14.5 and A9.14.6.

A9.9.3 Evacuation After Test

After pressure testing, the refrigerant system shall be evacuated to the satisfaction of the Architect before charged with refrigerant. The necessary equipment used to carry out the evacuation process shall consist of the following:

(a) A high capacity compressor capable of pulling down the system to 95,000 Pa absolute;

(b) A high vacuum pump to take over when the vacuum has reached 95,000 Pa absolute and pull it down to between 170 Pa absolute and 340 Pa absolute. The high vacuum pump shall be fitted with an accurate electronic gauge reading in Pa absolute.

(c) For compressors and systems of over 700 kW capacity, a cold trap to be included for condensing the water vapour before it reaches the vacuum pumps.

A9.9.4 Triple Evacuation

All connections between the evacuation units and the system shall be of ample size and the following system of triple evacuation shall be used:

(a) The system shall be pulled down to low vacuum and held for four hours. The vacuum shall then be broken with dry refrigerant or dry nitrogen.
(b) The system shall be pulled down to low vacuum for a second time, held for three hours and broken as in Sub-section A9.9.4.(a).

(c) The compressor shall be charged with clean dry oil of the proper type and grade, and all drier materials or cartridges shall be changed.

(d) The system shall be pulled down to low vacuum for a third time, held for two hours, and then broken with dry refrigerant. The system shall then be charged. During the time when the vacuum is being held, the vacuum pump, but not the electronic gauge, shall be isolated from the system to ensure that even small leaks, which may be less than the pump capacity, can be detected.

A9.10 TESTING OF DUCTWORK FOR LEAKAGE

A9.10.1 General

All ductwork shall be tested for air leakage in accordance with Sub-section B2.10.

A9.10.2 Chemical Smoke Test

The joints on ductwork shall be tested by using chemical 'white' smoke generators. All openings such as fan outlets, grilles, access panels, test holes, etc. shall be sealed before the smoke is introduced. If smoke leaks from any joint, that joint shall be made good. The smoke test shall be repeated until all joints are tested to be properly sealed.

A9.11 ELECTRICAL TESTS

A9.11.1 Electrical Tests on Motor Control Switchboard

(a) The tests shall be carried out before and after connection of power supply. The tests shall follow the requirements as stipulated in the General Specification for Electrical Installation in Government Buildings of The Hong Kong Special Administrative Region issued by Building Services Branch of Architectural Services Department for L.V. Cubicle Switchboard.

(b) The tests to be carried out for the high voltage motor control switchboard shall strictly follow the tests as recommended by the equipment manufacturer.
(a) Required Tests

The Contractor shall carry out the following tests on all electrical motors and provide test certificates in duplicate:

(i) Check motor nameplate voltage.
(ii) Check motor rotation and speed, prior to connection of the driven equipment.
(iii) Ascertain maximum kW absorbed by fan at the most demanding point of the pressure/volume characteristic curve at the specified fan speed.
(iv) Check the earth continuity loop resistance for every motor starter.
(v) Check the insulation to earth resistance for every motor starter taken with 500 V “Meggar” tester.
(vi) Test the full load current taken by all motors on each phase.
(vii) Test the tripping time of starter overloads set to 10% above the motor nameplate rating.
(viii) 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).
(ix) Check motor temperature in accordance with IEC 60034 or BS 4999 as applicable.
(x) Check starting current of each motor.

(b) Type Tests

Type tests and abbreviated tests shall meet the requirements of IEC 60072. The Architect 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.

(c) Contractor’s Responsibility

Approval of test certificates shall not absolve the Contractor from providing motors capable of driving the various items of plant under the conditions of loading stated in the tender documents.

A9.12 BALANCING AIR FLOW CIRCUITS

A9.12.1 General

Airflow tests shall commence as soon as a ducting system and fan are installed and wired up. In some instances, temporary electrical
supplies to fans may be necessary in order to test ductwork under working conditions.

A9.12.2 Method of Balancing

The Contractor shall balance all air diffusers and grilles by regulating the dampers provided. Each system of ductwork shall be balanced so that every branch duct, diffuser, grille and pressure relief valve shall carry the required quantity of air.

Generally, the test procedure shall comply with that set out in the current edition of the Chartered Institute of Building Services Engineers Commissioning Code “A” - Air Distribution Systems.

A9.12.3 Demonstration on Completion

After completion of the balancing, all dampers, grilles, diffusers, etc. shall be locked in position and the Contractor shall demonstrate to the Architect that the installation complies with the Particular Specification and that the air distribution is balanced in accordance with the air flow details shown in the original Contract Drawings or as later instructed.

A9.12.4 Instruments

The following calibrated instruments (within one year validity) shall as and where necessary be provided and used by the Contractor for the balancing of the air conditioning and ventilation air flow systems:

- Tube type velometer
- Sloping tube manometer
- Pitot tubes of various lengths to suit duct sizes
- Specially mounted anemometer fixed in a purposely made suitably designed hood for measuring air flow through grilles and diffusers.

- Tachometer
- Ammeter

Alternatively the Contractor may propose the use of equivalent modern electronic test equipment, the suitability of which shall be approved by the Architect for the purpose.

A9.13 FILLING WATER SYSTEMS AND VENTING

A9.13.1 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.
A9.13.2 Flushing of Water Systems

Before finally charging, the water systems shall be thoroughly flushed and all strainers, filters, etc. cleaned or replaced.

A9.13.3 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 Contractor shall disconnect the source, open the permanent supply and adjust the tank levels.

A9.14 HYDRAULIC TESTING FOR WATER DISTRIBUTION PIPEWORK SYSTEMS

A9.14.1 General

All water distribution pipework systems shall be hydraulically tested in sections as installation work progresses and before thermal insulation is applied.

A9.14.2 Test Pressure

The hydraulic test pressure shall be one and a half times the total working pressure.

A9.14.3 Precautions

Before hydraulic tests are carried out, all safety valves, gauges, etc. shall be effectively isolated or removed. These safety equipment shall be effectively tested at their design working pressure during commissioning of the installation.

A9.14.4 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 Architect or the 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.

A9.14.5 Hydraulic Test Certificates

Certificates of all hydraulic tests made on site shall be forwarded to the Architect for approval and such approval shall be obtained
before any thermal insulation is applied. A separate and duplicated set of the Contractor’s installation/shop drawings shall be provided for the purpose of keeping a accurate records of site tests. One copy will be kept by the Architect’s representative on site and the other retained by the Contractor.

A9.14.6 Details on Test Certificate

All test certificates shall be signed by the Contractor’s authorized site representative and by the Architect or the representative who has witnessed the test. All test certificates shall contain the following particulars :-

- Date of test
- Apparatus or section under test
- Makers number (if any)
- Nature, duration and conditions of test
- Result of test
- Name of Contractor’s representative (in block letter) in charge of test
- Name of Employer’s representative at witness the test

A blank test certificate form shall be submitted by Contractor for Architect’s approval prior to carrying out the actual test on site.

A9.15 BALANCING WATER CIRCUITS

A9.15.1 Method of Balancing

The Contractor shall balance all circuits by operating the regulation valves provided. Fluid flow through the cooling and heating coils shall be adjusted to provide the design air temperature drop or rise.

A9.15.2 CIBSE Commissioning Code 'W'

In general, the system shall be balanced using the procedure as outlined in the current edition of the CIBSE Commissioning Code “W” - Water Distribution Systems.

A9.16 SETTING AUTOMATIC CONTROLS AND INSTRUMENTATION SYSTEMS TO WORK

A9.16.1 Automatic Controls Specialist

Unless otherwise indicated, the Contractor shall include for all thermostatic and automatic controls to be commissioned and tested by the control manufacturer’s Engineer/Technician or by Specialist Automatic Controls Sub-contractor’s staff approved by the Architect.

A9.16.2 Final Positions of Thermostats, etc.
Positions for all space thermostats are provisionally shown on the Contract Drawings. The exact final locations shall be selected to give maximum coverage of each space by the control system. The location shall be proposed by the Contractor in the installation drawings and shall be approved by the Architect before installation of the conduit/box and thermostat.

A9.16.3 CIBSE Commissioning Code “C”

Generally, the commissioning procedure shall comply with that set out in the current edition of the CIBSE Commissioning Code “C” - Automatic Control.

A9.16.4 Calibration Charts

After installation of all the instruments and connecting leads and sampling points, the Commissioning Engineers shall check the installation and adjustment of the instruments to ensure they are in proper working order. Calibration charts shall be provided together with the test certificates. The Contractor shall provide records of settings/pressure-levels/positions of actuators, limits, etc.

A9.16.5 Alarm Testing

As far as practical, the Contractor shall demonstrate by simulation of fault conditions, the adequacy of the interlocking alarm circuits.

A9.16.6 Test relating to other Services

Functional tests shall be carried out for equipment inter-related with fire services and CCMS control.

A9.17 ACOUSTIC TESTS

A9.17.1 Site ambient noise levels shall be recorded prior to the commencement of tests. In order to minimise background noise, external noise levels shall be taken at night or at an agreed time.

A9.17.2 Checking Procedures

Before noise level checks are undertaken, the following checks shall be carried out:

(a) All ACMV systems are dynamically tested and balanced in accordance with the relevant sections of this document.

(b) All building works are completed and areas under test are vacated or under control for carrying out the noise test.
(c) All other noise generating activities and equipment are stopped.

Where circumstances require certain equipment to be kept operational, then this shall be clearly indicated on the final test data sheets.

(d) All areas under test are provided with safe access.

A9.17.3 Noise Screening Test

The Contractor shall carry out screening test on all noise emitting plant and machineries during the pre-commissioning phase of the installation work to identify potential problems that might infringe the current Noise Control Ordinance.

The Contractor shall submit to the Architect the test results and to notify the Architect on any likely problematic areas so that prompt action could be followed up.

A9.17.4 Noise Level Test

Prior to measuring noise levels, the Contractor shall check that all the plants in the air system and the water system are running.

If any item of plant is not running during the test, it shall be clearly identified on the test sheets.

Noise levels shall be measured by using an approved noise level meter capable of measuring noise levels in the frequency range of 63 Hz to 8 kHz.

Sound meter tests of the system shall include sound pressure readings relating to the NC levels in each room where stated in the Contract Drawings or in the Particular Specification.

In each selected area, noise levels shall be measured 1.5 metres above the finished floor level and at a distance of 1.5 metres from a wall.

In large areas, the floor area shall be divided into equal areas and readings carried out in each area.

The Contractor shall carry out external noise level tests in locations at agreed boundary positions.

In order to minimise background noise, external noise levels shall be taken at night or at an agreed time.

Upon completion of the noise level tests, the Contractor shall carry out a further set of noise level reading with all plant off, so as to determine the level of background noise.
In cases where measured noise levels are in excess of the specified criteria, additional checks shall be carried out to identify the sources of excessive noise generation.

All noise level readings are to be recorded and plotted on octave wave band frequency charts.

The date and time of test are also to be recorded together with any relative comments.

### A9.18 FINAL AIR CONDITIONING SYSTEM PERFORMANCE TESTS

#### A9.18.1 General

On completion of all inspections and tests as listed in Sub-sections A9.2 to A9.17, a final overall performance test shall be carried out on the air conditioning installation.

#### A9.18.2 Instruments

The Contractor shall provide the following calibrated instruments for this test:-

(a) All necessary wet and dry bulb mercury-in-glass thermometers.

(b) A wet and dry bulb weekly recorder.

(c) Where specified, multi-point recorders with Service Devices for monitoring temperature, humidity, current, voltage, etc.

(d) Surface contact dial indicating pyrometer.

(e) A sound meter capable of reading the noise level at 62.5, 125, 250, 500, 1000, 2000, 4000 and 8000 Hertz.

(f) Other equipment as found necessary or instructed.

#### A9.18.3 Method of Testing

During this test, the air conditioning systems shall be operated for a period of 5 days minimum. During which time, the following shall be noted and the results compared with the design criteria:-

(a) Note occupation rates, internal heat and humidity loads, and external conditions at time of test.

(b) Obtain temperature and humidity levels throughout all spaces.

(c) Obtain sound levels for all critical areas.
(d) Record exhaust and outdoor air extract system ventilation rates.

(e) Check efficiency of individual direct expansion refrigeration/cooling systems in accordance with CIBSE Commissioning Code 'R' - Refrigerating Systems.

(f) Check capability of chilled water system to maintain chilled water flow and return temperature under full load conditions.

(g) Check electrical loadings of all plants when operating under both full load and part load conditions.

A9.18.4 Full Load Requirement

When full load conditions cannot be achieved during the commissioning tests, the Contractor shall allow for returning to site to carry out a full load test when the desirable external and internal design conditions occur at the first opportunity during the maintenance period.

For particularly sensitive areas such as computer rooms, simulated full load tests shall be carried out at the time of commissioning using electric heaters to simulate the sensible load and electric steam pan humidifiers to simulate the latent load.

A9.18.5 When calculating the required simulated load, the following shall be taken into account.

(a) the anticipated heat gain from plant and machinery.

(b) the extra heat gain through the structural fabric due to the difference between the design external air temperature and the external air temperature at the time of the tests.

(c) the extra solar heat gain at maximum design conditions over that experienced at the time of the tests.

(d) the extra heat gain from the fresh air quantity due to the difference between the design external air temperature and the external air temperature at the time of the tests.

(e) the extra sensible and latent (if significant) heat gains due to the increase in the number of occupants normally present (i.e. allowed for in the design) over the number present at the time of the tests.

NOTE: The areas where simulated load tests are to be carried out shall be clearly indicated in the Particular Specification.
A9.19 IAQ EQUIPMENT AND SYSTEM TESTING

Before completion of ACMV installation, the Contractor shall carry out testing and commissioning of IAQ equipment and system to the satisfaction of the Architect or to meet the requirements as stated in the Particular Specification.

Testing and commissioning of IAQ installation shall be undertaken by the Contractor’s own competent specialist staff or by a competent Independent Commissioning Specialist nominated by and acting for the Contractor and approved by the Architect. The option chosen shall be declared by the Contractor in the Tender Document.

A9.19.1 IAQ Parameters

Detailed requirement relating to IAQ shall be under Section A5 of this General Specification. The level of control for each IAQ parameters shall be as specified under the Particular Specification. The Contractor shall check and obtain endorsement form the Architect for level of all control parameters.

A9.19.2 General Commissioning Requirements

Systems shall be properly adjusted and commissioned to ensure that the equipment achieve the designed airflow rates. The following general requirements shall be met before actual testing and commissioning of IAQ installation are carried out.

(a) Plantrooms are free of construction waste and debris.

(b) Access doors to plantrooms are fitted and lockable.

(c) All builder’s works associated with the IAQ systems must be completed and painted with dust preventing compound.

(d) All ceiling works are completed.

(e) All dust generating activities by other trades are completed and all areas thoroughly cleaned to prevent ingress of building dust and debris into the return air or fresh air intake systems

(f) Air intake screens and louvres are unobstructed and clean.

(g) Fan and other equipment chambers are clean and free of construction debris.

(h) Fans are checked for proper operation.
(i) Floor gullies and drainage traps are clear and operational.

(j) All condensate drains and trays are clear and water can be drained away satisfactorily.

(k) Dampers are clean.

(l) Ducting and other air passage ways are clean.

(m) All outside air, return air and spill air dampers are operative.

(n) All volume control dampers are fitted and are at appropriate opening positions.

(o) Ductwork systems are cleaned by purging of the supply air fan, or by robot duct cleaning recommended by the ductwork cleaning specialist.

(p) All VAV and CAV terminals are installed, together with grilles and diffusers.

(q) All filter media are installed.

(r) Air conditioning systems and the building indoor area are purged to the standard acceptable by the Architect.

A9.19.3 Testing and Commissioning Requirements

After the general commissioning requirements have been verified by inspection, testing and commissioning of the following IAQ equipment and systems shall then be carried out in accordance with the relevant BSB Testing & Commissioning Procedures.

(a) All air handling equipment: Fans, AHUs, FCUs, water scrubbers, Terminal Air Control devices, grilles and diffusers.

(b) Air cleaning equipment: All pre-filters, main filters, high efficiency filters and chemical filters.

(c) All ductwork and accessories: All ductwork, hoods and dampers.

Testing and commissioning procedures shall be carried out by licensed personnel as shown in Sub-section A5.10 of this General Specification to adjust and regulate the system and equipment so as to achieve the IAQ parameters as shown in Sub-section A5.3 of this General Specification.

A9.19.4 IAQ Assessment and Methodologies
IAQ assessment shall be performed as the last part of the testing and commissioning process upon completion of the ACMV installation. Further assessments shall also be done six months after the building has been occupied and at two months before the end of the Maintenance Period is certified, i.e.,

(a) First Assessment - After testing & commissioning

(b) Second Assessment - Six months after occupation of building or substantial completion

(c) Third Assessment - End of Maintenance Period

IAQ compliance shall be proved by results of measurements. In addition, an end user satisfaction survey shall be conducted before end of the Maintenance Period.

A9.19.5 IAQ Measurement

For measuring IAQ compliance, assessment shall be carried out by either the real-time monitoring method or the integrated sampling method. Real-time monitoring shall be used for detection of pollutant sources and provide information on variation of pollutant levels throughout the day. The integrated sampling method shall be carried out by taking samples of a particular pollutant over an 8-hour basis to obtain the total exposure level data. If it is not practicable to have 8-hour samples, short-term sampling to cover the worst scenarios shall be considered subject to approval of the Architect. All measurements shall be conducted with the use of calibrated instruments and equipment, standards and reference materials with traceability to international or national standards.

A9.19.6 Sampling Method

The sample method, location of measuring & monitoring IAQ parameters and measurement method of IAQ parameters shall refer to Section A5 and as detailed in the Particular Specification requirement.

A9.20 DOCUMENTS AND DATA REQUIRED FOR HAND-OVER MEETING

A9.20.1 General

The Contractor shall note that the system cannot be handed over until all the foregoing requirements (where applicable) have been carried out to the satisfaction of the Architect.

A9.20.2 Test Certificates
Before the handover inspection, the Contractor shall provide the follow test/record certificates where applicable:

(a) Copies of manufacturer’s works tests/record certificates on plant items comprising heat generating plant, heat exchangers, chillers units, packaged air conditioning units, tanks, vessels, motors, fans, pumps, etc.

(b) Copies of hydraulic and pressure test/record certificates for works carried out on site.

(c) Copies of boiler and/or refrigeration plant efficiency test/record certificates.

(d) Copies of Registered Surveyor’s test/record certificates for pressure vessels (if any).

(e) Copies of all performance test/record certificates including water balancing, air balancing, room conditions, etc. These certificates shall be accompanied with all appropriate charts and diagrams.

(f) 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.

A9.20.3 'As Fitted' Drawings

All necessary copies of 'As fitted' drawings as detailed in the Contract Documents and this General Specification.

A9.20.4 Operation Maintenance and Services Manuals

All necessary copies of Operating and Maintenance Manuals as detailed in the Contract Documents and this General Specification. The Contractor shall include functional spare parts and contact lists of the suppliers in the manual.

A9.20.5 Manufacturer’s Name Plate

Every item of plant supplied by a Manufacturer shall be fitted with a clearly engraved, stamped or cast manufacturer’s name plate properly secured to the plant item and showing:

- Manufacturer’s Name
- Serial and/or Model No.
- Date of Supply
- Rating/Capacity
- Test and Working Pressure (where applicable)
A9.20.6 Labels and Related Instructions

Provision of all labelling and the related instructions shall comply with Sub-sections A3.3.1 and A3.3.2 of this General Specification.
SECTION A10
OPERATION AND MAINTENANCE REQUIREMENTS

A10.1 GENERAL

The Contractor shall provide all the Level One Services as specified in this General Specification for all installation works.

Level Two Services detailed in this General Specification shall only be carried out if specified in the Particular Specification of the Contract. The specified Level Two maintenance responsibilities shall be priced separately in the tender with cost for each individual item.

A10.2 LEVEL ONE SERVICES – MANDATORY RESPONSIBILITIES DURING MAINTENANCE PERIOD

A10.2.1 Requirement for Training

Training for the operation and maintenance of sophisticated equipment shall be provided and arranged by the Contractor. The training shall include all training facilities, material and handouts etc. The Contractor shall submit a “Training Schedule” at least TWO months prior to installation for completion for the Architect’s Approval. The schedule shall consist of the following requirements:

(a) General Requirement

(i) The Contractor shall provide facilities and training programme to ensure that the Employer’s operation and maintenance staff acquire full knowledge and appreciation of all aspects of the design, day-to-day operation, breakdown and routine maintenance, diagnosis and hence operate and maintain reasonably effectively and efficiently the system/equipment including Central Control and Monitoring System offered. The training proposal shall be submitted at least three months prior to completion of the Contract and shall include all aspects of operation and maintenance of the plant including the use of special tools.

(ii) A training proposal together with a detailed breakdown unit price for such service shall be submitted at the time of tendering.

(iii) The training proposal shall also include details and duration of the training course(s), qualifications of the instructor and the qualification requirements for the trainee(s).
(iv) Whenever possible, the training courses shall be held before or during the commissioning period and shall be in Hong Kong.

Within 2 months after award of the Contract, the Contractor shall submit full details of the training syllabus for approval of the Architect.

(v) To reach the required depth of appreciation, the principles and theory and practical “hands-on” demonstration shall be lectured.

(vi) The operation and maintenance training of the IAQ equipment shall also be included in the training programme. Any manual for the IAQ equipment shall be prepared by qualified personnel.

(b) Particular Requirement

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 and shut-down.

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

(v) Trouble shooting procedures.

(vi) Identification of all the operating parameters which affects the performance of the plant.

(vii) Adjustment of the operating parameters to achieve optimum operating conditions.

(viii) Check-list of all the periodic inspection and servicing of the plant.

(ix) Illustration of the construction of major components of the plant by sectional views.

(x) Dismantling and reassembling procedures during a major repair.

(xi) Critical dimensions such as bearing clearance, wearing ring clearance, thrust clearance, torque table for bolts and nuts, etc.
(xii) The use of special tools.

(xiii) Calibration for testing equipment, measurement, record and performance assessment.

(xiv) Any other items as found necessary.

A10.2.2 Requirement during Maintenance Period

The Contractor shall be fully responsible for the following within the Maintenance Period:

(a) Instruction to Employer’s Operation and Maintenance Staff

After the installation has been successfully handed over and put into operation, the Contractor shall provide 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. Their duties shall be to operate the systems and to guide and instruct the Employer’s Operation Staff such that they will become fully conversant with the operation of the complete air conditioning installation.

Note: This commitment shall be carried out where the operational responsibilities are to be immediately transferred to the Employer’s own staff or at the end of Levels Two Service operational arrangements.

(b) Completion of Any Outstanding Work

Within one month of receiving the Architect’s substantial completion certificate, the Contractor shall complete all minor outstanding works listed thereon and rectify any defects that have arisen up to that time.

(c) Faults and Complaints

The Contractor shall attend to faults and complaints arising from defective work materials and/or system operation within one hour at any time during the Maintenance Period. The Contractor shall also be responsible for attending emergency calls and rectifying all defects leading to fault or breakdown of the equipment and/or system within reasonable time or specified. The Contractor shall keep records of all the faults/breakdowns calls for submission to the Architect. The costs for the attendance, labour, materials and spare parts for repair, submission of fault/breakdown reports etc. are deemed to have been allowed for in the submitted tender price.
(d) Inspection During Maintenance Period

The Contractor shall, in addition to the periodic visits as stipulated in the Conditions of Contract, make further working visit to the site one month before the end of the maintenance period to check and, if necessary, re-adjust the systems to meet the actual operation conditions.

(e) Joint inspection at the end of Maintenance Period

The Contractor shall include for making visit(s) to the installation at the end of the Maintenance Period in order to facilitate the acceptance and handing over of the installation to the Employer’s Representatives.

Note (1): If the installation is proved to be unacceptable by the Architect, (d) and (e) may have to be repeated at the Contractor’s expenses and with the effect of extending the contractual defect liability period.

Note (2): When the installation is accepted and handed over to the Employer’s authorized representative(s) at the end of maintenance period, the maintenance certificate will then be issued by the Architect.

(f) Servicing, Replacement and Replenishment

During the Maintenance Period, the Contractor shall supply and install, without additional charge to the Employer, replacements for all and any equipment or parts thereof or liquids or gases, which may, in the opinion of the Architect, became unserviceable, especially where the causes are attributable to faulty materials, workmanship, or inadequate performance. The liability of the Contractor shall cover replacement of liquids or gases, oils and refrigerant which may be lost by leakage or become contaminated or in other respects unserviceable.

(g) Record ‘Log Book’

For all Contract works under the Maintenance Period or ongoing Contract Maintenance, the Contractor shall have maintenance staff complete the site/installation record ‘Log-Book’ after each visit/installation. The Log-Book may be completed in either English or Chinese. The Log-Book will be supplied by the Government and kept in the plant room or location as agreed. Every attendance and details of work done for the installation shall be entered into the Log-Book so as to form a comprehensive maintenance record.

(h) Architect to be informed
A10.3 LEVEL TWO SERVICES – SPECIFIED CONTRACTOR’S MAINTENANCE RESPONSIBILITIES DURING MAINTENANCE PERIOD

Where specifically required in the Contract Documents, the Contractor shall allow for and carry out full and comprehensive maintenance of the installation for 12 months (or for a period as stated). The works shall in addition to those required under the LEVEL ONE SERVICE include also the followings:

A10.3.1 The Contractor shall be fully responsible for the following within the Maintenance Period:

(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 assistant the start-up, control, performance monitoring and shut-down of the plant;

(d) Test and commissioning of the installation after the completion of services, maintenance and repair;

(e) Submission of services record and test report.

A10.3.2 The Contractor shall provide labour, minor spare parts, components and consumable materials in the following services during the Maintenance Period:

(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;

(d) Preparation and submission of records/reports, compliance with miscellaneous requirements.

Upon practical completion of the construction work is certified by the Architect, the Contractor shall provide competent, experienced
and qualified staff and workshop facilities to undertake the Level Two maintenance works during the Maintenance Period. Detailed information of the organisation, workshop facilities and list of contact persons of the Contractor’s maintenance team shall be submitted to the Architect one month before the commencement date of the maintenance period.

A10.3.3 Contractor’s responsibilities for breakdown call-out

(a) The Contractor shall offer efficient and prompt response to breakdown call-out for the installation/equipment failure. The expedition of response shall be in accordance with the following categories:

(i) VERY URGENT for installation breakdown including failure of chiller, compressor, circulation pump, pipe burst, water dripping, fire alarm and electricity power failure, the Contractor shall respond and attend to the Very Urgent calls immediately.

(ii) URGENT for abnormality of equipment operation, the Contractor shall respond and attend to the Urgent calls within one hour from the receipt of the calls.

(iii) NON URGENT for inadequate of room condition, the Contractor shall respond and attend the fault within 4 hours.

Investigation report and proposal for repair/improvement/ modification shall be submitted.

(b) The Contractor shall promptly complete any repair necessary for resuming the breakdown installation. 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:

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

(ii) Complete permanent rectification works within 3 and 7 working days unless long component and parts delivery time is required.

A10.3.4 Maintenance programme and schedule

The Contractor shall prepare, submit and seek endorsement on the maintenance program before the commencement of the Contract Maintenance Period.
Upon the approval of the above maintenance program, the Contractor shall prepare a comprehensive maintenance schedule for all installations and indicate dates for routine maintenance of the installations before the commencement of the Contract Maintenance Period.

A10.3.5 Co-ordination

The Contractor shall co-operate and co-ordinate with the Architect’s Representatives, user department or EMSD, utility supply companies and the public authorities for the smooth execution of maintenance works.

A10.3.6 Plant log and breakdown/fault call report

The Contractor shall submit daily record of the following documentation and reports at 3 months intervals:

(a) Record of current status of plant and major equipment, all services, maintenance and repair/replacement carried out for the plant and equipment including the following details:

(i) supply and return chilled water temperature;

(ii) lubrication oil pressure gauge readings;

(iii) refrigerant pressure gauge readings;

(iv) system chilled water flow rate and its percentage against designed value;

(v) circulation pump suction and discharge pressure;

(vi) refrigerant compressor suction and discharge pressure;

(vii) 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

(viii) IAQ audit report with monthly measurements of all IAQ parameters.

(b) Equipment Breakdown Report

Equipment breakdown report shall be submitted after the rectification work and shall have full details of findings during investigation/examination on cause of breakdown, account of repair/replacement work needed, suggested precaution and/or action required to prevent the recurrence of similar incident.

A10.3.7 Monthly Works
(a) General

(i) 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 operating satisfactory within design conditions.

(ii) 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.

(iii) 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.

(iv) To check any water leakage from the pipework and to repair if required.

(v) To keep all supply and return grilles and louvers clean.

(vi) 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.

(vii) To check the operating conditions of water cooling tower including the running current, water refilling rate, and other important operating parameters.

(viii) To check and ensure that the operation conditions of the water treatment system are in accordance with the Contract Specification and recommendation by the manufacturer.

(b) Refrigerant Compressors, Chillers, Condensers and Heat Pumps

(i) 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.

(ii) 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.

(iii) To check condition of operating refrigerant, liquid level and lubrication level, refill or renew as necessary.

(iv) To examine the condition of joints, stop valves, covers and seals for leaks, repair as necessary.

(v) To remove debris and maintain the condenser in clean and tidy condition.

(vi) To check driving belts for proper tension and correct alignment, adjust and renew belts and lubricate bearings.

(vii) To check the vibration of machines as compare to the recommendations by the manufacturer for future baseline monitoring and maintenance.

(c) Motors for All motorized Devices and Equipment

(i) To clean motor casing, grease and lubricate.

(ii) To check and report any abnormal running noise and vibration. Replace the bearings, perform megger test on motor and repair as necessary.

(iii) To check, adjust and rectify/repair defect on circuit protective devices such as starters, control relay and indicators.

(d) Pumps

(i) To visually inspect the pumps, check for abnormal running noise and vibration.

(ii) To check and record on log sheets and where appropriate on system performance sheet the water pump suction and discharge pressure and motor current.

(iii) To check condition of gland for excessive wear. Replace if necessary.

(iv) To check drains are not clogged and rectify if necessary.

(v) To check pump bearing temperature thermostat and repair if necessary.

(vi) To operate the vent valves once.
(vii) To check for proper operation of flow switch control system and safety device, rectify if necessary.

(viii) To clean suction strainer.

(ix) To check for proper function of make up system to the chilled water or hot water circuit, rectify if necessary.

(x) To check for correct alignment of the motor and pump, rectify if necessary.

(e) Air Handling Units

(i) To check that the air handling units and related controls and control circuits are operating properly. Repair or renew if necessary.

(ii) 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 air temperatures, off coil, and supply air air temperature and humidity.

(iii) To check condensing water drain pan, drain pipe and floor drain to ensure no clogging and flooding. Rectify if necessary.

(iv) To clean and renew air filter as required.

(v) To check driving belts for proper tension and correct alignment, adjust and renew belts and lubricate bearings as required.

(vi) To check the operation of control valves and isolating valves, rectify as required.

(vii) To clean the fresh air inlet, exhaust air louvers, air dampers, accessible internal ductwork surfaces and fan blades.

(viii) To check the heaters for proper operation. Rectify if necessary.

(f) Fan Coil Units

(i) 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.
(ii) To check and clean the condensing water drain pan, drain pipes to ensure no clogging and flooding. Rectify if necessary.

(iii) To clean the supply and return air grilles and filters.

(iv) To check the heaters and their control/protective devices for proper operation. Rectify if necessary.

(g) Heat exchanger (include calorifier)

(i) To check on all joints for leak. Rectify if necessary.

(ii) 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.

(iii) To check the temperature settings and functioning of the controls and ensure compliance with manufacturers’ standards.

(h) Mechanical Ventilation System

(i) To clean fan blade and blades for wear and damage.

(ii) To check and if necessary to lubricate fan and motor bearings.

(iii) To check the fan belt and to adjust and replace it, if necessary.

(iv) To check flexible connections and that anti-vibration mountings are free to move, and function properly.

(v) To clean the air filters, supply and return air grilles and to renew air filters if necessary

(vi) To check the operation and function of the control devices

(vii) To check all electrical wiring and connections and circuit protection devices including switchgears and starters. Rectify if required.

(viii) To clear the vanes in the ductwork.

(i) Equipment
(i) To check and service all IAQ equipment including oxygen generator, UV light chambers and other filtration and sterilizing system and equipment for IAQ.

(ii) The Contractor shall take measurements of IAQ parameters and submit records to the Architect.

A10.3.8 Half-Yearly Work

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 CO₂ 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 necessary at no cost to Government.

A10.3.9 Annual Work
(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 pipe work and ductwork. Recondition and if instructed, replace the deteriorated portion in accordance with 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 Contractor shall arrange the cleaning work after the building office hour.

(i) To inspect aluminum 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.
SECTION B1
AIR CLEANING EQUIPMENT

B1.1 GENERAL

The complete air filter set for the following types of filters shall be of heavy-duty airtight factory fabrication designed to ensure a positive seal against leakage of unfiltered air. Generally, it shall be complete with robust enclosure, holding frames and housing as below:

B1.1.1 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.

B1.1.2 The holding frames, which are designed 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 galvanized 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.

B1.1.3 The housing shall be constructed of minimum 1.6 mm galvanized 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 galvanized sheet steel with 32 mm 80 kg/m³ mineral wool insulation or factory coated/injected with suitable thermal insulation material approved by the Architect. The above material shall have the insulation property same as that of the air-conditioning ductwork connected to the complete air filter set, whichever the insulation property is higher. The housing shall have finishing painting with colour to match the air handling equipment.

In any case, all components of the air filter set and its associated accessories, which are within the air stream, shall comply with latest requirements of Fire Services Department.

To indicate the filter condition, differential pressure gauge shall be provided for easy inspection, operation and maintenance, facilities for CCMS interfacing filter condition monitoring shall be equipped as
specified in the Particular Specification. It is to be fixed in such a position, outside the casing that it is accessible and easily read. The gauge shall be properly installed with all necessary galvanized steel support brackets and ductwork stiffeners onto the ductwork without damaging the thermal insulation. The complete mounting assembly shall be designed to ensure leakage-proof and to avoid condensation at any surface in contact with the filter section.

B1.2  DRY REPLACEABLE MEDIUM TYPE FILTER

B1.2.1  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 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 airside.

B1.2.2  Cartridge Filter

Refer to Sub-section B1.2.1.

B1.3  DISPOSABLE TYPE PANEL FILTER

B1.3.1  Disposable Panel Filter

The holding frames shall be equipped with fixtures for easy removal of the filter cells without the use of any special tools.

For the 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 airside.

B1.3.2  Disposable Pleated Panel Filter

Refer to Sub-section B1.3.1.

B1.3.3  Renewable Panel Filter

Refer to Sub-section B1.3.1.

B1.4  AUTOMATIC FABRIC ROLL FILTER

The holding frames shall be equipped with fixtures for easy removal of filter cells without the use of any special tools.
The Contractor shall include all necessary electrical cables/accessories for proper operation of the complete air filter set in accordance with the manufacturer’s installation details.

**B1.5 WASHABLE PANEL FILTER**

The holding frames shall be equipped with fixtures for easy removal of the filter cells without the use of any special tools.

For the 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.

**B1.6 AUTOMATIC VISCOUS FILTER**

The holding frames shall be equipped with fixtures for easy removal of filter cells without the use of any special tools.

The Contractor shall include all necessary electrical cables/accessories for proper operation of the complete air filter set in accordance with the manufacturer’s installation details.

**B1.7 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 the Contractor shall include all necessary electrical cables/accessories for proper operation of the complete installation. The Contractor shall provide 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.

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.

**B1.8 HIGH EFFICIENCY PARTICULATE AIR (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 the 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 airside.
B1.9 GAS FILTER

The holding frames shall be equipped with fixtures for easy removal of filter cells without the use of any special tools.

B1.10 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 the Contractor shall include all necessary electrical cables/accessories for proper operation of the complete installation.

B1.11 AUTOMATIC RECLEANABLE HEPA FILTER

Refer to Sub-section B1.10.

B1.12 BIO-OXYGEN GENERATOR (AIR PURIFIER)

The bio-oxygen generator shall be factory fabricated and assembled in accordance with the manufacturer’s installation details. The Contractor shall include all necessary electrical cables/accessories for proper operation of the complete installation. The Contractor shall provide 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.

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 without damaging the thermal insulation.

The mounting shall be designed to 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 bio-oxygen generator shall be installed in the return air duct and interlocked with the fan or air handling unit in such a way that the generator is in operation whenever the fan or air handling unit is operated.
The ultra-violet sterilizing light shall be factory fabricated and assembled in accordance with the manufacturer’s installation details. The Contractor shall include all necessary electrical cables/accessories for proper operation of the complete installation. The Contractor shall also provide all necessary safety measures including automatic cut-off switch and ultra-violet 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.

The complete assembly shall be mounted onto the wall of ductwork by the manufacturer’s mounting flange with the power transformer outside the air stream and the ultra-violet lamps within the air stream. The ultra-violet lamps shall be mounted perpendicular to the direction of air flow to allow maximum exposure. The power transformer shall be installed with all necessary support brackets and ductwork stiffeners onto the ductwork without damaging the thermal insulation.

The mounting shall be designed to 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. In accordance with the manufacturer’s recommendation, baffle filters may be necessary to install for those air discharge louvres or ductwork openings near the unit to reduce the ultra-violet light intensity level in case the safety limit of the exposure level exceeded.

The ultra-violet sterilizing light shall be installed in suitable location of the air stream for best operating efficiency recommended by the manufacturer and interlocked with the fan or air handling unit in such a way that the unit sterilizing light is in operation whenever the fan or air handling unit is operated.

**B1.14 WATER SCRUBBER**

Refer to Sub-section A5.5.6.
SECTION B2

DUCTWORK

B2.1 GENERAL

The zinc coating of the ducts shall not be damaged during fabrication, delivery and installation. Any damage to the galvanized finish shall be made good with three coats of aluminium zinc rich paint or other approved corrosion resisting paint to the satisfaction of the Architect, 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 - A Practical Guide To Ductwork Leakage Testing & DW/144 - Specification For Sheet Metal Ductwork published by HVCA 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.

Any damaged ductwork found shall be replaced. All performance 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.

All ducts 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.

B2.2 DESIGN 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 by the Contractor in accordance with the requirements of Sections B8 and C8.

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 or erection 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 Architect.
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 galvanized mesh bird wires and is additional to any grilles or louvers indicated for these locations.

Duct connections between individual components of an air handling assembly 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. All joints shall be made perfectly airtight and proprietary duct-flange shall be used for all cross-joints and for connection to plants.

The flanges shall be installed in accordance with the manufacturer's recommendations and clamped together with screw lock clamps.

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 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 Fire Services Department and Buildings Ordinance. All fire-rated enclosure shall have fire rating meeting the requirements of Fire Services Department and Building Ordinance, but shall in no case be less than 2 hours.

Take-off from main ducts shall be conical, bellmouth, or shoe type. Square take-off is not permitted.

B2.3 HANGERS & SUPPORTS

All ductwork shall be securely supported by hangers, brackets and other appropriate forms of support. Wherever possible, the requirements of Section B9 Sub-section B9.12.1 shall apply.

All supports and hangers for air duct installed shall be rigid galvanized steel rod, angle bar or U-channel construction approved by the Architect.

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. 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 of Sections B8 and C8 shall apply.

Approval shall be obtained from the Architect for hangers and support/installation/shop drawing designs before manufacture and installation. Furthermore approval for the method design and calculation of fixing to the structure shall also be obtained as this may have structural implications.

### B2.4 FLEXIBLE DUCT JOINTS

Flexible joints shall be provided on all in-line fan inlet and outlet connections, at expansion joints in the building 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.

Flexible joints shall consist of, or be externally protected by, material having a fire penetration time of at least 15 minutes when tested in accordance with BS 476 Part 8 and shall comply with BS 476 Part 7, Section 2, Class 1 (surface of very low flame spread).

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.

### B2.5 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 Architect. The maximum length of any individual flexible duct shall not exceed 2000 mm unless otherwise approved by the Architect.

Joints at flexible duct connections shall be made with a sealant which permanently retains adhesion and elasticity throughout the design working temperature range. The sealant and method of application shall be in accordance with the ductwork manufacturer's recommendations.

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. 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 galvanized 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.

**B2.6 DUCTWORK ACOUSTIC TREATMENT**

Where specialized acoustic attenuation is required either as in-line sound attenuator inserts or by internal duct lining acoustic treatment, these shall comply with the requirements of Section B8.

**B2.7 EXTRACT HOODS AND VALENCE FOR KITCHENS**

Hoods shall be of galvanized 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 but the Contractor shall check and (in consultation with the Architect) determine its exact position in relation to the associated item of kitchen equipment to be covered on site.

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 Architect, 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 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.

Kitchen exhaust hood should be complete with make-up air grilles and constructed in such position for the best efficiency in evacuating smoke.

Lighting fitting shall be provided within the hoods, fittings shall be bulkhead design with die cast aluminium base and glass diffuser suitable for kitchen hood design. The fittings as well as the wiring for the fittings shall be suitable for continuous use in ambient conditions of over 100°C temperature and 100 % RH.
For kitchen hood with water scrubber design, the requirement shall be in accordance with Sub-section A5.5 of this General Specification.

B2.8 GREASE FILTER

Hoods and valances positioned over cooking appliances shall be fitted with grease filters as specified in Section B1.

B2.9 AIR DUCT CLEANING POINTS

The Contractor shall supply and install proprietary air duct cleaning points to the ductwork systems. The cleaning points shall in general be installed at maximum distance of 4 meters 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 meters maximum distance apart.

The maximum distance of 4 meters may be increased if the Architect considers that the ductwork system has compatible service openings which can serve the similar purposes as the air duct cleaning points. The Contractor shall submit the proposed layout of air duct cleaning points and services opening in the ductwork system for the Architect’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 be the cleaning out points.

All joints shall be air/water tight to prevent leakage. Air leakage for cleaning points shall comply with DW/143 and all Fire Services Department requirements. The Contractor shall also provide 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. All operating and serving instruction manuals shall be supplied with the set of equipment.

The whole air duct installation shall be disinfected by the Contractor thoroughly using an approved disinfection agent immediately before the complete ductwork installation is handed over to the Employer, as directed by the Architect. The Contractor shall also supply ten bottles of the approved disinfection agent, each
with one litre of the agent, to the Architect before hand-over of the ductwork installation. The disinfection agent shall be easily available locally.

Interior of all ductwork shall be cleaned by rotatory mechanical brush. All contaminants shall then be removed by high efficiency vacuum pumps of sufficient degree of vacuum to ensure removal of heavier particles.

**B2.10 TESTING**

All installed ductwork shall be tested to the latest edition of “Code of Practice for Energy Efficiency of Air Conditioning Installation” issued by EMSD. The method of air leakage test shall follow Appendix A of DW/144 and to the latest edition of HVCA standard DW/143 and as directed by the Architect as necessary to prove the quality of the installation. Air leakage testing of ductwork on any section of a completed installation shall be carried out and shall be in accordance with Appendices A of DW/144 and “Method of Testing” of DW/143. For those items not covered in DW/144 and subject to the approval of the Architect, the recommendations of the latest editions of “Low Pressure Duct Construction Standards” and “High Pressure Duct Construction Standards” issued by the 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.
SECTION B3
AIR HANDLING AND TREATMENT

B3.1 GENERAL

Fans shall be installed using galvanized 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 Sections B8 and C8.

Fans heavier than 50 kg shall be provided with eyebolts certified by an authorized 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 (or related clauses of ISO254, 1081, 1813, 4183, 4184 & 5292) and shall be capable of transmitting at least the rated output with one belt removed. Minimum two belts per drive shall be used unless otherwise specified. Pulleys shall be exactly aligned. The Contractor shall ensure that any holding down bolts grouted in by builders are positioned to the correct alignment. Provision shall be made for positive adjustment of the tension in V-belt drives.

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. For full specification on motor drive guards refer to relevant clauses of Section C7.

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.

Galvanized steel or superior materials shall be used for all supports and fixing accessories, and suitable paint shall also be applied in accordance with Section A8.

B3.2 AIR HANDLING UNITS (AHUs)

Air handling unit shall be mounted on a hot dipped galvanized I beam or U-channel mounting frame which is either fixed on concrete plinths by builder or ceiling mounted by suspension galvanized 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 designed to account for the operation loading of the air handling unit and the associated ducting and piping. Hanging rods shall be threaded and complete with locking nuts for level adjustment. All AHU supports and supporting accessories shall be galvanized steel and painted.
Neoprene pad shall be installed continuously between the air handling unit and the mounting frame 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 purpose made lifting facilities nearby.

All gauges and meters other than insertion type shall not be mounted on the casing of the air handling unit on site to avoid breaking the thermal insulation. All such provision required for connection must be purposely designed and made in the factory.

Air handling unit designation, number and airflow direction shall be labelled on the casing of the unit.

**B3.3 AXIAL FLOW FANS**

Suitable galvanized steel mounting plates or bracket provided from the same manufacturer shall be used for fixing the fan.

**B3.4 CEILING FANS**

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 C3.12 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 then 400 mm or larger sweep rotary wall fixed fans in accordance with Sub-section C3.12 shall be used.

**B3.5 CENTRIFUGAL FANS**

For floor mounted arrangement, the fan shall sit on concrete plinth by builder with anti-vibration mountings.

For ceiling mounted arrangement, the fan shall sit on anti-vibration mountings fixed on steel mounting frame. Threaded suspension rods with locking 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.
B3.6 FAN COIL UNITS

B3.6.1 Threaded suspension rods with lock nut and washer shall be used for ceiling mounted fan coil units for level adjustment.

B3.6.2 Flexible joints shall be installed for air duct, water pipe, conduit and other services connection to the unit.

B3.6.3 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 shall be considered as an access panel subject to the approval of the Architect.

B3.6.4 Power supply will be provided by electrical sub-contractor and terminated at fused connector unit adjacent to each fan coil unit, all 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 carried out by the Contractor. 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 by the Contractor.

B3.6.5 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.

B3.6.6 All units shall be selected to suit the limited space within the false ceiling, with due consideration to access for maintenance and servicing.

B3.6.7 All blowers and motors of fan coil units shall be demountable from the ceiling void for maintenance purpose without causing damage to the associated ductwork and insulation.

B3.6.8 The condensate drain pan shall be of stainless steel and insulated for those fan coil units installed in switchrooms, lift machine room, UPS rooms, control rooms and other essential areas sensible to water damage. A second or additional larger stainless steel insulated drain pan shall also be provided underneath to avoid any possible dripping of condensate. A water overflow alarm indication shall be equipped at conspicuous place outside the room or connected to CCMS.

B3.7 CASSETTE TYPE FAN COIL UNIT

Refer to relevant requirements in Sub-section B3.6.

B3.8 IN-LINE CENTRIFUGAL AND MIXED FLOW FANS

In-line centrifugal and mixed flow fans shall be mounted on a G.I. steel support. Threaded steel rod wit locking nuts shall be used for ceiling mounted purposes. Neoprene pad shall be provided for vibration isolation.
B3.9 MECHANICAL ROOF EXTRACT UNITS

Mechanical roof extract unit shall be mounted on a vermin proof hard wood sill and concrete curb provided by builder with dimensions according to requirements of the manufacturer. All gaps between the mounting frame and structural base shall be sealed up properly.

B3.10 PROPELLER FANS

Where propeller fans are mounted in a casing, the casing shall be longer than the length of the fan and motor. The casing shall be of galvanized 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.

B3.11 PROTECTIVELY COATED FANS AND FANS FOR CORROSIVE OR HAZARDOUS APPLICATIONS

All steel mounting brackets, bolts, washers and nuts shall be hot dip galvanized and painted with protective coatings to meet the appropriated corrosive environment.

B3.12 ROTARY FANS

The installation of wall or ceiling mounted rotary fans shall follow the installation instruction of the fan manufacturer.

B3.13 TERMINAL AIR CONTROL DEVICES

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 for vibration isolation.

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 Sub-section B3.6.4, B3.6.5 and B3.6.6.

Flexible duct connecting the inlet/outlet of the unit shall be fixed by omega clip or similar approved devices.

B3.14 GRILLES AND DIFFUSERS

Grilles and diffusers shall be fixed on air duct by self-tapping stainless steel screw or purposely made spring or locking devices. 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.
The installation of domestic exhaust fans shall follow the installation instruction of the manufacturer or refer to contract drawings. All domestic fan shall be protected with safety guard.
B4.1 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 complicated Central Control & Monitoring System (CCMS) or as simple as an electronic controller with built-in real time clock for scheduling controls. The appropriate ACS shall be so designed to meet the requirements and operation needs of the building operation & 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 which do not require sophisticated CCMS (if so specified, the designed ACS shall have provisions for the proper interfacing and direct connection to the network of the future CCMS) for the normal operation and control of the air conditioning, refrigeration and ventilation systems, and other building services and electrical & mechanical (E&M) systems installed in the buildings if so specified. The main function of an ACS is for on/off controls, 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 be so designed to 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.

B4.1.1 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 including any holiday and special schedules 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, back-up battery with power healthy indicator and alarm shall be provided.

B4.1.2 Direct Digital Controller (DDC)

The requirements and operation of a standalone DDC is similar to that for an electronic controller as mentioned above. Unless otherwise
specified, the DDC shall be of open protocol design to BACnet and equipped with all the necessary auxiliary devices for future interfacing and direct connection to the network of a CCMS.

Unless otherwise specified, DDC type shall be of open protocol design to BACnet/Lonwork and equipped with all necessary auxiliary devices for future interfacing and direct connection to network of a CCMS.

B4.1.3 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 Contract Drawings:

- Manual on/off (maintenance/manual mode)
- On/off by the Automatic Control System as scheduled.
- 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)
- 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 Contract 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.
- Reset of supply chilled water temperature to optimize 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 Contract Drawings:

- Chiller output capacity modulated to maintain the pre-set supply or returned chilled water temperature (after mixing with the by-pass).
- 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 Contract Drawings:
(1) 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.

(2) The Chiller Plant Controller shall control the sequencing of chillers and cut-in or cut-out a chiller in accordance with the returned 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,
- Chiller(s) in manual or maintenance mode shall be by-passed from the automatic sequencing control operation.

B4.1.4 Control of Chilled Water Pumping System (by chiller plant controller)

Unless otherwise specified in the Particular Specification or the Contract 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 (1) chilled water pump to operate for monitoring the chilled water temperature shall be applied.

(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 Contract 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 (1) 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) 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 Contract Drawings.

B.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 energized accordingly.

(b) Capacity Control

(i) For energy saving, cycling of cooling tower fans shall be used 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.

(c) Faults and abnormal operation controls and monitoring by the condenser water plant controller

(i) High condenser water temperature
Extra high condenser water temperature (chillers to be cut off one by one if so specified)

Low water level of cooling towers

Faults of cooling tower fans

Faults of condenser water pump (associated chiller to cut off)

Faults of water treatment plant(s)

Faults of condenser water filtration and cleansing equipment.

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 Contract Drawings.

B4.1.6 Control of Primary Air Intake 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 Fire Services Department.


(iii) On/off control by the ACS as scheduled.

(iv) On/off controls by special demand overriding the preset 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 Contract Drawings, the following demand control function shall be adopted.

(v) Demand on/off control. The operation of any AHU/FCU served by the unit shall energize 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 CO₂ level within the specified range (applicable for single zone system only).
- 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 CO₂ 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 Contract 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 sterilizer, 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.

(iv) Status and fault alarms of air cleaner & sterilizer.

(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 Contract Drawings.
B4.1.7 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 Sub-section B4.1.6(a).

If so specified in the Particular Specification or the Contract Drawings, the following demand control function shall be adopted.

(ii) Demand on/off control. The operation of any VAV unit served by the unit shall energize 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).
   - 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 modulating 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 Sub-section B4.1.8(b) of this General Specification.

(iii) Humidity Control

- Dehumidification (indoor air relative humidity higher than 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 Contract 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 water spray humidifier shall be provided at the relevant AHUs as specified.

(d) Fresh Air Supply Control

CO₂ 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 CO₂ level at all zones to be within the range specified. If so specified, a minimum amount of fresh air supply shall be maintained for the proper pressurization of the air-conditioned areas.

(e) Filters and Air Cleaners/Sterilizers

Same as Sub-section B4.1.6(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 Contract Drawings.

B4.1.8 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 Fire Services Department. Automatic reset is required once the fire signal is clear
- Manual on/off control by the three-speed controller
- c/w space temperature sensor.
- 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 Contract 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.

(iii) Fresh Air Supply Control

For a variable volume primary air supply system, a zone CO₂ 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 CO₂ 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.
- Room temperature outside upper and lower limits pre-set.

b) Variable Air Volume (VAV) Unit
Controller for VAV unit 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 Fire Services Department. Automatic reset is required once fire signal is clear.
- Manual on/off control by user.
- 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 Contract 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.

- Pressure Dependent Type
The room temperature sensor shall send signal to the controller, which shall actuate the motorised modulating control damper to adjust the amount of cooled air to be supplied to the room in order to maintain the room temperatures pre-set in the room thermostat. There shall 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.

(iii) Fresh Air Supply Control

Fresh air supply control is generally carried out in the AHU. If so specified, zone CO₂ 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
- Part load signal to the AHU for supply air temperature reset

B.4.1.9 Ventilation System Control

(a) Toilet Exhaust System

(i) Start/stop
- Automatic fire tripping as specified or required by the Fire Services Department. 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 Sub-section B4.1.9 (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 Fire Services Department.
- 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 or
- 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 Sub-section C5.56 of this specification or the Particular Specification or Contract Drawings.

**B4.2 GENERAL REQUIREMENTS**

**B4.2.1 Control Equipment Features**

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 sensor, monitoring and measuring equipment. Suitable protection guard against damage shall be provided for equipment exposed to public contact.

**B4.2.2 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;

(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 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

(iii) The element must not be subjected to water hammering. If a fast-closing valve is located downstream of the element, a suitable water hammer arrester must be used

B4.2.3 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;

(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 meters 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;

(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;

(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;

(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;

(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;

(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;

(iv) For sensors exposed to view, the precise location shall be approved by the Architect.

(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;

(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 500m² per one detector;

(iii) For sensors exposed to view, the precise locations shall be approved by the Architect.

(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 latest 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 Architect;

(o) All sensors shall be arranged to give convenient access for servicing.

B4.3 AIR COOLING CONTROL

B4.3.1 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 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.

B4.3.2 The control valves shall be quiet in operation.

B4.3.3 All valves shall operate in sequence with another valve when required by the sequence of operations.

B4.3.4 All control valves shall be suitable for the system flow conditions and close against the differential pressures involved.

B4.4 AIR HEATING CONTROL

B4.4.1 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.

B4.4.2 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.

B4.4.3 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 cutouts 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.
B4.4.4 The control valves shall be quiet in operation.

B4.4.5 All valves shall operate in sequence with another valve when required by the sequence of operations.

B4.4.6 All control valves shall be suitable for the system flow conditions and close against the differential pressures involved.

**B4.5 ELECTRICAL/ELECTRONIC (LOCALISED) CONTROL SYSTEM**

B4.5.1 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.

B4.5.2 Where a particular manufacturer’s system is offered and accepted, the installation shall be installed to comply with that manufacturer’s recommended technical details and methods of installation.
SECTION B5
CENTRAL CONTROL AND MONITORING SYSTEM (CCMS)

B5.1 GENERAL REQUIREMENTS

B5.1.1 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 uninterrupt power supply with suitable capacity not less than 30 minutes shall be equipped for the CCMS.

B5.1.2 Compliance with Various Codes/ Standards

The installation shall comply with the standards as described below where applicable:


(b) International Telecommunication Union Recommendation V.90 – A digital modem and analogue modem pair for use on the Public Switched Telephone Network (PSTN) at data signalling rates of up to 56000 bit/s downstream and up to 33600 bit/s upstream and Recommendation X.25 – Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit.

(c) American Society of Heating, Refrigeration and Air-conditioning Engineers, Inc. 135-1995 BACnet communication Protocol for Building Automation and Control (BACnet)

(d) Echelon Corporation Lon Talk Protocol (LonTalk)

(e) Electronics Industries Association; EIA 232, Interface Between Data Terminal Equipment and Data Circuit Terminating Equipment Employing serial Binary Data Exchange EIA 485, Electrical Characteristics of Generators and Receivers for use in Balanced Digital Multipoint Systems EIA 568a, Commercial Building Telecommunications Wiring Standard Category 5 (EIA 568a Cat 5)
B5.1.3 Expandability

The installation shall be expandable at all levels as described in the following sections using the same software interface that replacement of either the workstation software or field controllers are not required.

B5.1.4 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 should be shown.

(d) Manufacturer’s data on all hardware and software products shall be indicated clearly. 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 design of graphics, reports, alarms and configuration to be furnished with the workstation software.

(f) Operation and maintenance manual together with CAD CD Rewritable Storage Media shall be submitted to the Architect in accordance with the Contract requirement.

B5.1.5 System Cleanup

Upon completion, the Contractor shall check and clean all equipment pertinent to this installation. Such cleaning shall extend to the exposed surfaces of tubing, hangers and other exposed metal of grease, plaster and other areas around the equipment.
B5.1.6 System Start up & Commissioning

Upon complete installation prior to put into operation, the Contractor shall ensure the work as described below are being carried out and the results are satisfactory:

(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) The Contractor shall carry out the commissioning 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 authorized representatives.

(c) Operation parameters and control settings shall not be modified without notification to the Architect

B5.1.7 Operation and Maintenance Manual

Operation and maintenance manual together with CAD CD Rewritable shall be submitted to the Architect in accordance with the Contract requirement:

(a) It shall contain all details necessary for operation, maintenance, replacement, installation and parts procurement for the system.

(b) It shall include specific part numbers and software versions and dates together with a complete list of spare parts.

(c) It shall include a copy of all application software both in written form and on diskette.

(d) It shall include step-by-step system recovery procedures for system re-start up after fatal breakdown. Such procedures shall be properly demonstrated to the Architect’s representatives during the T&C. Any special tools required for system re-start shall be supplied together with the System.

(e) It shall include all necessary passwords to initiate functioning of the complete CCMS to initial start up and to work after any modification or reprogramming.

B5.1.8 Training

Adequate training shall be provided to the operators for the day-to-day operation and future maintenance. Unless otherwise specified, the
training should 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

(b) Classroom training

It shall contain a comprehensive understanding of the hardware and software course materials covering workstation operation and controller programming. The period should be agreed with the Architect and should not be less than two weeks.

B5.1.9 Warranty

(a) The Contractor shall warrant the system for further 12 months upon expiry of the Maintenance Period.

(b) During the warranty period, the Contractor shall provide all services, materials and equipment necessary for proper operation of the system.

(c) The Contractor shall be responsible for all necessary revisions to the software as required to provide a complete and operable system being consistent with the sequence of operations. All updates to the manufacturer's software shall bear no extra costs.

B5.2 SYSTEM ARCHITECTURE

B5.2.1 General

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.

B5.2.2 Level 1 Network

It should be the highest level that is developed for management on a wide area fast speed network based on open protocol.
B5.2.3 Level 2 Network

It should be a high performance peer-to-peer operation level network that shall be able to connect to remote sites. This level shall apply for a single network system.

B5.2.4 Level 3 Network

It should be local area network with DDC controller for communication that shall be able to extend its performance and capacity by using remote sub-system controllers. The sub-system controller shall be microprocessor-based stand-alone controller capable of operation of ACMV installations independently.

B5.2.5 Local Area Network (LAN)

The system shall be able to segment through software into multiple local area networks distributed over a wide area network with a standalone DDC controller and communicate with other controllers on the network via a network controller unit.

B5.2.6 Standard Network Support

The workstations, controllers and file server etc. shall be able to use standard network components to utilize the existing network and/or structural cabling system.

B5.2.7 Remote Communication

It shall be able to manage remote system via standard component of software that is being incorporated.

B5.2.8 System Expansion

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 adverse effect on the system performance.

B5.2.9 Support for Open System Protocols

The network shall be capable of integration of the open system protocols such as BACnet, Lon Talk, etc.

B5.3 ELECTRICAL WIRING AND CABLE

The works shall be carried out in compliance with the requirements of the Electrical General Specification (See Sub-section A2.1) and Section B.7 of this Specification and should comply with TIA/EIA 568a Category 5 for Level 1 & 2 network and comply with TIA/EIA 485a Category 5 for Level 3 network and follow the
application guidelines of TIA/EIA-485-A-TSB89. It shall also meet other requirements covered in Sub-section A2.1 of the Electrical General Specification.

The Contractor shall provide all wiring work and electrical devices and material necessary to complete the Controls and Instrumentation System. 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.

The Contractor shall provide all interlock wiring required to make system operate in accordance with the drawings and specifications. 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.

**B5.4 HARDWARE INSTALLATION**

The installation shall comply with Statutory Requirements as specified in Section A2.

**B5.4.1 Wiring and Tubing**

Unless otherwise specified, wiring shall be dedicated runs with separate circuit breaker and each run shall include a separate neutral and ground wire.

A proper earth system shall be provided and should be separated from other services for dedicated run.

Wires shall be properly fixed at intervals.

Wires shall be kept away from hot water pipe, steam and condensing piping etc.

Wires shall not run across telephone equipment.

Unless otherwise specified, all conduit shall be of galvanized steel.

Surface conduits shall be installed in plant room or other area as approved by the Architect.
Flexible conduits shall be adapted for connection to the equipment and/or sensors etc.

Control air tubing shall be in concealed run unless otherwise approved by the Architect.

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.

All control air tubing shall be thoroughly cleaned before putting the system into operation.

B5.4.2 Field Devices

The installation shall comply with Sub-section B4.2 whenever applicable.

Thermal conduction compound shall be applied to ensure good heat transfer to the well-mounted sensor.

Sensors installed on pipeline shall be removable without shutting down the system.

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.

B5.4.3 Enclosures

All field interface devices shall be mounted in a panel that shall be provided with enclosures to protect from dusts and moisture.

The panel shall be adequate for installation of power supply for sensors, interfacing relays, contactors, safety circuits and transducers, etc.

The panel shall be steel enclosure with hinged door, keyed lock and earthed.

All outside mounted enclosures shall be weatherproof type.

B5.4.4 Identification
All control wires and pneumatic tubing shall be identified with labelling tape or sleeves using either word, letters, or numbers that will be cross-reference with the as-built drawings.

All field enclosures shall be identified with nameplates.

All junction boxes shall be marked to identify for “CCMS”.

All field devices mounted inside the panel shall be labelled.

All field devices outside the panel shall be identified with nameplate.

B5.4.5 Location

The panel for enclosing interface devices shall be installed immediately adjacent to the controller panels being interfaced.

Room humidity or temperature sensors shall be mounted away from the machines that would generate heat, direct sunlight and diffuser air streams.

Outside air sensors shall be mounted on suitable location on the north building face directly in the outside air.

B5.5 SOFTWARE INSTALLATION

B5.5.1 General

All system software under the Contract including operating software and the third parties software shall be installed initialised, started-up and debugged.

B5.5.2 Database Configuration

The installation shall comply with the schedule in Sub-section C5.57 and other schedules as specified in the Particular Specification.

B5.5.3 Colour Graphic Slides

The graphic displays shall be installed in accordance with the floor layout plans and the schematic diagrams, etc. Also, the display shall consist of associated points identified in the point list and shall allow for set point changes as specified.

B5.5.4 Reports

The installation shall configure a certain reports to be issued as specified. The Contractor shall provide adequate paper for periodic reports.

B5.5.5 Documentation
It shall cover all software being installed that shall include description of point lists and alarm list, printouts of all reports and graphics, application program listing, etc.
SECTION B6

CENTRAL REFRIGERATION/CHILLER, DIRECT EXPANSION
EVAPORATORS AND HEAT REJECTION PLANT

B6.1 GENERAL

All necessary refrigerant and lubricating oil shall be supplied by the Contractor during testing and commissioning and plant operation stages until the plant is accepted and end of maintenance period is certified completed by the Architect.

An electronic/microcomputer control panel shall be factory installed and tested on the unit. Full automatic control function shall be provided as detailed in Sections B4, B5, C4 and C5.

Eye wash and shower facilities and drain shall be provided by the Building Contractor and equipped at the exit(s) of the A/C plantroom where the central refrigeration plant is installed.

Refrigerant leakage warning alarm in accordance with ASHRAE Standard 15 shall be installed if the refrigeration plant is installed in indoor environment.

The plant shall be so selected and installed with sufficient space allowed for heat dissipation with circulating surrounding air, and for maintenance and servicing.

Appropriate corrosion resistant materials and assembly methods shall be used including isolation of dissimilar metals against galvanic interaction.

Mounting and fixing details shall include details and dimensions of equipment bases, fixing bolts, supporting steelwork, flexible connections, vibration isolators and any special builder's work requirement provided in sufficient time by the Contractor to meet the building programme.

Any damage to finishes which may have occurred during transit, storage, and installation or otherwise shall be made good in the manner recommended by the manufacturer and to the satisfaction of the Architect. 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 access service platform shall be equipped for the easy inspection and maintenance of the chiller plant and associated equipment. The platform shall be assembled by galvanised steel structure or fibreglass reinforced polyester, stainless steel fixing bolt and nut/washer and accessories approved by the Architect.

All mounting and fixing supports shall be galvanised steel and exposed metals shall be corrosion treated and painted in accordance with Section A8.
B6.2 LAYOUT AND ISOLATION OF PLANT COMPONENTS

The plant layout shall be so arranged by physical division and valves such that any plant component may be isolated for servicing without completely draining the refrigerant or liquid circuits of the whole plant and follows the ANSI/ASHRAE Standard 15-1994, the Safety Code for Mechanical Refrigeration. All plant equipment shall be located within safety marking perimeter. The clear floor safety marking in durable brilliant colour approved by the Architect shall be provided.

Motor control centre and central monitoring and supervisory console shall be located inside a control room which is free from water pipes with double glazing window for plant viewing provided by the Building Contractor.

B6.3 DELIVERY OF EQUIPMENT

All equipment delivered to site until final inspection and testing shall be properly protected as detailed in Section A3.

The Contractor shall take into account the site constraints when planning the delivery route of the equipment. The delivery route together with the information of the imposed loading of the equipment and/or any temporary structural openings required shall be submitted to the Architect for agreement prior to the transportation of the equipment to site. Any temporary hoisting or handling facilities and installations to facilitate the delivery of the equipment shall be provided and removed after use by the Contractor.

B6.4 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. Brazing shall be carried out to the requirements of the HVCA Code of Practice - Brazing and Bronze Welding of Copper Pipe and Sheet.

Joints in steel pipe shall be flanged or welded. Mitred 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 threads 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.

Plastics 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. Plastics 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 a number of 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 designed so 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 minimize vibration. Vibration eliminators shall be fitted to the compressor suction and discharge pipes to minimize transmission of vibration or noise. Where indicated, a gas pulsation damper shall be fitted in the refrigerant discharge pipe, in the plant room, as close as possible to the refrigeration compressor.

After completion, the refrigerant pipe work shall be pressure tested as detailed in Sub-section A.9.9.

All parts 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 with refrigerant to the refrigeration system, field pressure tests shall be carried out in accordance with Section A9. 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 avoided.

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.

For blended refrigerant pipe work, the Contractor shall employ qualified workers with recognised training for the installation. Those workers shall have certificates from the machine manufacturers or suitable authorised agents approved by the Architect certifying the competence level of the workers for the installation.

All installed blended refrigerant pipe work shall not be pressurized with refrigerant and air. Blowing of the refrigerant pipe works shall not be done by means of the blended refrigerant mixed with air. The Contractor shall pay particular attention and precaution when handing the blended refrigerant pipe works installation. For charging of refrigerant to the system, the recommendations from the supplier and the procedures stipulated in the latest Testing and Commissioning Procedure No.1 for Air-conditioning, Refrigerant, Ventilation and Control Systems in Government Buildings Hong Kong shall be followed. The work shall also be carried out by trained and qualified persons approved by the Architect.

**B6.5 AIR-COOLED PACKAGED REFRIGERATION MACHINE**

**B6.5.1 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 do not contact 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 Contractor shall, according to the manufacturer’s advice, advise the requirements on strength of the roof curb structure. Selection of the spring isolators shall be submitted to the Architect 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.

(d) Adequate clearance as recommended by the manufacturer opposite the evaporator connections shall be allowed so that cleaning of the tubes and maintenance of the evaporator can be carried out. Sufficient space at each end of the unit in order to open the fan access panel and the starter door shall be allowed.

(e) All components such as control panels, indicating lights and gauges shall be housed in a weather proof, water tight, insulated metal equipment cabinet with lockable door to protect the equipment. The equipment 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 chiller set separately enclosed in waterproof enclosures shall be provided in a conspicuous position within the cabinet.

(f) The Contractor shall allow the addition of a rigid sun/rain shelter in front of the control panel, starter and equipment cabinet of each chiller unit. The shelter shall be constructed with minimum 2 mm galvanised sheet steel and reinforcement framework or FRP materials. All metal work shall be treated with suitable paintings. The shelter shall be made of adequate sizes to cover the above mentioned panels and cabinets and extend at least 1 m from the refrigeration machine in depth, to provide a protective cover for the panels and cabinets, and for the servicing personnel, to the satisfaction of the Architect.

B6.5.2 Water Piping Connection

(a) All water piping to the unit shall be thoroughly flushed before make 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 chilled or hot (for heat recovery or heat pump application) water system. Necessary pressure gauges shall be installed to monitor the entering and leaving water pressures. Shutoff valves shall be provided in lines to the gauges to isolate them from the system when they are not in use.

(d) Thermometers shall be installed in the lines to monitor entering and leaving water temperatures. A balancing valve shall be installed in the leaving water line to control the water flow balance.

(e) Shutoff valves shall be installed on both the entering and leaving water lines so that the evaporator can be isolated for maintenance.

(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 isolate the vibration from the unit.

(h) A shutoff valve shall be installed on the drain line of the evaporator.

(i) A water pressure relief valve shall be installed in the evaporator water system.

B6.5.3 Installation and Connection of Temperature Sensors

(a) To allow the sensor to read a good mixed water temperature, the sensor finger shall be positioned 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 in order to ensure better thermal conductivity. The bottom of the sensor shall touch the sensor finger.

(c) The electrical cables connecting the temperature sensors shall be installed in G.I. conduit.

B6.5.4 Installation of Flow Sensing Devices

(a) Flow switch or differential pressure switch with pump interlocks shall be installed to sense system water flow. To provide refrigeration machine protection, the flow switch shall be installed in series with the pump interlocks for water circuit.
(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 closed to elbows, orifices or valves.

B6.6 WATER-COOLED PACKAGED REFRIGERATION MACHINE

B6.6.1 Installation Requirements

(a) Same as Sub-section B6.5.1 (a).

(b) Elastomeric isolation pads shall be installed on the foundation for the unit to isolate the vibration of the unit. The Contractor shall advise the Architect for the strength and mass of the foundation to support the unit operating weight.

(c) Enough space shall be provided around the unit to allow the installation and maintenance personnel unrestricted access 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. Sufficient vertical clearance above the unit shall be allowed. No services such as ductworks and water pipes shall be located over the compressor motor.

B6.6.2 Water Piping Connection

(a) Same as Sub-section B6.5.2 (a).

(b) Same as Sub-section B6.5.2 (b).

(c) Sufficient vents shall be provided at high points in the piping to bleed air from the chilled or hot and condensing water systems. Necessary pressure gauges shall be installed to monitor the entering and leaving chilled or hot and condensing water pressures. Shutoff valves shall be provided in lines to the gauges to isolate them from the system when they are not in use.

(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 and condensing water lines to control the water flow balance.

(e) Shutoff valves shall be installed on both the entering and leaving chilled or hot water and condensing lines so that the evaporator and condenser can be isolated for maintenance.
(f) A pipe strainer shall be installed in the entering chilled or hot and 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 and condensing water lines to isolate the vibration from the unit.

(h) A shutoff valve shall be installed on the drain line of the evaporator and condenser.

(i) A water pressure relief valve shall be installed in the evaporator and condenser water system.

B6.6.3 Installation and Connection of Temperature Sensors

(a) Same as Sub-section B6.5.3 (a).

(b) Same as Sub-section B6.5.3 (b).

(c) Same as Sub-section B6.5.3 (c).

B6.6.4 Installation of Flow Sensing Devices

(a) Flow switches or differential pressure switches with pump interlocks shall be installed to sense system water flow. To provide machine protection, the flow switches shall be installed in series with the pump interlocks for both chilled or hot and condensing water circuits.

(b) Same as Sub-section B6.5.4 (b).

B6.7 CONDENSER, AIR COOLED

Air cooled condensers mounted outside buildings shall have weather-proof fan motors. The units shall discharge air vertically upwards. If specified to discharge horizontally, then 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 proofed against corrosion after manufacture.

The unit shall be installed on vibration isolation as specified in Sections B8 and C8. The Contractor shall, according to the manufacturer’s advice, advise the requirements on strength of the roofcurb structure for supporting the unit. Selection of the vibration isolators shall be submitted to the Architect 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 satisfactory air circulation, sufficient distance as recommended by the manufacturer shall be maintained between the unit and the obstacle.
B6.8 EVAPORATOR, AIR COOLED

The cooling unit shall be dehydrated, charged with an inert gas pressure tested and sealed after manufacture.

B6.9 COOLING TOWER

The GRP warm water distribution basin shall be covered by removable GRP 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, exact tower orientation and architectural aesthetic consideration shall be submitted in sufficient time in following the building programme to the Architect 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 litre/hr, and the amount water in m³ used over a period of time. Isolation valves unions and a valved by-pass shall be provided to facilitate meter removal for maintenance.

A bleed pipe with stop valve and flow regulating device shall be provided on each cooling tower to the nearest builder’s drain.

Control and chemical or ozone treatment plant shall be located near the cooling towers and they shall be installed inside a covered plant room/space with proper ventilation.

B6.10 VIBRATION ISOLATION

All plants offered shall have minimum vibration and noise levels during operation, with particular attention to the requirement that the sound pressure level shall not be more than 5 dB higher than the ambient sound level measured at one metre from the plant with all plants fully operated at any time, or any other latest requirements of Environmental Protection Department or other statutory noise control requirements issued prior to tendering, whichever is the more stringent. The Contractor shall be responsible for provision of adequate vibration isolation and sound attenuation for the refrigeration plant to meet the requirements as detailed in Sections B8 and C8 and to the satisfaction and acceptance of the Architect.

B6.11 ELECTRICAL WORK

The Contractor shall supply and install suitable power cables, cable trays, G.I. supports, starters/motor drives, isolators, control, safety earth bonding and necessary accessories to connect power from the isolator to the each electricity-driven equipment. The Contractor shall allow for adequate cable size and protection devices to meet the current demand and voltage drop requirements of the equipment offered.

B6.12 SAFETY ANCILLARIES FOR AMMONIA CHILLER

B6.12.1 Pressure Relief Device
A pressure-relief valve connected via discharge pipe in accordance with ANSI/ASHRAE 15, 1994 relevant Sections shall be provided at both high side and low side pressure vessels of the ammonia refrigerating system which automatically relieve pressure of pre-determined excessive pressure due to emergency conditions. A solenoid valve shall be provided in addition to the pressure-relief valve which is opened by means of a manual emergency switch. The solenoid valve shall be installed in a parallel by-pass circuit of the pressure relief valve on the pressure vessels. The required capacity of the pressure relief valves shall be determined in accordance with ASME Boiler and Pressure Vessel Code, 1986 Section 8 and the maximum length and the size of the discharge pipe shall be determined in accordance with relevant sections as stipulated in ANSI/ASHRAE 15, 1994.

An emergency discharge system including discharge pipe line size, length, pipe route and material, valve size and pipe, common header, pipe support, control valve box and termination diffuser shall be designed and constructed by the Contractor according to ANSI/ASHRAE 15,1994 and ANSI/IIAR 2, 1992 relevant sections. All emergency discharge pipelines shall be connected above the liquid refrigerant level on the high pressure side and the low pressure side of the system. The lines shall be pitched so as to drain the system. These lines shall extend into an emergency refrigerant control box readily accessible outside the ammonia chiller plantroom. The box shall be locked and labelled with "Emergency Refrigerant Control Box - Ammonia R717". A readily accessible stop valve labelled with "High Pressure Refrigerant Discharge Valve" and a suitable pressure gauge shall be installed on the discharge pipes within the emergency refrigerant control box. The emergency discharge lines shall be connected to a common riser for discharge to the atmosphere. At the upper extremity of the common riser, it shall be fitted with a diffuser for mixing the refrigerant with air. The discharge termination shall be within 600mm of one side of the discharge outlet of the emergency ventilation fan at roof level to ensure good mixing of ammonia/air by forced ventilation. The emergency ventilation system shall in this case operate within 1 second after the actuation of any one pressure relief device or the manual discharge system.

The safety refrigerant relief discharge point shall be sited at safety location away from the pedestrian access approved by the Architect. A clear warning label shall be displayed near the point.

B6.12.2 Emergency Apparatus

The Contractor shall provide two sets of Fire Services Department approved type respirators and protective clothing and one First Aid Kit and one portable ammonia detector ranged 10-1500 ppm inside a waterproof stainless steel cabinet for use in emergency service. The equipment shall be stored near the entrance of the ammonia chiller plantroom or as indicated in the Drawings. The respirator shall be fullface gas mask, front sparing or back mounted type, with industrial size ammonia canister. The protective clothing shall include gloves, shoe covers, and aprons impervious to ammonia. The First Aid Kit shall
contain the Saturated Solution of Sodium Thiosulfate, or Sterilized Water, Sterile Compresses or Dressings, 0.5% Pontocaine Solution (with eye dropper), and Rubber Bulb Syringe.

B6.12.3 Warning Plate

The Contractor shall also provide the Fire Services Department approved type warning plates with the words 'DANGER-AMMONIA ASPHYXIATING GAS' to be prominently displayed on each exit doors and gas pressure relief/discharge point of the ammonia chiller plant room in 120 mm English and Chinese characters.

B6.12.4 Ventilation

The emergency, independent mechanical ventilation of the ammonia chiller plantroom is provided by means of exhaust ductwork constructed of stainless steel grade 316, extraction fans and its associated cables as shown in the Drawings. The capacity of the extractors for the emergency ventilation shall comply with the ventilation requirement stipulated in ANSI/IIAR 74-2, 1985 relevant sections and as shown in the Drawings, whichever is greater. The emergency ventilation system shall be actuated automatically by an ammonia vapour detector when the concentration of ammonia exceeds 0.03% (300 ppm) when leakage occurred or when the pressure relieve valves are actuated or when the manual discharge system is actuated. Manual means for actuating the emergency ventilation by means of emergency control switch shall be provided and located as shown on the Drawings.

B6.12.5 Ammonia Vapour Leakage Detection System

A/C plantroom where ammonia chiller is installed shall be provided with an ammonia vapour leakage detection system to monitor and indicate at least two concentration levels to warn the people in the surrounding and automatically actuates the emergency measures. The ammonia leakage detectors shall be based on semiconductor techniques and has a stable zero point, long life time up to 8 years and good resistance to fouling by gases containing high concentration of ammonia. The detectors shall have an adjustable relay output of 4-20 mA analog signal with a range of 0-1500 ppm for remote logic processing in the digital controllers. Fixed ammonia leakage detectors shall be installed. The low level alarm at 0.03% (300 ppm) by volume shall be actuated to warn the responsible personnel in the chiller plantroom and start the emergency ventilation automatically. The high level alarm at 0.1% (1000 ppm) by volume shall be actuated to shut down automatically the refrigeration system. Manual emergency switches shall also be provided immediately outside the A/C plantroom. The ammonia vapour leakage detection system shall be powered with battery charger and battery supply system. The power supply of all electrical consuming equipment shall be maintained for at least 6 hours for pre-alarm condition and 2 hours for full alarm condition. The ammonia detection panel shall be made of 1.2 mm thick stainless steel sheet and located as shown on the Drawings. The indication lamps and manual emergency buttons of the ammonia detection panel shall also be repeated in the Main Fire Alarm Annunciation Panel inside the F.S. Control Centre by means of dry
contacts and relays. In addition, means shall be provided by the Contractor to interface the ammonia detection panel with the CCMS Control System if such system is provided.

B6.12.6 Operation of Condenser Fans and associated Safety Protection

For air-cooled ammonia chillers, the condenser fans shall feature both noise control and emergency ventilation. During normal application, the fans shall run at low speed to achieve low noise level adequate for the ventilation requirement. On detection of ammonia leakage, the fans shall be speeded up to provide larger ventilation rate to dilute and blow away the ammonia to the atmosphere. Water sprinkler installed in the machine refrigerant compartment shall also be activated to dilute and drain away the ammonia safely.
SECTION B7
ELECTRIC MOTORS AND ELECTRICAL EQUIPMENT

B7.1 LOW VOLTAGE-GENERAL

B7.1.1 Unless otherwise specified, the Contractor shall provide and install all low voltage electrical equipment necessary for the complete installation under the Contract and shall carry out all necessary wiring from the points of power supply provided by others as indicated on the Contract Drawings.

B7.1.2 The Contractor shall be responsible for the accuracy of all installation and shop drawings and wiring diagram and for the correct internal wiring of all pre-wired equipment supplied under the contract.

B7.1.3 All electrical equipment, wiring and installation work, and materials shall comply with the provisions of the relevant parts of the Electrical General Specification.

B7.1.4 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.

B7.1.5 The Clauses in this Section related with Control and Metering shall be read in conjunction with the relevant parts of Sections B4, B5 and B10.

B7.2 LOW VOLTAGE-ELECTRIC MOTORS

B7.2.1 Maintenance Access and Safety

(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.
B7.2.2 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.

B7.2.3 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.

B7.2.4 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.

B7.2.5 Protective Guards

The protective guards shall be rigidly constructed. It shall not be possible to remove any guard without the aid of a tool.

B7.3 LOW VOLTAGE-VARIABLE SPEED DRIVES

B7.3.1 The drives shall be either wall mounted or floor mounted in a well ventilated location and in accordance with the Manufacturer’s standard installation recommendations.

B7.3.2 The drives shall be located away from any nearby water pipeworks to avoid possible damage by water leaking or water pipe bursting. In case that such location could not be identified, the Contractor shall provide all necessary protective means to avoid the damage.

B7.3.3 The distance between the drives and the controlled motors shall be within the range as recommended by the Manufacturer. The Contractor shall submit calculations including his selected interconnecting cable sizes to the Architect to substantiate that the overall performance shall meet the design requirements.

B7.4 LOW VOLTAGE-MOTOR SWITCHGEAR, STARTER AND CONTROL PANELS

B7.4.1 General
Motor switchgear, starters and controls shall be supplied and installed to perform the operation and control of the air-conditioning 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.

B7.4.2 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.

B7.4.3 Motor Control Switchboard

(a) 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 air-conditioning and ventilation equipment etc.

(b) 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.

(c) Unless otherwise specified in this Specification or the Particular Specification, the Switchboard shall comply with the requirements as stipulated in the Electrical General Specification.

B7.5 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.

B7.6 HIGH VOLTAGE-GENERAL

B7.6.1 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 Contractor shall sign the Work Completion Certificate for the individual high voltage electrical installation and submit to the Architect before the electrical installation is energised.

B7.6.2 Unless otherwise specified herewith, all electrical equipment, wiring and installation work shall comply with the relevant parts of the Electrical General Specification and the respective recommended installation practices and standards of the equipment manufacturers.

B7.7 HIGH VOLTAGE - ELECTRIC MOTORS

B7.7.1 Motor Foundation

A motor bedplate/foundation block shall be provided unless the motor is to be mounted on the soleplate of the compressor. Jacking screws shall be fitted at perpendicular directions on the foundation block for alignment of the coupling.

B7.7.2 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 tinned copper strip shall be provided. A tapped hole with screw external to the cable box will be acceptable.

Permanent terminal marking and direction of rotation in accordance with IEC 60034-8 or BS 4999 Part 108 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 Sub-section C7.12.

(e) Motor Termination Boxes

The termination of motor supply cables shall be done by bolts and nuts on to stud terminal stems, and so designed that the motor can be removed to another location with the termination chamber in-situ. No cable joint is permitted in the termination chamber.

Front access detachable cover plates shall be fixed by studs and nuts. Separate plates shall be supplied for termination chambers.

Joints shall be machined flat and fitted with neoprene rubber gaskets.

A shroud having a minimum breakdown voltage of 20 kV shall be fitted over each cable terminal.

B7.8 HIGH VOLTAGE MOTOR CONTROL SWITCHBOARD

B7.8.1 General Requirements

(a) 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 be designed to 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.

(b) The height of the instrument panel above floor level shall not exceed 2400 mm. All panels constituting a complete switchboard shall be of equal height.
Bolted on rear and top covers shall be designed to 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 such as grit blasting to ISO 8502 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 Architect.

B7.8.2 Primary Busbars and Connections

(a) 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.

(b) 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 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.

B7.8.3 Anti-Condensation Heaters

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.

B7.8.4 Cables Boxes

(a) Cable boxes shall be suitable for terminating the cables directly into the switchgear.

(b) Where cable boxes are used for three-core cables, the sweating sockets on the two outer phases shall be so fixed to incline 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 fixed as to minimise bending of the cable cores, and spacer clips shall be used.

B 7.8.5 Labels and Warning Notice

(a) Labels shall be fixed by screws on the non-detachable parts of the panel at a height of 1350 mm or above.
(b) 'Danger - H.V. Live Terminals' 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 & Chinese characters.

(c) In addition to automatic screening shutters and barriers, warning labels shall also be provided for all live parts, such as test terminal blocks.

**B7.9 HIGH VOLTAGE AUTO-TRANSFORMERS**

**B7.9.1** The auto-transformers shall be mounted firmly on to the concrete floor finished to the standard requirements as recommended by the equipment manufacturer. The floor construction shall be designed to withstand the operating weight of the auto-transformers.

**B7.9.2** The installation shall be carried out in strict accordance with the recommendations so as to keep the noise and vibration generated by the auto-transformers to the minimum.

**B7.10 HIGH VOLTAGE POWER FACTOR CORRECTION CAPACITORS**

**B7.10.1** Positioning of the power factor correction capacitors shall be done by means of the built-in combined jacking and haulage lugs.

**B7.10.2** The installation shall strictly follow the equipment manufacturer ‘s recommendations.

**B7.11 HIGH VOLTAGE POWER CABLES**

**B7.11.1** No straight through cable joints shall be installed without the approval of the Architect.

**B7.11.2** For identification, the rating of the cable shall be impressed into the outer insulation at regular intervals.

**B7.11.3** 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.

**B7.11.4** Cable Terminations

Cables shall be terminated by approved non-ferrous mechanical glands complete with compression devices for securing the cable sheath. An armour clamp shall be provided for bonding to metal sheaths as necessary. Where the cables are installed in entirely dry situations, the gland shall be designed with a compressible gasket or packing for securing the inner sheath and 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.
B8.1 GENERAL

The Contractor shall install sufficient noise and vibration control measures on the plant/equipment, the interconnected piping, ductwork and conduit 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 following limits when all the plant/equipment installed by the Contractor are put into operation:

Table B8.1 Noise Control Criteria

<table>
<thead>
<tr>
<th>Activity</th>
<th>Noise Control Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcasting and recording studios</td>
<td>NC 25</td>
</tr>
<tr>
<td>Concert and opera halls</td>
<td>NC 25</td>
</tr>
<tr>
<td>Theatres, assembly halls and churches</td>
<td>NC 30</td>
</tr>
<tr>
<td>Cinemas</td>
<td>NC 35</td>
</tr>
<tr>
<td>Hospital wards and operating theatres</td>
<td>NC 35</td>
</tr>
<tr>
<td>Homes, bedrooms</td>
<td>NC 35</td>
</tr>
<tr>
<td>Private offices, libraries, courtrooms and schoolrooms</td>
<td>NC 35</td>
</tr>
<tr>
<td>General offices</td>
<td>NC 40</td>
</tr>
<tr>
<td>Mechanised offices</td>
<td>NC 45</td>
</tr>
<tr>
<td>Restaurants, bars, cafeterias and canteens</td>
<td>NC 45</td>
</tr>
<tr>
<td>Department stores and shops</td>
<td>NC 45</td>
</tr>
<tr>
<td>Swimming baths and sports arenas</td>
<td>NC 50</td>
</tr>
<tr>
<td>Kitchens</td>
<td>NC 50</td>
</tr>
<tr>
<td>Factories (light engineering)</td>
<td>NC 65</td>
</tr>
<tr>
<td>Factories (heavy engineering)</td>
<td>NC 75</td>
</tr>
</tbody>
</table>

The specified noise criteria shall apply to all areas as measured at a level of 1.5 m above the floor, and the measuring points shall be 1.5 m away from the walls or doors of the rooms.

The Corrected Noise Level at potential Noise Sensitive Receiver in the adjacent or nearby building, if so identified in the Contract Documents, 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 Environmental Protection Department when the plant/equipment installed by the Contractor are put into operation.

B8.2 EQUIPMENT BASES

B8.2.1 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.

B8.2.2 Welded Structural Steel Bases

Detailed design calculation of the base and its anti-vibration isolator arrangements plus shop drawings for each base shall be provided for approval by the Architect before manufacture.

B8.2.3 Concrete Inertia Bases

Detailed design calculation of the base and its anti-vibration arrangements plus shop drawings for each base shall be provided for approval of the Architect before manufacture.

B8.3 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.

B8.3.1 Type 'A' - Free Standing Spring Mounts

Springs shall be designed and installed so that the ends of the springs remain parallel. They shall be corrosion-protected.

Submittals for approval shall include spring diameters, 'compressed' spring height, 'solid' spring height, rated capacities and rated deflections.

B8.3.2 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.

B8.3.3 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.
B8.3.4 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.

B8.3.5 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° swing capability.

Application - See Sub-section B8.5.2 for pipework vibration isolation.

B8.3.6 Type 'F' - Spring and Double Deflection Neoprene Hangers

Submittals for approval shall include scale drawing of the hanger
showing its 30° swing capability.

Application - See Sub-section B8.5.2 for pipework vibration isolation.

B8.3.7 Type 'G' - Pre-Compressed Spring Hangers

Submittals for approval shall include scale drawing of the hanger
showing its 30° swing capability.

Application - See Sub-section B8.5.2 for pipework vibration isolation.

B8.3.8 Type 'H' - Spring Hangers (Ductwork Support)

Submittals for approval shall include scale drawing of the hanger
showing its 30° swing capability.

Application - See Sub-section B8.6.1 for ductwork vibration isolation.

B8.3.9 Type 'I' - Double Deflection Neoprene Hangers

Submittals for approval shall include spring diameters, 'compressed'
spring height, 'solid' spring height, rated capacities and rated deflections.

Application - These isolation hangers may be used where only noise of
high frequencies needs to be isolated. They will not prove effective for
the isolation of low frequency motor type noises.

B8.3.10 Type 'J' - All Directional Anchor Units
Submittals for approval shall include rated capacities and rated deflections.

Application – The units may be used to provide high frequency noise and vibration isolation for those locations where movement must be controlled.

B8.3.11 Type 'K' - Pipe Anchors and Guides

Submittals for approval shall include rated capacities and rated deflections

B8.3.12 Type 'M' - Split Wall/Floor Seals

The seals shall be tightened around the pipes to eliminate clearance between the inner sponge faces and the pipings.

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 pipings which pass through walls, ceilings or floors of these rooms.

B8.3.13 Type 'N' - Horizontal Thrust Restrainers

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.

B8.3.14 Type 'O' - Built in Inertia Block Plant Support

Where specified, the Contractor as the case may be, shall provide plant foundations and housekeeping pads in form of large concrete blocks recessed into the main floor slab.

B8.4 PLANT/EQUIPMENT VIBRATION ISOLATION

B8.4.1 General

All rotating or reciprocating equipment shall be mounted on vibration isolation mountings or suspended from vibration isolation hangers.

The Contractor shall ensure that there is 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 by the Contractor.
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 must 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 Contractor shall verify that the isolation requirements are complete, the equipment offered is correct and suitable in meeting the design requirements on the vibration levels.

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.

B8.4.2 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 installation 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.

B8.5 PIPEWORK VIBRATION ISOLATION

B8.5.1 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 should provide the same deflection as the equipment isolators, with a maximum limitation of 50 mm deflection. The first two hangers adjacent to the equipment shall be of “positioning” or “precompressed” 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.

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 fiber or rock wool and caulked airtight after installation of piping. Alternatively, factory fabricated Type 'M' 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.

B8.5.2 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.

B8.5.3 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 'K' pipe anchors or guided by Type 'K' 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.

B8.5.4 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.

B8.5.5 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 BS 5500 : 1985.

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 vibrational movement is perpendicular to the axis of the hose. A Type 'K' 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.

B8.6 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 15 m from the connected vibrating equipment with a discharge pressure of 1 kPa or above shall be isolated from the building structure by means of Type 'H' hangers. 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 fiber, 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.

B8.7 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 C-916, 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.
B8.8  **ACOUSTIC DUCTLAG**

Acoustic ductlag 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 ductlag shall be installed in such a way that the material is completely decoupled from the vibrating duct wall. The Contractor shall submit installation details to the Architect for approval prior to installation.

B8.9  **DUCTWORK SILENCERS**

Ductwork silencers shall be supplied and installed as indicated in the Particular Specification or Drawings.

Manifolded 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 Contractor shall submit for the Architect's approval the proposed manufacturer's certified test data for pressure drop and insertion loss ratings.

The silencers shall be located at least three ductwork equivalent diameters from fans, coils, elbows, branch takeoffs, or other ductwork elements.

B8.10  **ACOUSTIC DOORS**

The Contractor shall supply and install proprietary made acoustic doors to plant rooms only where specified in the Particular Specification or Drawings.

B8.11  **ACOUSTIC LOUVRES**

The Contractor shall supply and install acoustic louvres to the external walls of plant rooms only where specified in the Particular Specification or Drawings.

B8.12  **ACOUSTIC ENCLOSURES**

B8.12.1  **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.

B8.12.2  **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.

B8.12.3 Openings and Sealings

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 fiber 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.

B8.13 PLANT ROOM ACOUSTIC LININGS

Where specified in the Particular Specification or Drawings, the Contractor shall supply and install acoustic linings to walls and / or ceilings of the plant rooms in order to reduce the reverberant noise levels of the plant rooms.

The wall liner board shall be secured by 1.5 mm thick galvanized 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 galvanized perforated metal plates which shall be secured by self tapping screws to the galvanized steel sections. The perforated metal plates shall be removable to enable future maintenance.

B8.14 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 by the Contractor, the detailed design and construction for the floating floor will be provided to the Contractor. In such cases the Contractor shall avoid any action that may subsequently 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 the Contractor shall avoid any action that will undermine the acoustic programme of the acoustic absorption membrane.

B8.15 SPECIALIST MANUFACTURER'S INSPECTION

On completion of the installation of all noise and vibration control devices, the (local or overseas) representative of the acoustic and vibration equipment/materials manufacturer shall inspect the completed system and report in writing to the
Contractor concerning any installation errors, improperly selected isolation devices, and/or other faults that could adversely affect the overall performance of the system.

The Contractor shall then submit a report to the Architect 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 by the Contractor, further inspections shall be carried out until all faults are rectified.

The Contractor shall allow the cost of visiting the site by the (local or overseas) representative of the noise and vibration equipment/materials manufacturer for this purpose.

**B8.16 INDEPENDENT INSPECTIONS**

In addition to the inspection of the Contractor's works by the specialist manufacturer's representative, independent parallel inspections and tests may be carried out by others under direct instructions of the Architect. Any deficiencies revealed by these inspections and tests shall be rectified by the Contractor at no additional cost to the Employer.
B9.1 GENERAL

This section covers pipework for :-

B9.1.1 Chilled or hot water circulation, vent & drain.

B9.1.2 Condensate drainage.

B9.1.3 Condenser cooling - fresh water circulation.

B9.1.4 Condenser cooling - sea or brackish water circulation.

B9.1.5 Make-up cold water supplies.

Note :- Pipework fitting and accessories for refrigerant systems shall read in conjunction with Section B6 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 galvanized.

B9.2 AIR VENTING

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.

Air bottles shall be made from 50 mm size tube, 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.

B9.3 BELLOW EXPANSION JOINTS/ANCHORS AND GUIDES

B9.3.1 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 should be within the prescribed limits in BS 5550.

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).
B9.3.2 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 10029, 10051 and 10259 of appropriate type. Bellows should be argon arc welded to carbon steel end fittings utilising a stainless steel seal ring to reinforce the bellow cuff end.

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 or carbon steel flanges to ISO 7005 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 to provide 25 years working life. 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 should be installed in strict accordance with the manufacturers recommendations. Manufacturers of expansion joints should be approved to BS EN ISO 9002.

B9.3.3 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 fully designed to contain the pressure thrust. End termination to be flanged to ISO 7005 Standard to suit the line pressures.

The joints shall be designed to meet the required angular movement or the required movement in all directions perpendicular to the axis of the bellows.

B9.3.4 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 Architect 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 introduced by the Contractor.

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 must not be greater than 4 pipe diameters, and the distance between the first guide and the second guide must not be more than 14 pipe diameters. Guides thereafter should 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 should 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.

B9.4 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 Architect.

Reduction by means of straight through reducing sockets is permitted.

Care must 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.
B9.5 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, 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.

B9.6 FLOW MEASURING

Methods for measuring flow rates in chilled or hot water and/or other liquid circuits shall be in accordance with Section C10 of this General Specification.

B9.7 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.

Larger drain cocks will be required for rapid flushing down in connection with water treatment.

B9.8 JOINTS AND FITTINGS FOR STEEL PIPEWORK

B9.8.1 Joints on all permanently concealed pipework and all pipework over 100 mm size shall be welded unless otherwise agreed by the Architect. The other pipework may be of screwed or welded joints. When the Contractor chooses to use screwed joints at least one of the two engaging components shall be taper-threaded to ISO 7-1 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 galvanized painting before making such joints.

B9.8.2 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 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.

B9.8.3 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.

B9.8.4 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.
B9.8.5 Where specified, and/or subject to the Architect'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 (except for connections to units incorporating reciprocating compressors or where the water temperature exceeds 93°C).

Mechanical pipe couplings shall be self-centered, 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 trackhead 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.

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 under in accordance with the pipe coupling manufacturer's latest specifications. 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.

The entire coupling installation shall be in accordance with manufacturers’ recommendations.

B9.8.6 Couplings or flange adapters for plain ended pipework shall be cast iron or steel, slip-on type, such as Viking Johnson or approved by the Architect:

Coupling shall consist of:

(a) Sleeve (without centre register)
(b) End flanges
(c) Sealing rings
(d) Bolts and nuts

Flange adapter shall consist of:

(i) End flanges/sleeves
(ii) Sealing rings
(iii) 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.

**B9.9 JOINTS AND FITTINGS FOR COPPER TUBES**

Fittings for copper pipework shall be as follows :-

**B9.9.1** Size up to and including 65 mm shall be of the capillary or compression type to ISO 2016. Size of the 76 mm and 108 mm shall be the flanged compression or capillary type. Size for pipework above 108 mm shall be flanged or welded.

**B9.9.2** Pipework shall be arranged with adequate connection points to allow easy dismantling. Connection points in copper pipework size up to and including 65 mm size shall be unions and for pipework of size 76 mm and above shall be flanged.

**B9.10 PIPEWORK GENERAL DETAILS**

**B9.10.1** 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.

**B9.10.2** 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.

**B9.10.3** Purpose-made sets or springs may be used where it is necessary to deviate from a straight run in ungalvanised pipework.

**B9.10.4** 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.

**B9.10.5** 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.

**B9.10.6** 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 Architect. 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.
B9.10.7 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.

B9.10.8 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.

B9.10.9 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.

B9.10.10 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.

B9.10.11 For forming bends in small bore, copper pipe up to size 25 mm pipe bending springs may be used but again there must be no distortion of the pipe involved.

B9.10.12 In the case of all bends formed in the pipe, these shall constitute long radius bends.

B9.10.13 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/m². Spiral appearance is permissible only if there is no bare patch.

B9.10.14 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.

B9.10.15 Short radius elbows shall only be used at the discretion of the Architect where long radius elbows will not fit or are not manufactured.

B9.10.16 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.

B9.10.17 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.
B9.11 PIPEWORK LAYOUT

The Tender/Contract 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. The Contractor shall accurately set out the various pipelines in the installation in compliance with the provisions of Sub-section A4.3, A4.6.1 and A4.6.5 of this general specification.

B9.12 PIPEWORK SUPPORTS EXPANSION JOINTS AND ANCHOR POINTS

B9.12.1 Where the Employer’s latest Guide Drawings & Details for pipework supports and brackets, expansion joints and anchor points are issued with the specific Contract Documents or have previously been issued to Approved Contractors for general application on the Employer's projects, these standard details 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 Contractor's own Installation/Shop Drawing Submissions and be approved by the Architect before work commences.

B9.12.2 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 not exceed the centres given in Tables B9.17-(1), B9.17-(2) and B9.17-(3) at Sub-section B9.17. Where there are two or more pipes, the spacing shall be based on the centres required by the smallest bore pipework.

B9.12.3 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, the Contractor must draw particular attention to the Architect for structural reinforcement to the floor slab and also allow for additional treatment to the base as required by the Architect.

B9.12.4 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.

B9.12.5 Brackets screwed to walls shall be secured by expanding plugs. Other purpose designed fixing devices or softwood plugs will not be permitted.

B9.12.6 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 Architect.
B9.12.7 Unless otherwise specified, hangers for horizontal pipework at high level shall be supported from mild steel angle or channel sections or approved proprietary devices supplied by the Contractor, 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.

B9.12.8 Where pipework is fitted in service duct or trenches or where it is of 65 mm size or greater and supported from walls, the design of the pipe supports, guides and anchors shall be in accordance with the Contract Drawings. Otherwise, the Contractor shall submit details and proposal to the Architect 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 by the Contractor at the time of erecting the pipework.

B9.12.9 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.

B9.12.10 The Contractor shall 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.

B9.12.11 Supports for plastics pipework may be of any approved pattern that prevents free axial movement of pipe at all temperatures and have radiused edges to prevent cutting into the pipe. All the bearing surface must be sufficiently wide to prevent indentation.

Valves, meters and other heavy 'in-line' equipment must be supported independently.

Supports for pipes carrying water at a maximum temperature of 15°C and covered with lightweight insulation shall be spaced in accordance with Table B9.17-(3) under Sub-section B9.17. 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.

B9.12.12 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.

B9.12.13 Supports, steadiers 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.

B9.12.14 The spacing of supports for steel copper and plastic pipework shall be in accordance with Tables B9.17-(2) and B9.17-(3) under Sub-section B9.17.
B9.12.15 Cold bridge should be prevented between the insulated pipework and the associated hangers and pipework supports.

B9.13 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 Sections B8 & C8 of this General Specification.

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.

B9.14 PLASTIC PIPEWORK

Fittings for plastics pipework shall be as follows:

B9.14.1 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 PVC pipe should only be made threaded and screwed into metal 'Female' threaded fittings.

B9.14.2 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.

B9.14.3 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.

B9.14.4 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.

B9.14.5 Where uPVC is used for condenser cooling circuits and for the inlet and outlet to pumps, it must 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.

B9.15 SPECIALISED HYDRAULIC SYSTEM BALANCING VALVES

B9.15.1 In addition to those specified, the Contractor shall allow to provide necessary hydraulic valves at all points on the system where circulation flow balancing must be carried out in order that the system balancing can be done.

B9.15.2 These valves shall be of manufacture approved by the Architect and be designed to:

(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)
(f) Provide for draining (where required)

B9.15.3 Construction

10 - 50 mm Gunmetal Working pressure up to 2 MPa
( to ISO 9461 )
65 - 300 mm Cast iron Working pressure up to 1.6 MPa
( to BS EN 1561 and ISO 185 )

The valve will be constructed with angled seat and valve handle complete with two plug type pressure tappings on each side of the valve seat.

Drain or vent plug valve.

Valves 10 - 50 mm with screwed ISO connections.

Valves 65 - 300 mm with flanged ISO 2084 connections.

B9.15.4 Commissioning and Test Equipment

One set (or more if specified) of electronic measuring equipment for use with hydraulic balancing valves shall be provided by the Contractor 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 Architect for subsequent monitoring and adjustment by the Employer's operation and maintenance staff.

See also Section A9 of this General Specification.
B9.16 '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.

B9.17 TABLE 'B'

Table B9.17 – (1) Supports for Steel Pipework

<table>
<thead>
<tr>
<th>Size of tube</th>
<th>Intervals for Horizontal runs</th>
<th>Intervals for Vertical runs</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>Bare Lagged</td>
<td>Bare and Lagged</td>
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<td>25</td>
<td>2.4 m 2.4 m</td>
<td>3.0 m</td>
</tr>
<tr>
<td>32</td>
<td>2.7 m 2.4 m</td>
<td>3.0 m</td>
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<td>40</td>
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<tr>
<td>300</td>
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Table B9.17 – (2) Supports for Copper Pipework

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<th>Size of tube</th>
<th>Intervals for horizontal runs</th>
<th>Intervals for vertical runs</th>
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</thead>
<tbody>
<tr>
<td>mm</td>
<td>Bare Lagged</td>
<td>Bare and lagged</td>
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Table B9.17 – (3) Supports for Plastics Pipework
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<th>Intervals for horizontal runs</th>
<th>Intervals for Vertical Runs</th>
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<td>m</td>
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<td>1.5</td>
</tr>
<tr>
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<td>1</td>
<td>1.8</td>
</tr>
<tr>
<td>28 to 35</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>42</td>
<td>1.2</td>
<td>2.4</td>
</tr>
<tr>
<td>53 to 65</td>
<td>1.4</td>
<td>2.8</td>
</tr>
<tr>
<td>76</td>
<td>1.8</td>
<td>3.5</td>
</tr>
<tr>
<td>108 and over</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

B9.18 WELDING AND BRAZING

The procedure and the competence of the operative shall be in accordance with the recommendations contained in the following British HVCA publications:

B9.18.1 "Welding of Mild steel Pipework"

B9.18.2 "Code of Practice - Brazing and Bronze Welding of Copper Pipework and Sheet."

Welding operations which are beyond the scope of (a) and (b) shall comply in particular with:

B9.18.3 BS 2633 and BS 2971 - relevant subsections for metal-arc welding (steel pipe)

B9.18.4 BS 1821 and BS 2640 - relevant subsections for Oxy-acetylene welding (steel pipe)

B9.18.5 ISO 5187 and ISO 10564 - Brazing (copper pipe)

B9.18.6 BS 1724 - Bronze welding by gas (copper pipe).

Where the visual inspection and tests reveal those welding joints which are reasonably believed to be unacceptable, the Architect shall be entitled to have such welding examined by radiography or other approved inspection method and independently assessed. The Contractor shall be responsible for the cost of the tests and subsequently remedy the work to the satisfaction of the Architect if tests prove the welding joints to be non-compliance with the specification.

B9.19 LABELLING AND CIRCUIT CONTROL DIAGRAM OF VALVES

All plant room valves and circuit control valves shall be provided with approved plastic labels in compliance with Sub-sections A3.3.1 or A3.3.2.

A circuit control diagram 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 Architect or as specified in Sub-section A4.6.9.
SECTION B10
SYSTEM MONITORING INSTRUMENT

B10.1 GENERAL

Clauses related to electrical control shall be read in conjunction with Sections B4, B5 and B7.

All instruments, gauges and devices with indication scales shall be mounted in such a position that they can be accessed and read easily.

B10.2 SYSTEM STATIC PRESSURE GAUGES FOR AIR DISTRIBUTION SYSTEMS

System static pressure gauges shall be provided for all fan systems (cooling towers, evaporative or air cooled condensers excluded) where the main fan power of the respective system exceeds 3 kW. 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 points where the static pressures are steady. 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.

B10.3 THERMOMETERS - AIR IMMERSION

Two 12 mm diameter test holes shall be provided for the insertion of thermometers (for measuring both dry and wet bulb temperatures at the same time) in each of the following locations of each air handling unit (fan coil units excluded):

- B10.3.1 Outdoor air connection
- B10.3.2 Return air connection
- B10.3.3 Supply air connection
- B10.3.4 Mixed air connection
- B10.3.5 Before and after each air cooling coil/heater bank
- B10.3.6 Before and after each humidifying device

Sealing plugs shall be provided and fitted to all test holes. Test holes shall be positioned so that thermometers are not affected by thermal radiation.

Permanent thermometers shall be inserted in test holes for systems with air volume flow rate of or greater than 5 m³/s.

For systems with flow rate less than 5 m³/s, four numbers of thermometers or in quantity equivalent to 10% of the total numbers of the test holes, whichever is
greater, shall be provided with each individual packed in protective casings and to facilitate identification of correct location, and handed to the Architect. Each thermometer shall be complete with a pierced plug to fit the test hole and each wet bulb thermometer shall be provided with a fabric sleeve.

**B10.4 THERMOMETERS - LIQUID IMMERSION**

In chilled water system with cooling capacity exceeding 30 kW or hot water system with capacity exceeding 40 kW, 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.

Cylindrical brass case, mercury-in-glass thermometers of straight or angle type shall be provided and permanently installed in pockets.

**B10.5 PRESSURE GAUGES FOR WATER SYSTEMS**

Pressure gauges shall be provided at suction and discharge sides of chilled or hot water pumps with water flow exceeding 1.3 l/s. 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.

**B10.6 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 with capacities or flow rates less than the values mentioned in Sub-section B10.2, B10.4 and B10.5.

The test plugs shall be fitted with captive caps for sealing them when not in use and shall have internal self-sealing devices. The plugs and probes shall be of materials suitable for the respective application and shall be submitted to the Architect for approval prior to ordering or installation.

Valved pressure tappings shall be provided for water systems.

Four thermometers and four pressure gauges for each range of temperatures and pressures, suitable for use with the test plugs, shall be packed in a protective casing and handed to the Architect together with adequate supply of all necessary insertion lubricant.

**B10.7 VOLTAGE AND CURRENT READINGS**

As detailed in Section B7 of this General Specification or specified in the Contract, the Contractor shall provide instruments to monitor the supply voltage, and/or current to individual or groups of refrigeration plant, except for split units.
B10.8 POWER FACTOR MONITORING

Where indicated elsewhere in this General Specification or in the Contract, the Contractor shall provide instruments to monitor the power factor of the equipment provided and installed under the contract as individual items or groups of plant.

B10.9 POWER CONSUMPTION METERING

Power Consumption (kWh) metering devices shall be installed for the following plants and equipment:

B10.9.1 Each main chilled water circuit with cooling capacity exceeding 200 kW;
B10.9.2 Chilled (or hot) water pump with motor power rating exceeding 30 kW;
B10.9.3 Fan motor with power rating exceeding 15 kW (for 24-hour plant only).

B10.10 LIQUID FLOW RATE METERING

Appropriate type of flowmeters shall be installed for the following plants and equipment:

B10.10.1 Chilled water circuit with a cooling capacity of 200 kW or more;
B10.10.2 Hot water plant with flow rate exceeding 9 l/s;
B10.10.3 Chilled (or hot) water pump with water flow rate exceeding 9 l/s.

B10.11 OTHER TYPES OF METERING DEVICE

B10.11.1 Pitot Static Tube

The device shall provide differential pressure reading through:

(a) The high pressure velocity head sensor, with interpolating tube to continuously average velocity pressure, facing the flow.

(b) A low pressure sensor which detects the static pressure.

The resultant differential pressure can be transmitted through the instrument head to a differential pressure flow responder meter.

The sensor shall not be inserted near any bends or other fittings likely to affect the water flow by turbulence or differential velocities across the pipe. The distance from any such fitting upstream of the measuring point shall not be less than 10 diameters of the pipe.
Where indicated, flow measurement as displayed on the responder meter shall be capable of transmitting to central control and monitoring system or simpler control system through electronic relay amplifier.

B10.11.2 Water Consumption Meters

WSD approved impeller type water meter complete with inlet/outlet isolating valve unions and a strainer shall be provided to measure the make up water consumption rate.

B10.11.3 Hour Run Meters

Hour run meter shall be provided for the chiller/condensing unit with cooling capacity exceeding 70 kW. The meter system shall be of reputable and proven manufacturer's make. Where required, it shall be suitable for working with central control and monitoring system.

B10.11.4 Energy Meters

Where specified in the Contract, energy meters for chilled (or hot) water system shall be provided. The energy meter shall consist of temperature sensors for both flow and return water circuits, electrostatic or ultrasonic flowmeter, flow transmitter/converter unit and a calculator unit.
B11.1 GENERAL

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 should be used at support points as recommended by the insulation manufacturer and as directed by the Architect.

At the point of support, specially prepared blocks of hardwood or styrofoam material must 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 should 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 insulate, 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 lineable 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 Architect. The separate type vapour barrier where employed shall not be pierced or otherwise damaged by supports or by the application of external cladding.

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. The Contractor shall be responsible for any damage on the insulation or barrier found and any subsequent wetting of the insulation shall be the full responsibility of the Contractor.

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 that conforming to Sub-section C11.4. The blanket shall be wrapped around the flexible connection, overlapped and secured in place by metal bands at both ends to the rigid ducts.

Minimum 10% of insulation installation workers worked in a project should have a certificate certifying that the installation workers have satisfactorily completed relevant thermal insulation installation courses organised by recognized organisations such as Hong Kong Institution of Engineers (HKIE), and Air-conditioning & Refrigeration Association of Hong Kong (ACRA) etc.

**B11.2 TYPES OF THERMAL INSULATION MATERIALS APPLICATION**

**B11.2.1 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 of 10mm long 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 100 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. All tapes shall be conformed to Sub-section C11.4.

Preformed factory fitting insulators cut to suit standard radius elbows, long bends and where available tees shall be used, otherwise, if not available, the Architect’s permission may be sought to neatly cut and mitre the insulation to fit around fittings. In this latter case, great care must be taken to ensure that all mitred joints are a close fit and that the finish coat of aluminium foil adhesive tape is neatly applied.

Flanges and other protrusions shall be insulated by fabricating oversize preformed 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 on each side.

Pipe supports shall fit around the outside of the insulation. The insulation at the support points shall be heavy density load bearing phenolic foam in preformed sections made to the 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 correct load bearing and dimensions of high density foam inserts and associated galvanised metal plate supports are correct to spread the point loads involved.

B11.2.2 Glass Fibre Insulation

All fibreglass insulation shall be completely sealed by effective vapour barrier and self adhesive foil tape as required by Sub-section C11.4.

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. If damage in a defined area exceeding 5% of the insulation surface or duct or pipe, the Contractor shall be responsible for replacement with new one.

When pins are required to use to support the fibreglass blanket, all the pins must 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 slabs are to be adhered to flat surfaces such as ductwork the method of fixing shall be approved by the Architect before commencing work.

B11.2.3 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 in ductwork so that the top and bottom pieces overlap the sides. Adhesives shall be applied evenly to the entire contact surfaces if the elastomeric insulation sheet is not a self adhesive sheet.

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 coats recommended by the insulation manufacturer shall be applied.

All coatings must be supplied by the original insulation manufacturer and applied strictly following the manufacturer’s installation manual to obtain the required result.

**B11.2.4 Polystyrene Insulation**

Unless otherwise instructed by the Architect, polystyrene insulation shall be covered in galvanised iron wire netting of 25mm mesh, 1mm dia. coated with 15mm cement plaster smoothed and finished with painting completion as Sub-section B11.8.

**B11.2.5 CFC, HCFC and HCF free Polyurethane Foam Insulation**

Whenever the polyurethane foam insulation is used for pre-insulated duct system without galvanised iron sheet metal, the following guidelines should be followed:

Wherever necessary, the ducts must be provided with appropriate reinforcements to guarantee sufficient mechanical seal against a maximum internal pressure of 500Pa during operation. The maximum deformation of the duct must not exceed 3% of its width or 30mm in any case.

The joints between one duct and the next shall be performed using flanges with unexposed bayonet coupling and ensure the appropriate pneumatic and mechanical seal. Elbows shall be provided with tuning vanes wherever indicated.

The ducts shall be supported by appropriate supports at intervals of no more than 4m whenever the greater side of the duct is less than 1m, and intervals of no more than 2m whenever the greater side of the duct is more than 1m.

Accessories such as volume dampers, fire barriers or duct coil and etc., shall be provided with independent support in such a way that their weight does not beat on the ducts.
Wherever indicated, the ducts shall be provided with appropriate test points for the sensors and inspection doors for cleaning and inspection all along the route.

B11.3 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 to 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 0.8mm 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.

Valves, flanges, strainers, glands etc. are to be provided with insulation of similar type to that employed on 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 0.8mm 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.

B11.4 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.

B11.5 DUCT WORK AND AIR HANDLING PLANT - METHODS OF APPLICATION

B11.5.1 Thermal insulation shall be applied to air distribution ductwork and to components within distribution systems such as fans, heater and cooler 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 should 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 passing conditioned space.

B11.5.2 Fixing methods for insulation shall provide a minimum of 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 purpose made boxes or by increasing the general thickness of insulation. Where insulation is applied in layers, all joints in all layers shall be staggered.

B11.5.3 At all points of support, the insulation and outer covering and vapour seal shall be continuous and shall not be pierced or fouled 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.

B11.5.4 Pre-formed slab insulation shall be applied with adjacent sides lapped to maintain a uniform thickness at corners. The insulation shall be fixed securely with adhesives conforming to ASTM C-196-Type II and NFPA-90A and by impaling on fasteners which must 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. In no circumstances shall adhesives be used which attack or dissolve the ductwork or insulation.

B11.5.5 Aluminium foil or plastics faced pre-formed slab insulating materials shall be placed on the outside of ductwork with adjacent sides lapped to maintain a uniform thickness at corners. All joints shall be sealed with foil tape as indicated in Sub-section C11.4 and held in place with contact adhesive. The adhesive shall be suitable for the range of ambient temperature and humidity encountered.

B11.5.6 Reinforcement of self-setting cement shall be 25 mm mesh, 1 mm dia. galvanised wire netting. 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.

B11.5.7 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. Polyisobutylene sheet shall be not less than 0.8 mm thick and have a tensile strength not less than 3.4 MN/m².
B11.5.8 Where an insulated duct passes through an external building element, adequate precautions shall be taken to prevent the entry of rainwater into the building. Details shall be submitted to the Architect for approval well before the construction starts.

B11.5.9 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 and galvanised wire netting of 25 mm mesh, 1 mm dia. 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.

B11.5.10 Thermal insulation and/or acoustic insulation materials shall be applied to the inside of ductwork only where indicated. 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. The provisions of Sub-section B8.9 and B8.11 shall also apply where applicable.

B11.5.11 Unless otherwise specified in Particular Specification, glass fibre insulation with scrim fibre glass cloth face finish or elastomeric insulation shall be used for internal lining material.

B11.6 CHILLED WATER PIPEWORK AND EQUIPMENT - MATERIALS AND FINISHES

All thermal insulating materials and finishes shall be as indicated in Sub-section C11.2 subject to the requirements of fire properties (Sub-section C11.1) and vapour barriers (Sub-section C11.4).

B11.6.1 Inside buildings for services concealed from view; the insulation shall be provided as indicated 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 pre-formed sections secured by external vapour seal and left unpainted. Where necessary on site vapour sealing compound shall be applied to ensure a 100% seal.

(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 pre-formed sections over 25 mm mesh, 1 mm dia. galvanised steel wire netting reinforcement, sealed and left unpainted. Alternatively, the insulation shall be vapour sealed as in Sub-section C11.4 and then protected with neatly applied external aluminium sheet cladding of not less than 0.8 mm thickness with all joints sealed.

B11.6.2 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 pre-formed 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 Architect finally painted or

(b) Aluminium foil faced pre-formed 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 must be maintained.

B11.6.3 Services in plant rooms and elsewhere where indicated shall in order to avoid possible mechanical damage receive the following treatment or be provided 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 as indicated under Sub-section C11.2, covered as Sub-section B11.5.5 and finally painted in accordance with Sub-section B11.8.

(c) Be treated with an effective high quality water based vapour barrier coating, Class 'O' surface to UK Building Regulation 1985.

The vapour barrier coating must 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 must be tough, flexible, washable and resistant to many acids and alkalis for a long service life.

Glass fiber reinforcing mesh shall also be applied in between coat. The reinforcing mesh should incorporate a thread of 10 strands by 10 strands per 650 mm² into its construction. When tested according to ASTM method D-579, the materials should have a tensile strength warp of 50 g/mm² and fill of 50 g/mm².
B11.6.4 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 mesh, 1 mm thick, galvanised wiring netting, 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/m², lapped and sealed at all joints.

(d) Be treated with two coats of an elastomeric polymer-based heavy duty mastic with reinforcing membrane to give a weather resistant finish.

The product shall meet the requirement of NFPA Standard 90-A. The non-combustible shall be in accordance with NFPA National Fire Code 220(b). Dry Film Fire Hazard requirements meet GSA and the product should be tested by ASTM E-84 (Surface Burning Characteristics of Building Materials).

B11.7 CHILLED WATER PIPEWORK AND EQUIPMENT - METHODS OF APPLICATION

B11.7.1 Thermal insulation shall be applied to chilled water pipework distribution systems, drain pipes, and all components within distribution systems such as valves and storage vessels, etc.

B11.7.2 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 items whether specifically mentioned or not.

B11.7.3 The insulation shall fit closely to the pipework and other surfaces without gaps between joints. Each section of pre-formed insulation shall be secured to the pipe by means of circumferential bands of non-ferrous metal, plastics fabric, or adhesive tape. Pre-formed slab 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.
B11.7.4 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.

B11.7.5 At entries into buildings the weather-proofed insulation shall extend not less than 150 mm beyond the inner face of the wall and be sealed to the satisfaction of the Architect.

B11.8 PAINTING AND IDENTIFICATION

B11.8.1 Thermal insulation exposed to view (including that within plant rooms) shall be painted the colour of which shall be approved or is acceptable to the Architect where insulation is protected by aluminium foil or self coloured sheet, plastics film or a weather-proof finish and is in concealed space, painting will not be required.

An undercoat and not less than two finishing coats shall be applied. Absorbent surfaces shall also receive an initial coat of priming paint. All paints shall be compatible with the surfaces to which they are applied.

B11.8.2 Painting shall be carried out generally as detailed in Section A8. The colour(s) of paint(s) shall be to the requirements of Section A8 and/or the instructions of the Architect and shall be selected from the range contained in BS 4800.

B11.8.3 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 HVCA Standard DW/144. For pipework, including thermal insulation, the basic colour and colour coding shall be in accordance with BS 1710.

B11.8.4 Uninsulated pipework or ductwork and thermal insulation which is 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.

B11.8.5 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
- Condenser water: CONDW
- Hot water: HW
- Supply air: SA
<table>
<thead>
<tr>
<th>Returned or recirculated air</th>
<th>RA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor air</td>
<td>OA</td>
</tr>
<tr>
<td>Exhaust air</td>
<td>EA</td>
</tr>
</tbody>
</table>

The letters F and R shall be added to piped distribution to show 'flow' and 'return' respectively.
SECTION B12
UNITARY AIR-CONDITIONER

B12.1 GENERAL

B12.1.1 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 control and indoor fan coil units,
(e) Multi-split system and
(f) Water cooled package and water pump package

B12.1.2 Unitary air-conditioners shall be factory fabricated and assembled. The equipment shall be rated and tested in the same country of manufacturing and meet the requirements of the American Air-conditioning and Refrigeration (ARI) Standards 210 or other international recognized design and quality assurance standards approved by the Architect.

B12.1.3 The most energy efficient model in the series shall be selected for submission and shall be referred to Sub-section C12.20 of this General Specification.

B12.2 INSTALLATION AND SERVICING

Installation and servicing of unitary air-conditioners shall comply with the practice set out in the ARI Standard 260 and the manufacturer’s recommendation.

B12.3 ANTI-VIBRATION MOUNTING

Vibration mounting shall be installed in accordance with relevant clauses of Section B8.

B12.4 CASING

Removable panel for casings shall be provided to give access to all working components, parts, and connections for installation and service. The casing shall be rigid G.I. Sheets and Paint in accordance with relevant clauses of Section A8. The compartment housing for the direct-expansion coil and blower shall be adequately insulated to prevent sweating 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.
**B12.5  COMPRESSOR**

Each compressor shall form a separate refrigerant circuit with its own condenser, evaporator and controls.

**B12.6  SUPPLY AIR FAN AND MOTOR**

All fans shall be statically and dynamically balanced. Fans shall be equipped with self-aligning bearings suitable for the installed altitude of the fan. Motors shall be installed in accordance with the relevant clauses of Sections B7 & C7.

**B12.7  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.

**B12.8  AIR FILTER**

Air filters shall be installed in accordance with the relevant clauses of Section B1 & C1.

**B12.9  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.

**B12.10  ELECTRIC DUCTWORK HEATER**

Electric ductwork heaters shall be installed in accordance with Sub-section C3.2.12.

**B12.11  REFRIGERANT PIPING**

Refrigerant piping and insulation shall be installed in accordance with relevant Sections in B6, C6, B11 and C11.

**B12.12  CONDENSATE DRAIN PIPE**

Condensate drain pipe shall lead to the nearest convenient drain in the building or as indicated on the Contract Drawings or as directed by the Architect on site.
Table B12.13  Standard Provision

<table>
<thead>
<tr>
<th>Associated Components/facilities</th>
<th>Unit Cooling Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Up to 7kW</td>
</tr>
<tr>
<td>1. Self-contained safety and operational components of factory standard</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Pressure gauges c/w stop valves, sight glass</td>
<td>-</td>
</tr>
<tr>
<td>3. Renewable filter-drier c/w accessories</td>
<td>-</td>
</tr>
<tr>
<td>4. Externally mounted adjustable Hi-Lo pressure cutout with hand reset for High side</td>
<td>-</td>
</tr>
<tr>
<td>5. Anti-recycling device</td>
<td>Yes</td>
</tr>
<tr>
<td>6. Emergency Stop Switch</td>
<td>Yes</td>
</tr>
<tr>
<td>7. Crankcase Heater</td>
<td>-</td>
</tr>
<tr>
<td>8. Pump down function and facilities</td>
<td>-</td>
</tr>
<tr>
<td>9. Refrigerant</td>
<td>R407C/R410a</td>
</tr>
<tr>
<td>10. Mechanical and weather protection to thermal insulation which exposed to view</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**B12.14 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 yet painted with attractive appearance.

**B12.15 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.

**B12.16 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.

**B12.17 VARIABLE REFRIGERANT VOLUME SYSTEM**

The refrigerant piping shall be capable of extending up to 100 meters equivalent length with 50 meters level difference without any oil trap. The entire system completed with all necessary piping and accessories shall be supplied and designed by a single proprietary manufacturer who has proven record for its product.
B12.18 MAINTENANCE SERVICING PLATFORM

Where unitary air-conditioners are installed on side walls of building at levels that are normally inaccessible from ground these shall be provided with an adequately sized service platform complete with railings and steel cat ladder with safety wings. Such platforms shall be of reasonable substantial rigid galvanized metal construction and shall be well protected against corrosion. The design must be approved by the Architect before installation.

Under Labour Department Ordinance, it is required to provide working platform for activity over 3 metres. This maintenance servicing platform requirement shall apply to all equipment and installation.
B13.1 GENERAL PUMP INSTALLATION REQUIREMENTS

The installation details should be in accordance with the instruction prepared by the manufacturer.

Pumps shall be 'Type-tested' in accordance with the requirements of BS 599 and BS 5316 or ISO 2548, ISO 3555 and ISO 5198. Test certificates with performance curves shall be submitted to the Architect.

Pumps and their drives shall be segregated such that failure of pump seals shall not result in damage to the drive motors.

B13.2 STORAGE

The equipment should 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 should then be re-lubricated.

B13.3 CENTRIFUGAL WATER PUMPS

B13.3.1 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 designed and 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 pipe-work 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 pipe-work to interconnect such pumps.

B13.3.2 Sump Pumps
The sump pumps shall be of vertical centrifugal design 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 should 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 should 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.

B13.3.3 Bore Well Pumps

The bore well pumps 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 mercury type.

The 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 3m long to facilitate the withdrawal of the pump from the pit for maintenance.
B13.4 PLANT ROOM LOCATION

The Contractor shall check and assure that 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 should be sited so that it will use the shortest and most direct suction and smallest vertical lift. Where possible, the pump centreline should be placed below the level of the liquid in the suction tank.

The Contractor shall observe all precautions 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.

B13.5 PUMP FOUNDATIONS

The foundation for a pump should 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 100mm thick and 150mm wider than the pump base-plate.

The space between the pump unit and the foundation bolts should be allowed in accordance with the manufacturer’s recommendation. Each foundation bolt should be installed in a pipe sleeve type holder and should 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 should be used as a bearing surface for mounting of a vertical wet-pit pump. The mounting face of the curb ring or soleplate should be machined for pump alignment. Tie rods should be installed to secure the pump that is designed to discharge below ground.

B13.6 PUMP ALIGNMENT

The pump unit should be accurately aligned in accordance with the manufacturer’s instructions prior to operation. The unit should 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 should be rechecked and adjusted correct at the expiry of the Maintenance Period.

B13.7 GROUTING OF PUMP BASE

The base-plate shall be grouted before piping connections are made and pump alignment is finally rechecked. Grouting should be properly done with concrete that shall compose of one part of pure cement and two parts building sand 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 should be rechecked thoroughly after the grouting has hardened for a period that should not be less than 72 hours.

B13.8 SUPPORT FOR PIPING

Suction and delivery pipes shall be supported independently of the pump. The connecting pipes to a pump should not strain the pump. Pipes installation should match up to the respective flanges without being strained into position. The faces of the coupling should be checked with a straight edge to make sure that they are parallel and concentric.

B13.9 CONNECTION PIPING TO PUMP

B13.9.1 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 installation should be laid out such that a continuous fall can be maintained from the pump to water source to prevent air pockets forming. Concentric reducers should 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 installation to create less friction and provide more uniform flow distribution.

B13.9.2 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 meter per second for pumping water over long distance. The
check valve shall be installed between the pump and the gate valve. The gate valve should 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 that are designed to absorb reactions or turning forces to ensure no mechanical and hydraulic forces imposed on the pump.

**B13.9.3 Pipe Flanges**

Pipe flanges should match with the sizes of pump flanges with full-face gaskets.

**B13.9.4 Expansion Joints**

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.

**B13.9.5 Intake**

The installation work should 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 should 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.

**B13.10 SUCTION STRAINERS**

The suction strainer shall be installed as close as practically possible to the pump. This suction pipe strainer should not be used for flushing the pipe. A temporary
strainer fitted with a finer mesh than the permanent strainer should be used for flushing all piping and cleaning thoroughly all possible mill scale and other foreign matter. The temporary strainer shall be removed afterwards.

B13.11 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.

B13.12 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.

B13.13 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.

B13.14 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 32mm whichever the greater and shall discharge to a conspicuous visible location outside the building.

Connections to a mild steel tank shall be made by means of bossed, screwed flanges or pads and studs and should be welded before galvanizing. 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.
B13.15 WATER FILTERS

Unless otherwise specified, water filters shall be provided for the installations with details as follows:

B13.15.1 Suitable and approved coarse and fine filters shall be fitted on all non-recirculating cooling or flushing water supply water system e.g. sea water system.

B13.15.2 For re-circulating systems of the water tower type, fine filters and sludge traps shall be provided.

B13.15.3 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.

B13.15.4 For the installation of a seawater pump house, in addition to the intake coarse filter, the strainer in the plant room shall be an automatic self-cleaning and approved type. The strainers in the plant room shall comprise a motorized continuously rotating inner drum located within the strainer body, and have an automatic backwash arrangement. Proper drainage facility should be provided by the builder.

B13.16 PLATE TYPE HEAT EXCHANGER

The installation shall be in accordance with the manufacturer’s recommendations and shall be easily accessed for maintenance and repair.

B13.17 SEA WATER STRAINER

The installation shall be in accordance with the manufacturer’s recommendations and shall be easily accessed for maintenance and repair.