

Technical Specifications

Section B - Technical Specification for Mechanical, Electrical, Plumbing & Drainage Installation



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A1 DESCRIPTION OF THE PROJECT

This Project is the fitting out for China Life Insurance Office at 14/F & 25/F, CLI Building, 313 Hennessy Road, Wanchai

The fitting out works include removal or alteration of the existing services and the supply and installation of new services, material and equipment as required suiting the interior decoration.

The Contract will be awarded as a Lump Sum fixed price Contract. Any additional works will be treated as variations evaluated according to the unit rates submitted. Also refer to the scope of works and drawings for particulars of this project.

A2 PROVISION OF EVERYTHING NECESSARY

It is the intent of this Specification and of the Drawings to call for finished work which is tested and commissioned and ready for operation.

Any apparatus appliance or material not shown on the Drawings, but which is mentioned in this Specification or vice versa or any incidental appliance, or materials or services, which may be necessary to make the work complete in all respects and ready for operation even if not particularly specified shall be supplied, delivered and installed without any additional cost as though specifically shown on the Drawings of mentioned in this Specification. All such apparatus appliances or materials shall conform to the same standard and shall be of the same make as for other similar items which are specified in this Specification.

A3 ENVIRONMENTAL CONDITIONS

Take cognizance of the environmental conditions applicable at the site location and ensure that all individual item of plant supplied shall be suitable for operation and long life under these conditions.

The following parameters will generally apply:-

Temperature	:	Indoor	<u>Summer</u>	<u>Winter</u>
			23°C	18°C
		Outdoor	33.5°C	7°C
Relative Humidity	:	Indoor	<u>Summer</u>	<u>Winter</u>
			50%	50%
		Outdoor	up to 100%	-
Control tolerance	:	Temperature	± 1°C	
		Humidity	± 10%	
Salt corrosion	:	Salt atmosphere as found in tropical coastal regions;		
Chemical corrosion I	:	Atmospheric vapors of sulphur combustion products;		
Chemical corrosion II	:	Atmospheric vapors of hydrogen sulphide;		
Sealing	:	Equipment shall be vermin proof. Outdoor items shall be weather and splash proof to prevent ingress of rain. Items that are not fully sealed shall have adequate provision for ventilation;		
Solar radiation	:	Equipment sited outdoors subject to direct sunlight should be capable of withstanding the effect of solar radiation without deterioration or changes in protective properties of finishes.		

Mould growth	:	Materials should not be used which promote mould growth.
Shock	:	Equipment must be capable of withstanding knocks and jolts likely to occur during repair work or rough handling on a work bench.

A4 POSITIONING AND CO-ORDINATION

All outlets, fittings, conduits, pipework, and ductwork shown on the Drawings are diagrammatic. Do not scale the Drawings. Consult the Engineer's details and construction drawings for actual spaces available and for building details before installing outlets, fittings, conduits, pipework, ductwork and apparatus. Make such offsets and deviations from work shown on the drawings as may become necessary to fit the actual space conditions and to accommodate apparatus installed under the several sections of the work.

Locate all equipment which must be serviced, operated, or maintained in fully accessible positions. If any equipment cannot be so located call same to the attention of the Engineer prior to fabrication.

The Contractor shall at all times be fully responsible for the correct positioning and installation of all work and equipment installed by him in accordance with this Specification and in consultation and co-operation with all other trades. No extras of any kind will be allowed if work and equipment has to be removed and replaced.

The Contractor shall particularly note that it is a requirement of this fitting-out contract that all visible services outlets including air diffusers, light fittings, sprinkler heads, PA speakers, power outlets, switch plates, etc. be fully coordinated with each other to the satisfaction of the Engineer. No claims shall be considered as a consequence of the Contractor's failure to co-ordinate.

A5 CODES AND STANDARDS

All equipment material and installation practices shall comply with the requirements of this Specification and the current governing codes and standards including but not limited to:

- Local Environmental Protection Standards
- The local Building Ordinance
- Local FSD Codes of Practice, the FOC Rules and/or LPC Rules
- All relevant British Standards and Codes of Practice or comparable
- IEE Regulations for Electrical Installations
- Local Electricity Supply Rules
- Local Water Supplies Department regulations
- The requirements of any other local authority or statutory body having jurisdiction
- The Heating and Ventilating Contractors Association's Specification for Sheet metal Ductwork specifications DW/144

In the event of any conflict between the express requirements of this Specification and any statutory requirement then the statutory requirements shall take precedence. Notify the Engineer in the event of any such conflict.

Where any equipment or materials are considered for use on this project which do not comply with this Specification but which satisfy equivalent international code of standards, the Contractor must demonstrate such equivalence provide appropriate details and documentation to the Engineer for approval prior to acceptance. The Contractor shall not offer any such alternatives which do not comply with the statutory requirements.

All materials and apparatus required for the work shall be new, of first class quality, and shall be supplied, delivered, erected, connected and finished in every detail. Where no specific kind or quality of material is specified or shown, first class articles as approved by the Engineer shall be supplied.



Where disagreements occur between the Drawings and the Specification or within either document itself, the item or arrangement of better quality, greater quantity, or higher cost shall be deemed to be included in the Contract.

All work shall be carried out by skilled, experienced craftsmen. In particular, all electrical work shall be performed by registered electrical workers within the meaning of the Electricity Ordinance. All welding shall be carried out by certified welders.

A6 EQUIPMENT SELECTION

All equipment selections shall be in accordance with this Specification and the relevant Drawings to the satisfaction of the Engineer.

The capacities of all plant and equipment described in the Specification or the Drawings are the required minimum output capacities taking into account any loss or reduction factor due to the restriction imposed by the position or orientation of the equipment as shown on the Drawings.

The Contractor shall take into account any variations which may be made to the systems during the progress of the Contract Works and inform the Engineer of their effect from time to time.

The Contractor shall be required to demonstrate at site that the duties required of the equipment are obtainable.

Physical size of all plant and equipment are to be suitable for the space allocated for the accommodation of such plant and equipment, taking into account the requirement of access for maintenance purposes.

In selecting makes and types of equipment, the Contractor shall ascertain that facilities for proper maintenance, repair and replacement are provided.

Where the Contractor proposes to use an item of equipment other than that specified or detailed in the drawing, which requires any redesign of the system, drawings showing the layout of the equipment as required shall be prepared to the satisfaction of the Engineer by the Contractor at his own expenses. Where such approved deviation necessitates a different quantity and arrangement of materials and equipments from that originally specified or indicated in the Drawings, the Contractor shall furnish and install any such additional materials and equipments required by the system at no additional cost.

Equipment catalogue and manufacturer's specifications must be submitted for examination and details shall be provided to the satisfaction of the Engineer before any equipment is to be ordered.

This shall include all information necessary for the Engineer to ascertain that the equipment complies with this Specification and Drawings. Date and sales catalogue of a general nature will not be accepted.

Before ordering equipment, The Contractor shall provide the Engineer with full details of the weights and electrical characteristics of the equipment for purposes of determining floor loadings, power consumption etc.

A7 SUBMISSIONS

All materials and equipment proposed for incorporation in the works must be approved by the Engineer prior to use.

The Contractor shall submit to the Engineer prior to construction sufficient technical data on all equipment and materials to enable the Engineer to assess and approve the items. Such submissions shall include but not be limited to:

- Manufacturers' catalogues and selection data for all equipment
- Product drawings and specifications
- Duty and part-load operating characteristics



- Statement on local service back-up and spare parts availability
- Any calculations which may be required in support of the selection
- Service connection requirements

All submission must be made early enough in the contract period to allow for review by the Engineer and for resubmission and further review as necessary until the submitted items are approved. Allow seven (3) days for each review by the Engineer. The Contractor shall ensure that the submissions are approved before any equipment and material requires to be ordered to meet the Installation Programme.

No claims for extensions of time or additional costs will be entertained as a result of the Contractor's failure to make his submissions in adequate time.

If, in the opinion of the Engineer, the Contractor's failure to make his submissions in adequate time may result in a delay in the completion of the project as a whole, then the Engineer shall have the authority to instruct the Contractor to order materials and/or equipment of a type from a source approved and nominated by the Engineer at no increase to the contract Sum.

If the Contractor subsequently fails to place such orders within period of one week from receipt of the Engineer's Instruction, then the Engineer shall have the right as his sole discretion to order the materials and equipment directly from the manufacture(s). The cost of all such orders, including freight, shipping, insurance, handling and administrative charges shall be deducted from the Contract Sum or recovered in any other method at the discretion of the Engineer.

Such an action by the Engineer shall not affect the Contractor's responsibilities under this contract and the Contractor shall accept deliveries of such directly ordered materials and incorporate them in the works as though provided by the Contractor.

A8 REJECTION OF UNSUITABLE MATERIALS

The Engineer will reject any plant, materials and workmanship not complying with the requirements of this Specification or which are in any way unsuitable and to order their removal and replacement, without increase to the Contract Sum.

The Engineer's decision as to what constitutes compliance with requirements and suitability shall be final and binding; the true intent and meaning of the Contract being that the whole of the Contract Works shall be completed to the satisfaction of the Engineer.

No rejected item shall be considered as a reason for failure to meet the completion date of the project.

A9 ORDERING, DELIVERY

Immediately after appointment, the Contractor shall obtain approval of all particulars and details necessary for the placing of orders and thereafter shall, as soon as possible, place orders for all plant, equipment and materials. The Contractor shall on request provide the Engineer with copies in duplicate of orders so placed. In placing such orders, it shall be the Contractor's responsibility to ensure that his suppliers are fully acquainted with and have agreed to work strictly to the requirement and time limits of the Contract.

The Contractor shall ensure that the delivery of equipment and materials meets the installation program. The Contractor shall provide temporary storage at his own expense in case the equipment or material is delivered earlier than the program requires and the site condition is not suitable for storage of such equipment or material. The Contractor shall also at his own expense, provide air freight and/or courier service in case normal freight cannot meet the installation program. The Contractor shall examine the Specification and Tender Drawings in detail and make full allowance in his Tender Price to provide air freight and/or courier service for certain critical items.



A10 PACKING, STORAGE AND PROTECTION

All plant, equipment, apparatus materials and parts shall be delivered to the site in new condition properly packed and protected against damage due to handling, adverse weather or other circumstances and as far as practicable, they shall be kept in the packing cases of under protective coverings until required for use.

Any items suffering damage in transit or on the site shall be rejected and replaced at the Contractor's expense. No item so rejected will be considered as a reason for failure to meet the Contract Completion Date.

A11 WORKING DRAWINGS

After receiving approval of the equipment manufacturers, submit for examination in accordance with this section detailed dimensioned shop drawings in hard copy and cuts of equipment showing general construction, size, arrangement and operating clearances.

The Contractor shall prepare, or be responsible for providing, the following drawings:

- Installation drawings of Electrical service
- Installation drawings of Mechanical service
- Installation drawings of Fire service
- Installation drawings of Plumbing & Drainage service
- Installation drawings of Cable containment for security/IT/ AV service
- Manufacturer's shop drawings
- Builder's work drawings
- Installation drawings for Lighting Systems
- Positions of all control equipment shall be shown in shop drawings.

Each item shall be identified by name and number as shown on the Schedules, Drawings and in these Specifications.

The Contractor shall be responsible for ensuring that all working drawings, including all calculations, proposals, documentation and information where necessary, are submitted to the Engineer in a timely and logical manner to ensure that the Engineer's approval is obtained by the target dates which are in accordance with the installation program.

To assist in the obtaining of such consent Contractor shall produce within 3 days of award of the Contract detailed lists of the drawings, calculations, proposals, documentation and information he intends to produce together with a program detailing the dates on which they will be submitted. Such lists shall give due allowance for the time taken by the Engineer to examine and check these submissions and shall allow for any necessary corrections and resubmission prior to obtaining the Engineers approval. Generally 3 day will be required for review of submitted material.

The failure of the Contractor to include all shop drawings on his schedule shall not relieve him of his responsibility to submit all required shop drawings in time to permit correct processing as specified herein.

Each submission shall contain two (2) copies of the Contractor's working drawings. The drawings shall show. Inter alia, full details of the installation including the size and routes of cables, conduits pipes and ducts; wiring drawings; layouts with respect to the building fabric; schematic and interconnection diagrams and drawings and any details as requested by the Engineer for assessment of compliance with the design intent an specification.

In producing the designs drawings calculations, proposals, documentation and information required by this Clause the Contractor shall co-ordinate his work with other contractors and trades. The Contractor shall ensure that all interfaces and work required for by other trades are clearly shown on the working drawings.



Any work commenced by the Contractor prior to obtaining the Engineer's approval shall be at Contractor's failure to first obtain the Engineer's approval or redone due to the Contractor's failure to first obtain the Engineer's approval than any additional cost shall be borne by the Contractor and no extensions of time will be allowed.

The symbol notation on all drawings on all drawings shall be the same as the Tender Drawings. New symbols, not previously used on Tender Drawings shall be agreed with the Engineer. All drawings shall have a title block, and unique reference numbering system and CADD file reference consistence these with.

The Contractor shall be responsible for verifying the accuracy of all dimensions abstracted from Tender Drawings or the Engineer's drawings and used in the preparation of his drawings.

Inspection of shop drawings is not to be considered as a guarantee of measurements or building conditions. Where drawings are inspected, said inspection does in any way relieve the Contractor from his responsibility nor from the necessity of furnishing material or performing work required by the Contract Drawings and Specifications which shall, in the event of a dispute, take precedence over shop drawings.

The submission of shop drawings (in either the original submission or resubmitted with corrections) constitutes evidence that the Contractor has checked all information thereon and he accepts and is willing to perform the work as shown in a workmanlike manner an in accordance with the best standard practice. It also constitutes evidence that all control diagrams, all electrical diagrams and all submissions of any kind are fully understood by the Contractor and that in his opinion the equipment will perform as specified.

All drawings submitted, including those by Suppliers, shall be signed by a responsible person of the Contractor's staff on behalf of the Contractor.

3 sets of approved drawing shall be submitted to the Engineer for distribution. The Contractor's drawings shall be prepared on the following metric scales:

- Floor plans - 1:100
- Sections - 1:50
- Details and plant room layouts - 1:20

The Contractor shall note that it is a particular requirement of this Contract that the pre-construction period be utilized to fully and thoroughly co-ordinate each of the services with each other and with the structure and architectural finishes such that all congested and conflicting areas are fully resolved to the satisfaction of the Engineer prior to construction.

A12 RECORD DRAWINGS, AS-BUILT DRAWINGS

Keep a complete set of approved working drawings, contract Drawings and Specifications on site all latest amendments, revisions and the like.

As the work progresses, mark all deviations and changes from the approved working drawings thereon, due to site conditions, variations, and other reasons, keeping an accurate record of work as actually installed.

After consultation with the Engineer for correct presentation and contents of as-built drawings the Contractor shall supply a full set of prints of these documents to the Engineer for approval, 20 day prior to Practical Completion. The prints shall show in detail the full extent of the installations in logical sequence.

Upon approval of these record drawings the Contractor shall make two sets of prints neatly bound with cover sheet and index and a set of computer diskettes of computer aided as-built drawing which shall be AutoCAD version & PDF and hand them over to the Engineer. In addition, provide 3 sets each of the as-built drawings ad commissioning reports in bound A3 format similar to the existing. Existing documents can be inspected at the office of the Engineer. All drawings ad computer diskettes for computer aided as=built drawing shall be at the Contractor's expense.



A13**OPERATION AND MAINTENANCE INSTRUCTIONS AND MANUALS**

Upon completion of all work and after completion of all tests furnish the necessary skilled labor and helpers for operating and maintaining all systems and equipment for a period of one week within 30 days of the issue of the Certificate of Practical Completion at a time to be instructed by the Engineer.

During this period instruct the Engineer or his representative fully in the operation, adjustment, and maintenance of all mechanical and electrical equipment.

The Contractor shall be fully responsible for the operation of all plant and equipment supplied and installed by him until the Engineer acknowledges having received all necessary instructions in the operation of equipment and system.

Operating and Maintenance Instruction Manuals shall be submitted as drafts for examination 20 days prior to practical completion and shall be issued as final at Practical Completion. Three copies of each Manual shall be supplied by the Contractor to the Engineer.

Manufacturer's advertising literature or advertising catalogues will not be acceptable for operating and maintenance instructions, but may be included for classification purpose.

Operating and Maintenance instruction Manuals shall have a hard cover with solid spine with name and title of the installation clearly marked on the spine and front cover. They shall contain all material A4 size pages in loose-leaf form and shall be of sufficient size to prevent cramping or binding. The manuals shall be properly indexed and shall contain divider with tabs between each section. All data shall be organized in a neat and concise manner. The sections shall consist of:

- General Description of systems and Equipment:
Include brief overall description of systems, design references, and description of each individual system and equipment involved.
- Operation and Equipment:
Include maintenance duties in general, daily and all periodic maintenance, lubrication chart, and spare parts list.
- Include a maintenance schedule for all equipment, including but not limited to:
 - Lighting control system
 - Air Handling Units
 - Pumps
 - Direct Digital Control System
 - Electrical Installations
 - Fans
 - Fan coil Unit and split type units
 - Fire Dampers
 - Fire Services Installations
 - Plumbing and Drainage Installations
 - Water Detection System
- Equipment Schedules:
Include schedules of equipment showing quantity, location, make, type, supplier, etc, and a schedule of all suppliers with addresses and telephone numbers.
- Manufacturer's Literature:
Include manufacturer's data on maintenance and operation of all equipment installed. Do not include irrelevant data or data that does not pertain to the model of equipment actually installed.
- Miscellaneous:
Include any miscellaneous charts, graphs, descriptions, data, etc, needed for complete maintenance and operating instructions of all systems and equipment installed.

A14**SAMPLES**

Submit samples of material and items of equipment, as listed below for approval by the Engineer. After being approved by the Engineer, the samples shall be stored on site in a safe place and be available for inspection at any time by Engineer.

It is the intent of this Specification that approved samples stored on site shall be samples of the approved finished product for each element of the work against which all such similar items of work are considered for acceptance. Returned samples or samples requiring modification are not to be considered as acceptable.

Samples shall be submitted three weeks before the date required for approval. Samples shall be submitted including, but no limited to, the following items:

- Identification labels and markers
- Insulation, Acoustic and lining materials
- All paint products and color charts
- Piping and accessories
- Conduit, trunking and accessories
- Cabling and wiring
- Support brackets
- One of each type of light fitting
- One of each type of supply and return air fitting
- Power outlet plates
- Lighting switch plates
- One of each type of sprinkler head
- One of each type of supply and return air boot
- Thermostats and fan speed switches
- One sample each of any other exposed service outlet or fitting
- Extension Power Bar
- Industrial Type Socket and Plug

Decorative and Architectural lighting fixtures shall be supplied and installed by contractor. Mock-up installation of such fixtures shall be required.

A15 RESPONSIBILITY FOR DESIGN

The Contractor shall be responsible for the detailed layout of works in Accordance with the design provided by the Engineer. The Contractor shall warrant and guarantee the design of all equipment and material to be incorporated into the works. The Contractor shall obtain the same warranties of guarantees from his suppliers.

A16 MISTAKES IN INFORMATION

The Contractor shall be responsible for any discrepancies, errors, or omissions in the Drawings and information supplied by the Contractor, whether they have been approved by the Engineer or not, provided that such discrepancies, errors or omissions are not due to defective drawings of information furnished to the Contractor by the Engineer. Or not, provided that such discrepancies, errors, or omissions are not due to defective drawings of information furnished to the Contractor by the Engineer.

The Contractor shall at his own expense carry out alterations or remedial works necessitated by reason of such discrepancies, errors, or omissions and modify the drawings and information accordingly, or if the same be done by or on behalf of the Engineer then the Engineer shall bear all costs reasonably incurred therein.

A17 AS-NEW CONDITION

At the time of handover of the Contract Works, the installed items shall be in 'as-new' condition. The Contractor shall, during the course of the Contract, protect all plant and equipment and shall restore/repaint as necessary before Practical Completion.



A18 GUARDS OR RAILINGS

The Contractor shall provide readily removable guards or railings for moving or rotating parts.

A19 LABELS

The Contractor shall provide stick on type labels for all equipment, fuses, terminals, lamps, switches, handles, keys, instruments, gauges, valves, circuit and piping diagrams, indicators and wherever their provision will facilitate the proper operation and maintenance of the system.

A20 TEST CERTIFICATES

Not less than 1 months prior to the date for Completion, the Contractor shall deliver to the Engineer three copies of the following documents for approval as appropriate to the work required to be carried out for Practical Completion:

- Preliminary test date specified to be submitted under “Commissioning and Testing”
- Proposed draft of the Operating and Maintenance Instructions for Mechanical and Electrical Equipment and Systems.

Within twenty (20) days of the issue of the Certificate of Practical Completion the Contractor shall deliver three copies of the following documents to the Engineer for approval.

- Final test date specified to be submitted under “Commissioning and Testing”.
- Acknowledgement from the Engineer that that the Engineer's authorized representatives have received instruction in operation of all equipment and systems.
- As-built record drawings. (See elsewhere in this Specification for information on how record drawings are to be prepared.)
- Certificates of approval from the authorities having jurisdiction.

A21 MAINTENANCE PROVISIONS

All equipment shall be designed to facilitate inspection, cleaning, replacement and repair of individual component without need for unnecessary removal of other components. Identical items of equipment shall have parts interchangeable one with another or, matched sets forming interchangeable units, and this shall be recorded and described in the O & M Manual.

Facilities shall be provided for proper isolation of equipment for maintenance work without affecting the working of other parts of the system. Protection for ‘live parts’ shall be given by the use of interlocks, isolators, shrouding or by a combination of these. There shall be warning labels to show when parts remain live when the isolator is opened and these parts shall be properly screened from inadvertent contact.

The Contractor shall inform the Engineer the exact dimensions and locations of access panels in the proper time during the construction period. Failure to do so shall render the Contractor responsible for the cost of any abortive or consequential work incurred.

Maintenance in Defect Liability Period

The Contractor shall submit an annual maintenance proposal for the Engineer's consideration. The proposal shall cover all items installed under this Contract. The maintenance proposal shall have priced scope of service for each item. The acceptance of the proposal in part, whole or none shall be at the sole discretion of the Engineer.

A22 PREVENTATIVE MAINTENANCE

Preventative maintenance of equipment supplied and installed under this Contract shall be carried out by the Contractor during the Defects Liability Period.

The cost for preventative maintenance during the Defects Liability Period shall be included in the Contract.



All equipment installed under this Contract shall be maintained by the Contractor in accordance with the appropriate maintenance manual, the manufacturer's recommendations and these Specifications.

All maintenance, including maintenance by manufacturers and/or local suppliers, shall be carried out in accordance with the following procedure:

- The pro-forma to be used and full detail of maintenance shall be to the approval of the Engineer and shall be submitted not later than three months after signing the Contract.
- A monthly visit shall be made by an experienced service engineer during the last week in each month of the Defects Liability Period.
- A register held by the Engineer or his representative shall be signed by the service engineer at each visit.
- A monthly return in triplicate to the Engineer shall be made by the first week in each month of the Defects Liability Period stating maintenance work completed and action taken on defects by the service engineer.
- Breakdown maintenance shall be attended to promptly on call from the Engineer and details entered on the monthly return.
- Maintenance plan shall be submitted one month prior to practical completion for approval.

All minor lubricants and consumable materials required for preventative maintenance shall be supplied by the Contractor.

A23 DEMOITION PRECAUTIONS

The following are the guidelines for the Contractor to proceed with demolition work.

The contractor shall note that these guidelines are not exhaustive and extreme care shall be taken during the course of the demolition work. It is the Contractor's responsibility to ensure that there is no damage to the existing installations which are to be retained.

A23.1 General

Before commencing demolition, assume that all services are in operating condition and therefore:-

- . Electrical wiring and accessories are energized
- . Water pipes are pressurized or have fluid inside
- . Equipments are ready to operate

Check as-installed drawings to ensure that no work is stripped out which serves other areas of the building not included in this project, notify the Engineer of such instances and make temporary diversion provision to maintain continuity of all services.

Adequately protect the premises from water damage.

Notify the building management if there is any of the building's central system affected by the demolition.

Minimize the duration of shut down of any services for other areas.

A23.2 Mechanical Services

Isolate and drain down each section of chilled water piping prior to any stripping out.

Provide advisory labels, printed in both English and Chinese, on all valves used for the temporary isolation of system.

Adequately protect all equipment intended for re-use.

Where appropriate, remove, store and re-install re-usable equipment.



A23.3 Electrical Services

All electrical works must be carried out by a registered electrical contractor.

Before stripping-out any portion of any electrical installation, make sure the portion is isolated and de-energized.

Provide warning notices in both English and Chinese at all switchboards advising of works being carried out.

Do not strip-out or disconnect any communications or fire alarm cabling- this must be referred to the Landlord for action.

All main distribution must be properly protected during the execution of demolition work.

A23.4 Fire Services

All fire services installation works must be carried out by a registered fire services contractor.

Isolate and drain down each section of the wet systems prior to any stripping out and notify the building management that the protection is being temporarily restricted.

Provide adequate temporary fire fighting appliances during periods when the fire fighting installations are out of service.

Minimize the duration of any shut downs in the fire fighting installations.

A23.5 Plumbing & Drainage

Isolate and drain down each section of the domestic fresh and flushing water system prior to any stripping.

Provide labels, printed in both English and Chinese, on all valves used for the temporary isolation of systems.

Seal all redundant drainage and vent pipe connections after stripping out.

Plumbing works must be carried out by a licensed plumber.

A24 **LEGIONNAIRES' DISEASE**

The entire works shall be designed and installed in such a way as to comply with the recommendations and provisions of local regulations.

A25 **ASBESTOS**

No asbestos or compound containing asbestos or equipment item containing asbestos or asbestos components shall be permitted on this project.

A26 **CFC's**

No CFC's of products containing or manufactured using CFC's will be used on this project.

A27 **POWER SUPPLIES**

The power supply on this project shall in general 380/220 Volt unless otherwise specified, 3-phase, 50 Hertz, with tolerances set by the Local Electricity Supply Company. All equipment supplied shall be suitable for the power supplies.

A28 **FIRE STOPS**

Provide proprietary fire stop at a locations where ducts, pipe or cables pass through fire rated



walls or slabs. Such fire stops to be rated to preserve the required fire rated construction of the wall or slab.

A29 NON-COMBUSTIBLE MATERIALS

All materials used in ceiling voids be non-combustible.

A30 PROTECTED STAIRS AND LOBBIES

No part of the Building Services Installations is to be installed within fire escape stairs or protected lobbies, except for that part of the Installation which directly serve such areas.

Where it is necessary to install any part of the Building Services Installation in such stairs, or lobbies, then these shall be encased in fire rated material to the same level of protection as the protected area.

A31 SPARE PARTS

The Contractor shall provide within seven (7) days after the issuance of "Certificate of Practical Completion" the following spares (whichever is the highest) and house into a wooden enclosure, install as directed by the Engineer.

- Valves: Ten (10) percent spare valve packing and seals (minimum of two (2) of each size properly labeled.
- Indicating lamps for control panel and motor starters. Ten (10) percent spare lap bulbs (minimum of two) of each type and size.
- Indicating lamps for control panel and motor starters. Ten (10) percent spare lap bulbs (minimum of two) of each color.
- Gauges, pressure, flow and level switches: Ten (10) percent spare gauges, pressure, flow and level switches (minimum of two (2) of each type and size.
- Lubricants: Spare capacity adequate for one year.
- 10% of lamp for all lighting fitting type.
- Spare part as per relevant Clause of this specification.

A32 LICENCES, PERMITS & FEES

Give all necessary notices, obtain all licenses and permits, perform all tests and pay all fees and other costs in Connection with the work. File all necessary plans and obtain all necessary approvals from the statutory and licensing authorities having jurisdiction over the work. Provide the Engineer with copies of all required.

A33 LANDLORD'S FITTING-OUT RULES

The Landlord has enforced rules governing the fitting-out of premises within the building site. These are engrossed in a "Fitting-out Guide", and shall be fully complied.

Section B SCOPE OF WORK

B1 GENERAL

- B1.1** The scope of work given herein must not be read as a complete description of the work forming this contract but only as an indication of the general extent of the works. The Contractor is deemed to have also read other related documents, schedules, specifications, drawings, etc. and in particular the tender drawings, to be fully aware of the true extent of the work.

- B1.2 The Contractor shall be responsible for the following general items.
- B1.2.1 Liaison with and application to utility companies and government authorities, including provision of all drawings, documents and fees to fulfill the statutory and licensing requirements.
- B1.2.2 Provision of comprehensive maintenance during the Defects Liability Period.
- B1.2.3 Training of the Engineer's staff in operating and maintaining the installation.
- B1.2.4 Provision of spare parts according to the requirement of the specification.
- B1.2.5 Provision of Landlord submission drawings, as-fitted drawings, O&M Manual, working drawings and submissions as required by this Specification.
- B1.2.6 Provision of equipment and material guarantees as detailed in this Specification.
- B1.2.7 Provision of painting and labeling.
- B1.2.8 Provision of safe demolition and disposal of all redundant existing services installations.
- B1.2.9 Provision of commissioning and testing in accordance with the C.I.B.S.E. commissioning codes or an equivalent standard.
- B1.2.10 Provide all labor, services support, supervision, and incidentals require to install the systems complete and in operation, all in accordance with the Contract Documents.
- B1.2.11 Seal all openings to maintain fire rating and sound rating.
- B1.2.12 Provide temporary and permanent diversion of existing services.
- B1.2.13 Liaise with the Landlord and other trades regarding all interfacing works with the building's central services.
- B1.2.14 Liaise with the UPS contractor regarding all interfacing works with the UPS System.
- B1.2.15 Prior to submission of the tender, visit the site and become familiar with the site conditions and any restrictions or constraints which may affect the execution of the work. No claim will be entertained for ignorance of the site restrictions.
- B1.2.16 Provide any other miscellaneous items or incidentals which may be required for the complete and satisfactory operation of the entire installations to the satisfaction of the Engineer.
- B1.2.17 Fire rated enclosure shall be provided for any new or existing combustion materials inside the ceiling return plenum used in this project.
- B1.2.18 Phasing arrangement for the project might be adopted. The contractor shall allow all necessary temporary work and interfacing work to facilitate the phasing arrangement if required. The Engineer's office will keep operation during construction period, the completed on time and will not cause any disturbances to the end-user's operation.

B2 Electrical installation

- B2.1 Take down and remove all existing installations that are not required for the works.
- B2.2 Supply and installation of LV distribution system, including:-
- Liaison with and application to the power company for power co.'s meter if required
 - Main distribution system
 - Emergency distribution system including Plug-in Unit and Changeover
 - Trunking, cable tray, conduit and accessories for main distribution
 - Main distribution MCCB board and MCCB units

- B2.3 Supply and installation of final circuit power installation, including:-
- ☐ MCB boards and accessories
 - ☐ Trunking and accessories
 - ☐ Cable, conduit and accessories
 - ☐ Socket outlets
 - ☐ Connection units
 - ☐ Floor Boxes
 - ☐ Power point as specified on the drawings
- B2.4 Supply and installation of final circuit lighting installation, including:-
- ☐ Switches
 - ☐ Motion sensors and by-pass switches if need
 - ☐ Lighting points for all lighting fittings as shown on the drawing
 - ☐ Timer and contactors
 - ☐ Trunking, cable, conduit and accessories
- B2.5 Alteration and addition of all existing Office light fittings (ceiling, trough, furniture etc.) including lamps transformer, ballast, wiring, conduit/ trunking, switch points as specified by the Lighting Designer.
- B2.6 Supply and installation of all new Office light fittings (ceiling, trough, furniture etc.) including lamps, transformer, ballast, wiring, conduit / trunking, switch points as indicated on the drawings & specified by the Lighting Designer.
- B2.7 Supply and installation of all emergency lighting (i.e. Exit Sign and battery pack for Office Lightings) as shown on drawings, including wiring, conduit/ trunking, switch points.
- B2.8 Supply and installation of trunking and conduit installation for AV system and intercom system.
- B2.9 Supply and installation of trunking and conduit installation for IT system, computer system and telephone system.
- B2.10 Supply and installation of trunking and conduit installation for Security system, i.e. CCTV system and door access system.
- B2.11 Supply and installation of the earthing protection including protective conductor for the low voltage distribution system and equipotential bonding to all extraneous conductive parts in the site area.
- B2.12 Supply and installation of Motion Sensor Lighting Control System as specified in the tender drawings. Contractor shall be responsible for the modification of lighting circuits; addition of new motion sensor and programming work.
- B2.13 Supply and installation of Timer Lighting Control System as specified in the tender drawings. Contractor shall be responsible for the modification of lighting circuits; addition of timer control panels and programming work.
- B2.14 Supply an installation of new emergency power supply including all necessary protective devices, cable wiring and cable containment provisions as shown in the Tender Drawings. **(Provision of incoming essential cable and accessories required shall be carried out by Landlord's Nominated Contractor under this Contract)**
- B2.16 Alternation of building's PA system and mobile phone antenna according to new layouts. Contractor shall be responsible for the addition of PA equipment such as amplifier and speaker if required. **(Work shall be carried out by Landlord's Nominated Contractor under this Contract)**

- B2.17 Provision of miscellaneous items such as
- testing and commissioning,
 - liaison and applications for approval to utility companies, regulatory and licensing authorities,
 - Provision of completion certificates to suit the requirements of utility companies regulatory and licensing authorities,
 - Companies, regulatory and licensing authorities,
 - Instructing Engineers staff,
 - Provision of Operating and maintenance manuals,
 - Maintenance during the Defects Liability Period,
 - As-fitted drawings (in both PDF and AutoCAD format).
 - Painting and labeling,
 - any other incidentals not specifically listed and which may be required for the completion of the whole works.

B3 Fire Services Installation
(Works shall be carried out by Landlord's Nominated Contractor under this Contract)

- B3.1 Take down and remove all existing installations that are not required for the works.
- B3.2 Alteration and addition to the existing sprinkler system including dismantling, relocation, supply and installation of sprinkler, pipework and all necessary fittings.
- B3.3 Alteration and addition to the existing fire hose reel system including dismantling, relocation, supply and installation of pipework, valves & fittings, hose reels, electric alarm bell, breakglass, conduit, wrings and all necessary accessories. Contractor must provide sufficient numbers of alarm bells to fulfill the statutory sound level requirement.
- B3.4 Supply and installation of all electrical works for fire services systems including conduit, trunking, wiring and all necessary equipment.
- B3.5 Drain off and refill the fire services systems as often as required for the execution of the work.
- B3.6 Provision of miscellaneous items such as
- preparation of shop drawings for Landlord's approval,
 - submission of samples,
 - testing and commissioning,
 - liaison, applications for approval to utility companies, regulatory and licensing authorities,
 - provision of completion certificates to suit the requirements of utility companies, regulatory and licensing authorities,
 - instructing Engineer's staff,
 - provision of Operating and Maintenance manuals,
 - maintenance during the Defects Liability Period,
 - as-fitted drawings,
 - painting and labeling,
 - any other incidents not specifically listed and which may be required for completion of the whole works.

B4 MVAC Installation
(Works shall be carried out by Landlord's Nominated Contractor under this Contract)

- B4.1 Take down and remove all existing installations that are not required for the works.
- B4.2 Supply and installation of condensate drain piping system to A/C units including pipework, condensate sump pump and tank, insulation, valves and all necessary fittings.
- B4.3 Supply and installation of new Package A/C Unit including all necessary fittings, controls and accessories.
- B4.4 Alteration and installation of existing branch air ductworks for VAV system including all necessary fittings and accessories.

- B4.5 Alteration and installation of existing VAV boxes including all necessary fittings, thermostats, controls and accessories.
- B4.6 Supply and installation of entire duct work system including diffuser, insulation, acoustic lining, volume control dampers, motorized dampers, air grilles and all necessary fittings.
- B4.7 Supply and Installation of Acoustic transfer air duct work system including insulation, acoustic lining, air grilles and all necessary fitting.
- B4.8 Alteration and installation of new VAV boxes including all necessary fittings, thermostats, controls and accessories.
- B4.9 Alteration, supply and installation of condensation water piping system for essential and supplementary cooling including pipework, energy meters, condensate drain pipes, insulation, valves, fittings and equipment.
- B4.10 Supply and installation of exhaust air fan including ductwork including termination devices, insulation, acoustic lining, controls, all necessary fittings and accessories.
- B4.11 Supply and installation of electrical and control system including all necessary power and control devices and accessories, conduit and wiring, etc.
- B4.12 Relocation of ceiling mounted thermostats according to new layouts.
- B4.13 Alteration of existing BMS system including all programming and mapping work.
- B4.16 Provision of miscellaneous items such as
- submission drawings to the Landlord for approval
 - shop drawings,
 - submission of samples,
 - testing and commissioning,
 - liaison and applications for approval to utility companies, regulatory and licensing authorities,
 - provision of completion certificates to suit the requirements of utility companies, regulatory and licensing authorizes.
 - instructing Engineer's staff.
 - Provision of Operating and Maintenance manuals.
 - Maintenance during the Defects Liability Period
 - As-fitted drawings,
 - Painting and labeling.
 - Any other incidentals not specifically listed and which may be required for the completion of the whole works.

B5 Plumbing and Drainage Installation
(Works shall be carried out by Landlord's Nominated Contractor under this Contract)

- B5.1 Take down, demolish and remove all existing installations that are not required for the works.
- B5.2 Supply and installation of potable and hot water supply system, including pipes and fittings, valves and accessories, final connection to fitments.
- B5.3 Supply and installation of the drainage system and connect to the base building drainage system.
- B5.4 Supply and installation of sump pump system for pantry, food preparation room including acoustic and thermo insulation of the tank, drip tray, water detection system and control panel as specified in the drawings.
- B5.5 Provision of miscellaneous items such as
- submission drawings to the Landlord for approval
 - shop drawings,

- submission of samples,
- testing and commissioning,
- liaison and applications for approval to utility companies, regulatory and licensing authorities,
- provision of completion certificates to suit the requirements of utility companies, regulatory and licensing authorities.
- instructing Engineer's staff.
- Provision of Operating and Maintenance manuals.
- Maintenance during the Defects Liability Period
- As-fitted drawings,
- Painting and labeling.
- Any other incidentals not specifically listed and which may be required for the completion of the whole works submission.

B6 Builder's Work

The Contractor shall provide all necessary builder's work and attendance for the electrical and mechanical installations including, but not limited to:

- All concrete equipment plinth and concrete piers in plant rooms, keyed to the floor slab and graded where required.
- The building in of all pipes sleeves and equipment holding down bolts required to be built in during construction.
- Access hatches, cat ladder, maintenance platform, doors and panels as nominated by the Contractor and in accordance with details as required in false ceilings, masonry risers, plant rooms and at other places as required to allow access for adjustment, maintenance and cleaning.
- All cutting, patching, framing up, furring in, chasing and making good associated with the building construction for the passage of pipes, ducts conduits cable trays, sprinkler heads, alarm bells, etc.
- Provision of builders work drawing for co-ordination and approval as specified elsewhere.
- Provision of cabinets to house hose reels.
- Provision of localized wall strengthen to support panels.
- Provision of power supply including all necessary wiring and associated cable containment.

B7 SCHEDULE OF TENDER DRAWINGS

The drawings issued at the time of tender are for the guidance of the Contractor in producing his working drawings for the system and are not a complete design. The Tender Drawings show the basic principles on which the Contractor's design is to be prepared. The Tender Drawings indicate an acceptable method of laying out the system/equipment and how the various items of equipment are related to each other. The Contractor shall develop the detailed design for the system/equipment and shall produce all working drawings.

Section C PARTICULAR SPECIFICATION

C.1 ELECTRICAL INSTALLATION

C.1.1 Main Distribution

C.1.1.1 Main Distribution Boards

Every MCCB distribution board is to be controlled by means of an isolating switch mounted adjacent to the board.

The enclosure of an MCCB distribution board shall be constructed from sheet steel have a thickness of not less than 1.5mm, and shall be designed for general commercial and light industrial applications.



MCB distribution boards shall be provided with vertical triple- pole and neutral copper busbars of rating not less than that of the supply side protective device subject to a minimum of 200A.

Busbar supports and busbar mounting arrangement shall be type tested to a short-time withstanding current of not less 22.4kA for 1 second at a voltage of not less than 380 volts.

Outgoing MCCBs shall be mounted horizontally on both sides of the vertical busbars. The connection between the MCCBs and the phase busbars shall be by means of copper tapes and bolted joints. Plug-in type of current carrying contacts shall not be accepted.

A circuit chart shall be provided and affixed to the rear side of the MCCB front panel, which gives the total information of the numbers and locations of power points served by each circuit, total load per way and the circuit rating. The chart shall be fixed inside a metal trim panel with transparent plastic front plate inside the board door.

C.1.1.2 MCB Distribution Boards

MCB distribution boards shall comply with and be type tested to BS 5486 and/or other relevant international standards. Rated voltage shall be 220V, single phase or 380V, three phase, Rated frequency shall be 50Hz. The MCBs, MCB distribution boards and consumer units shall be from the same manufacturer.

Enclosures and doors for MCB distribution board shall be constructed from sheet steel having a thickness of not less than 1.0mm and stove enameled to a light grey finish or to the nearest manufacturer's standard color. The MCB distribution board shall be of robust construction and suitable for indoor application in commercial and light industrial situation. Hinged enclosure doors are to be fitted with ball catch locks or similar approved.

MCB distribution boards shall be of two types, viz Type I and Type II. Type I MCB distribution boards shall be suitable for accommodating single- pole MCBs only while Type II MCB distribution boards shall be suitable for accommodating, in any combination, single-pole and multi-pole MCBs.

All Type I MCB distribution boards shall each be provided with a molded-case, double pole incoming switch having rating not less than that of the supply side protective device.

The back plate assembly shall be of sheet steel of substantial thickness and be attached to the back of the distribution boards enclosure for mounting of MCBs and switches.

The metal front plate assembly shall be of sheet steel and shall be finished to the same color as the distribution board enclosure. The front plate shall be screwed onto the enclosure, making the assembly suitable for both surface and flush mounting. The front plate shall be affixed with labels for circuit identification.

All current carrying parts of the distribution board such as busbars, neutral and earthing terminals, incoming cable terminals etc, shall be of electro-tinned copper.

The configuration of the busbars, busbar supports and mounting arrangements for the MCB board shall be type tested and certified for a short time withstanding current of not less than 6KA for 0.2 second at a voltage of not less than 280V.

Blanking-off plates shall be supplied for spare circuits for all distribution boards.

All distribution boards shall be provided with live, neutral & earthing terminals for the incoming cables. There shall be one neutral and one earthing terminal for each outgoing MCB way.

Space shall be provided for the future accommodation of 20% additional circuit breakers in all distribution boards. All necessary busbars, studs and neutral bar ways shall be allowed. The Contractor shall correctly price his tender according to this requirement.

C.1.1.3 Busbar Chamber

The busbar chamber shall be constructed in compliance with B.S. 5486 Part 1 & Part 2 with full size neutral consisting of electro-tinned, hard drawn copper busbar of appropriate size insulated by porcelain supports or other approved insulation material spaced at 600mm intervals. The enclosure shall be made of 2mm thick mild steel and, epoxy powder paint finish to B.S. 4800.

The busbar chamber shall be of metal clad, air-insulated, totally enclosed type. The length of the busbar chamber shall be sufficient to accommodate all switchgear connected to it without staggering one above another. Spaces shall be provided for future installation of switchgear.

The front cover and end plates of the enclosure shall be removable and normally held in position by captive, non-ferrous metallic screws.

Busbar and busbar connections shall comply with B.S. 159

Busbars shall be so arranged that all conductors can be brought onto the Bars without undue bending. Each busbar shall be colored in one position or labeled to indicate the phase to which it is connected.

Switchgear shall be coupled to the busbar chamber by means of proper galvanized connection flanges or conduit couplers and male bushes.

Conductors between the busbars and switchgear shall be copper cable with Cross-sectional area not less than that of the outgoing cable from the switchgear.

The busbar chamber shall be fabricated by a reputable manufacturer and shall be fully type tested by ASTA for a withstanding capacity of 50kA for second. Locally made busbar chambers are acceptable provided ASTA certificate is available.

C.1.1.4 Fused Switches, switchfuses and Isolators

All fused switchgear and isolators shall be heavy duty type conforming to the requirements of B.S. 5419. All contacts are to be fully shrouded.

The fuse links for fuse-switches and switchfuses are to be high rupturing capacity, cartridge type conforming to B.S.88: Part 1.

Each switchgear shall be supplied in a complete unit consisting of a basic unit, enclosure and fuse links. Adequate space shall be provided in the enclosure for proper cable termination, otherwise cable boxes shall be provided.

The enclosure shall be of totally enclosed type, made of heavy gauge sheet metal, adequately rust protected and finished in enamel. An earthing terminal shall be provided. The enclosure shall be suitable for conduit, trunking and armored cable entries and also for connection to busbar chamber from top or bottom. Frame sizes for the range of switchgear shall be kept to a minimum.

The switchgear shall be of quick-make and quick-break type and switching operation shall be independent of the speed of the manual operation. An interlocking device shall be provided such that the front cover of the switchgear cannot be opened if it is at the 'On' position.

Insulation material used shall be of non-hygroscopic and non-ignitable type. The contacts shall be self-aligning so that the contact pressure can be maintained at all times. All live parts shall be adequately shielded from the front of the unit but easily accessible for maintenance by using a tool.

The 'ON' or 'OFF' positions of all switches and isolators shall be clearly indicated by a mechanical flag indicator or similar device.

Switch and isolator operating handles shall be retractable into the unit when the switch is in either the 'ON' or 'OFF' positions.

In T.P.&N. fused switches or switchfuse units, bolted neutral links are to be fitted. For single pole and neutral switchfuses and isolators, the neutral conductor is to be taken through a bolted link. Breaking the neutral conductor, either with linked or non-linked switch will not be permitted.

Unless otherwise specified, switches shall be to utilization categories AC-22 for general application and AC-23 for electrical motor circuits.

C.1.1.5 Fuses

Fuse-links complying with BS 88: Part 1 and 2 :type G. Type gM fuse-links may be used for the protection of motor circuits where the characteristics of the circuit do not permit the use of similar rated type G fuse-links/ Fuse carries. Bases and parts shall comply with BS 88.

All low voltage fuses in a fuse-combination unit shall be of the same make and shall be chosen from the same range of from complementary ranges designed to be operated in conjunction with each other.

C.1.1.6 Moulded Case Circuit Breakers (MCCB)

C.1.1.6.1 General

MCCB shall be four-pole, triple pole or double pole, independent manual closing air break type. They shall be totally enclosed in a moulded casing formed from an insulating material. The construction of the casing shall be capable of withstanding the appropriate rated short circuit current and reasonably rough use without fracture or distortion. The moulded casing shall have protection not less than IP 30.

C1.1.6.2 Operation Characteristic

MCCBs shall have thermal-magnetic tripping mechanism giving a fixed, stable, inverse time-current characteristic which cannot be adjustable on site. The operating characteristic shall be such that:

- The time delay on overload tripping shall be inversely proportional to the over currents up to a threshold value of approximately 7 times the rated current.
- There shall be no intentional time-delay on over current tripping due to short-circuit or heavy over currents exceeding the threshold value.

C1.1.6.3 Performance Characteristic

MCCBs shall be certified, according to BS 4752:Part 1, to have the following performance Characteristics:

- Rated short circuit breaking capacity- not less than 22kA for submain.
- installation or the prospective fault current at the point of installation whichever is greater.
- Short circuit performance category P-2.

C1.1.6.4 Shunt Trip Release

This shall operate correctly at all values of supply voltage between 70% and 120% of the nominal supply voltage under all operating condition of the MCCB. MCB incorporated with shunt release shall be provided with block terminals and shunt release lead cables.

C.1.1.7 Miniature Circuit Breaker (MCB)

All MCBs shall be of triple-pole or single-pole and conform to BS 3871: Part 1 and/or other relevant international standards. MCBs shall have the tripping classification of Type 2, for lighting and Type 3 for motor. The short circuit capacity of the MCB shall be 9Ka minimum.

The body and base of the units are to be molded bakelite, or similar material and the units are to be sealed after assembly.

The load handling contacts are to be silver / tungsten and the contacts and operating mechanism so designed as to give a wiping action both at make and break.

The breaker operation mechanism is to be of trip-free type so designed to prevent the load handling contacts from closing on a fault.

Circuit protection against overload and fault conditions is to be provided by means of a thermal-magnetic device designed to give thermal operation on overload and magnetic operation under fault conditions.

The tripping mechanism shall be designed to give stable time/current characteristics in accordance with Table 5 of BS 3871: Part.

Circuits for socket outlets shall be equipped with RCD of 30mA sensitivity and breaking capacity of at least 9kA.

Cable terminals of the MCBs shall be at top and bottom of the unit with access

From the front and suitable for terminating the size of solid or stranded conductor in accordance with Table 6 of BS 3871: Part 1.

Positions of the breaker operating handle are to be clearly indicated for 'ON' or 'OFF'.

All cable and busbar terminations shall be sweated and flared prior to connection to M.C.B.

C.1.1.8 Residual Current Device (RCD)

Residual Current Device (RCD) shall comply with BS 4293 and/or other relevant international standards

RCD shall be of 30mA sensitivity and short circuit current capacity of not less than 9kA.

The casing of the RCD shall be made of insulating material designed to withstand reasonably rough usage.

Multi-pole RCD shall be interlocked internally so that earth leakage on any one phase shall trip all three phases of the device simultaneously.

RCD shall be suitable for independent toggle operation. The automatic tripping operation shall be of the passive type, i.e., it shall not involve the amplification of the operating residual current and shall not rely on the supply voltage.

An integral test device shall be provided on the front of the RCD to enable the operation of the RCD to be tested. Operation of this test device shall create an out-of-balance condition simulating an earth fault.

C.1.1.9 Combined Miniature Circuit Breaker / Residual Current Device Unit (MCB/RCD)

Combined MCB/RCD units shall comply with BS 3871: Part 1 for overload protection and BS 4293 for earth fault protection.

The unit shall be of 30mA sensitivity and short circuit breaking capacity of not less than 9kA. The rated continuous current of the units shall be as specified or noted on Drawings.

The casing of the units shall be made of insulating material and be designed to withstand reasonably rough usage.

The units shall be suitable for independent toggle operation. The automatic tripping operation of the earth fault protection shall be of the passive type, i.e. it shall not involve the amplification of the operating residual current and shall not rely on the supply voltage.

An integral test device shall be provided on the front of the unit to enable the operation of the unit to be tested. Operation of this test device shall create an out-of-balance condition simulating an early fault.

C.1.1.10 Switches

Switches shall be metal clad and type-tested in accordance with Table VI of B.S. 5419 suitable for surface mounting. The rated fused short-circuit current shall be at least 50Ka.

Switches shall be of continuous duty and shall be capable of closing onto and

Remaining closed on a fault without overheating or damages.

C.1.1.11 Contactors

Contactors shall be electromagnetically controlled, double air-break, four-pole, triple-pole, double-pole or single-pole as required, and comply with and be tested to B.S. 5424: Part 1.

Unless otherwise specified contactors shall be of utilization categories AC-1 for general application and AC-3 for motor circuits.

The rated operational voltage shall be 380 volt $\pm$ 15%, 3 PHASE, 50 Hz, or 220 volt $\pm$ 15%, single phase, 50 Hz, The rated power and quantities of the contactors shall be as indicated on the Drawings.

C.1.1.12 Control Wiring

Wiring shall be arranged in a regular manner with bends set at 90 degrees and securely held in position with suitable clips and where convenient shall be installed in uprights and/or backstays.

Meter wiring for the switchboard shall be carried out in pvc insulated cable of not less than 1.5mm², All meter wiring shall be of similar colours to those of the respective busbars to which connections are made.

The cable terminations shall be made with approved lugs.

Wiring shall be carried out in such a manner as to make circuits and connections easily traceable. Cable marking ferrules shall be used at each termination. Terminals shall be designated in an approved manner.

C.1.1.13 Switchgear located Outdoor

Switchgear located outdoors shall be provided with an IP54 enclosure to protect the switchgear against adverse weather conditions. The enclosure shall be so selected that derating of the switchgear is not required.

C.1.2 Cable

C.1.2.1 General

All main power cables shall be provided with all necessary trays, conduits, supports and cable trunking, glands, shrouds end boxes, camps, compounds, special tools, etc, necessary to install, terminate and connect the cables in accordance with good engineering practice.

Where multi-core cable are for indication, protection and control applications, each core shall have an indentation number and the Contractor shall in addition to the cable identification labels provide engraved ferrules over the cable tails. The ferrules shall be numbered according to a wiring diagram approved by the Engineer. All wires shall be terminated with an approved type of clamp connector. Pinching screw type connectors are not acceptable.



The Contractor shall be responsible for the off loading and handing of the cables on side and shall ensure that cables are new and delivered to side on new drums. They shall be properly protected against mechanical damage and with manufacturer's seals still intact. Partly used drums of cable which has already been used elsewhere are not acceptable unless special approval is given by Engineer in writing.

C.1.2.2 PVC/SWA/PVC Copper Cable

PVC insulated steel wire armoured cable (PVC/SWA/PVC) shall be 600V/1000V grade complying to B.S. 6346 with full size neutral. The copper conductor shall be of high annealed copper complying with B.S. 6360.

The PVC insulated cores shall be color coded and shall be sheathed with PVC which shall serve as a bedding for galvanized single steel wire armouring. The armouring shall be served with an outer pvc sheath.

Cables shall be terminated in a gland fitted with an armour clamp. The gland body shall be provided with an internal conical seating to receive the armour clamping cone and a clamping nut which shall secure the armour clamping cone firmly to the armor wires, ensuring that the armour wires shall be tightly clamped between the armour cone and conical armour seating. The spigot in the gland body shall be threaded to suit standard conduit accessories. A PVC shroud shall be fitted to cover the entire gland body.

The minimum bending radius shall be not less than eight times the overall cable diameter.

Where cables run horizontally, they shall be properly supported on perforated cable trays and be cleated at intervals not exceeding 2m, directly to the tray. Where cables are installed vertically, they shall be cleated at distances not exceeding 1m.

C.1.2.3 PVC Cables

The cables shall consist of copper conductors insulated with pvc complying to B.S. 6004 or equivalent international standards. Cables for three phase and single phase circuits shall be 600V grade and 870 degree heat-resistant type.

All wiring shall be carried out by the loop-in system and the wiring shall be enclosed in conduits or in metal trunking. Joints or connectors shall not be allowed in any such cable length, except that connectors may be used in accessible positions within fittings.

The maximum number of cables that may be accommodated in a given size of conduit shall not exceed the limits given in the current Edition of I.E.E. Wiring Regulations.

For copper cables size 6mm² and above, compression type cable connectors/lugs shall be used for all cable terminations. Where apparatus is fitted with tunnel type terminals, stranded cable conductors shall be tinned solid for direct connection to such terminal. If for any practical reason different termination method is used, prior endorsement must be obtained from the Engineer. Connections to electric fixed equipment shall be by means of PVC cable in conduits, with the final connection being made by pvc covered pliable conduit, and suitable adaptable box. A separate earth continuity copper earth in accordance with I.E.E. Wiring Regulations of not less than 2.5mm² shall be provided outside the flexible tube and solidly connected at each tube termination.

C.1.2.4 Mineral Insulated Cable

All mineral-insulated copper cables shall be copper sheathed with copper conductors complying with BS6207:Part 1, and any subsequent amendments.

Mineral-insulated copper cables shall be run neatly on the surface of the walls,

columns, beams or ceilings in a vertical or horizontal direction, and at least 150mm clear of all plumbing and mechanical services. The use of conduit and/or cable trunking to enclose such cables shall be kept to the minimum.



Mineral-insulated cables shall be adequately supported by saddles which shall be of the same manufacture as the cables. Saddles shall be provided throughout the entire cable route at regular intervals of 600mm maximum. Saddles shall also be provided at a distance not exceed 150mm away from a termination and from both sides of a bend.

The minimum internal bending radius for mineral-insulated cables shall be 6 times the overall diameter of the cable.

A loop shall be introduced in a cable immediately before its entry into the connected equipment which is subject to vibration or occasional movement. A clear space of at least 10mm shall be maintained at the point in the loop where the cable passes over itself.

Cable terminations shall generally comply with BS6018:1978. The cable to be terminated shall be cut, screwed, sealed with cold compound and fitted with brass terminating glands, nuts, compression ring, gland body, sealing pot, disc and sleeves. The conductors shall be carried unbroken through the sealing pot to the terminal sockets or clamping screws.

Where more than one cable terminates at a galvanized or zinc coated enclosure, the gland plate shall be of brass or insulating materials.

The cores of the mineral-insulated cables shall be identifiable at their termination by the application of sleeves or discs of appropriate colours as described below. Identification sleeves shall comply with BS3858, Type 3, where appropriate and shall have temperature rating similar to that of the seals.

For Protective Conductors:	Green-and-Yellow
For 3-Phase Conductors:	Brown, Black and Gray (L1, L2 & L3), as appropriate
For 1-Phase Conductors:	Brown
For Neutral Conductors:	Blue

Where a mineral-insulated cable passes through or makes contact with any metal, the metal and cable sheath shall be effectively bonded together.

C.1.3 Cable Installation

C.1.3.1 Cable Trunking

Trunking shall be fabricated with sheet steel having a nominal thickness of 1.2mm.

Manufacturer's standard fittings such as tees, angle pieces, connectors etc. shall be used unless prior endorsement has been obtained from the Engineer.

Trunking and fittings shall have at least class 2 protections against corrosion in accordance with BS4678: Part 1.

Steel trunking shall be of square or rectangular cross section. One side of the trunking shall be removable or hinged. No projection from screws or other sharp objects will be allowed inside the trunking.

Connection between adjacent lengths of trunking, tee or angle pieces, accessories, etc. shall be made by means of butt joints. The two adjacent ends of trunking shall be fixed so that no relative movement can occur between them.

Electrical continuity shall be achieved by means of connecting a 25 x 3mm tinned copper tape across the two adjacent ends of the trunking.

Trunking and fittings shall have removable or hinged covers extending over the entire length. The covers shall be of the same material and finish as those of the trunking body.

Removable covers shall be held in position on the trunking either by the quick-fix pattern with centre captive screw or spring-on type.

Bends, tee junctions, etc. shall also be fitted with removable or hinged covers.



Connection between trunking and conduit/equipment shall be by a screwed coupler and brass male bush, or a standard flange coupling or an adaptor neck, fabricated or cast.

Direct attachment of trunking to apparatus will only be permitted if cable entries are provided with smooth bore bushes or grommets and the return edge of the lid of the trunking is left intact.

Where connection is made between trunking and a distribution board, the cable entry or entries shall be sized to accept all cables from all used and 'spare' ways.

Trunking shall be adequately supported throughout its length. Trunking support shall be fixed at regular intervals with maximum spacing of 1.2 meters.

Cables penetrating through trunking shall be protected by conduits except for PVC insulated and sheathed cables if such cables form part of a surface wiring system. In such case, the holes in the trunking, through which such cables penetrate, shall be fitted with suitable rubber grommets or insulated bushes.

Whenever trunking passes through a fire resistant structural element, such as floors and walls, designated as fire barriers, the opening thus formed shall be sealed with approved type fire resisting material. In addition, suitable internal fire barriers shall be provided inside the trunking to prevent the spread of fire or smoke through the trunking.

In vertical trunking installations, internal fire barriers shall be provided between floors or at intervals of 5 meters apart, whichever is the less.

Every entry to the trunking shall be so placed as to prevent and/or to be protected against the ingress of water.

Holes in trunking shall be drilled, punched or cut by ring saw. After cutting, burrs and sharp edges on the trunking shall be removed to prevent damage of cables.

Trunking, which is installed in such a position that the cables would fall out when the cover is removed, shall be fitted with cable retaining bars or other suitable devices to prevent the cables from falling out.

Trunking installed in a vertical plane shall contain sufficient supporting devices within the trunking to prevent strain on the cables due to the weight of the cables, and to prevent vertical movement of the cables.

C.1.3.2 Cable Tray

Cable trays shall have a perforated pattern and be of 1.6mm minimum thickness hot-dipped galvanized mild steel with returned edges.

Trays shall be supported from the soffit of structural slabs and beams by hot-dipped galvanized rods not less than 15mm dia. and/or hot dipped galvanised angle brackets fixed on side walls. Minimum coating thickness of the hot dipped galvanising shall be 85µm. All bolts and nuts shall be electroplated with zinc or cadmium with minimum plating thickness of 25µm.

Tray supports shall be spaced according to the number and size of cables being carried on the tray, but nowhere shall they be at greater than 1.2 metre intervals.

Cables mounted on the trays shall be laid after installation of the tray. Cables shall be grouped in circuits and individually clipped, cleated or tied at intervals of not less than 2 metre lengths on horizontal runs and 1 metre lengths on vertical runs.

The cable tray gauge shall be of sufficient strength to prevent sagging between supports.

Cables leaving cable trays shall be installed properly without damage to cables by cutting edges of trays and rubber pads shall be inserted to the underside of cables.

Trays shall not be bent for change in direction of run. Proper bends or straight trays meeting at



angles shall be employed at change of direction. Cable trays shall be supported at either sides of junction.

Cable shall be fixed on tray by saddles. Sample of the saddle shall be submitted for approval.

C.1.4 Conduit System

Conduit shall generally be concealed except in plant room, duct space or inside false ceiling.

The Contractor shall prepare drawings of proposed conduit runs showing the number, size and circuit reference of all conductors to the satisfaction of the Engineer prior to the commencement of works. The Engineer's endorsement shall not relieve the Contractor from liability in respect to the provision of an adequate number and/or sizes of conduits for the installation.

All conduits and fittings used in the installation, except flexible conduits, shall be heavy gauge, screwed, steel, longitudinally welded, solid drawn, galvanised on both internal and external surfaces with Class 4 protection against corrosion in accordance with BS 4568: Part 1 and Part 2.

Flexible conduit and fittings shall comply with BS 731: Part 1: 1980 and in addition shall be of the metallic watertight pattern, PVC oversheathed and with a separate earth wire enclosed within the conduit.

The minimum size of conduit used in the installation shall be 20mm diameter.

Separate conduits shall be provided for circuits of different category.

Conduits shall be installed to enable "loop-in" wiring to be carried out.

Conduit systems shall be electrically and mechanically continuous after installation.

The Contractor shall make good any damage to the finish of all conduits (including threads cut at site) by painting two coats of cold galvanized paint to match the non-damaged galvanized surface

All surface conduits shall be run in a vertical or horizontal direction. Diagonal runs are not permitted. The conduits shall be secured to the surface by means of heavy spacing saddles fixed with brass or non-ferrous screws.

On straight runs, 20mm and 25mm dia. conduits shall be supported by not less than one saddle every 900mm and conduit above 25mm dia. shall be supported by not less than one saddle every 1200mm in addition to any support provided by structures, boxes, or fittings etc. In all cases bend shall be supported by two saddles fitted as near to either side of the bend as practicable.

All bends in conduit shall be formed on site by bending machines.

Conduit run between draw-in boxes shall not have more than two right angle bends or their equivalent and the length of such runs shall be limited to 12m to permit easy draw-in of cables.

In concealed conduit systems all adaptable boxes for accessories and draw-in boxes shall be installed such that the outer rim of the box is flush with the finished surface of the wall.

In concealed conduit systems where flush type distribution boards are installed, a separate 20mm conduit for each spare way, shall be installed from the distribution board to a convenient point in the wall near the ceiling and shall be terminated in a common adaptable flush type box.

All conduits shall be entirely separated from other piping services and no circuit connections shall be permitted between the conduits and such pipes.

Conduits and outlets fixed in areas where there is waterproofing to building shall be installed with no damage to the waterproofing.

All conduit systems shall be efficiently earthed. Before any cable is drawn into the conduit, a



continuity test of the conduit system shall be carried out and the result of the test shall be notified by the Contractor to the Engineer for approval.

Where conduit crosses an expansion joint, special arrangement shall be made to allow relative movement to occur on either side of the expansion joint. A separate circuit protective conductor shall be installed to maintain an effective electrical continuity across the expansion joint. The circuit protective conductor shall have a cross-sectional area rated to suit the largest live conductors drawn into the conduits in accordance with the IEE Wiring Regulation.

The maximum number of cables permitted in one conduit shall be in accordance with the Local Wiring Regulations.

C.1.5 Final Circuit Installation

C.1.5.1 Luminaires in General

All luminaires shall be as indicated on the light fitting schedule. Luminaries by alternative manufacturers may be considered provided that the performance and quality are the same or higher than the specified ones and shall be subject to acceptance by the Engineer.

Luminaires shall be well constructed and shall comply with the requirements of BS4533 and be chosen to suit the conditions under which it will operate. They shall be suitable for operation on 220 volt, single phase 50 Hz supply.

The mains power failure detector and the automatic mains power/battery changeover switch shall be provided with the fluorescent fitting.

Means of radio frequency suppression and charger failure indication shall also be provided in the fluorescent fitting.

C.1.5.1.2 Gas Discharge Luminaire

Luminaires for gas-discharged lamps, such as fluorescent, mercury vapour, sodium vapour etc., which utilise chokes as part of the circuit shall be complete with capacitors of sufficient capacitance to ensure that the overall power factor of the lighting circuit does not fall below 0.85 lagging. The control gear shall be placed as near as possible to the discharge lamp it serves.

C.1.5.1.3 Exit Sign and Directional Sign

Exit sign luminaries shall be provided as shown on the Drawing and shall be of maintenance free type and provided with self-contained charger, built-in converter and Ni-cd battery. The capacity of battery shall be able to light the lamp for a minimum of 2 hours at functional operation and be fully re-chargeable within 16 hours.

The following components shall be included:

- A battery charger unit, capable of re-charging the fully discharged battery within 16 hours.
- A sealed, rechargeable maintenance free nickel cadmium battery unit.
- A mains power failure detector.
- An automatic mains power/battery changeover static switch.
- Inverter / ballast to operate the fluorescent lamp.
- Condensers and radio interference suppressors.
- An integral switch for 'normal', 'battery off' and 'test' position.
- Charger failure and battery discharge visual indicating lights.

The construction details and the size and color of the wording on the luminaries shall comply with the current requirements of Local Authority and the Engineer.

C.1.5.1.4 Suspended Lamps and Luminaries

Suspended lamps and luminaries shall be supported by rigid steel conduit. A sample of the method of suspension of lamps shall be demonstrated on site for the approval of the Engineer before commencement of actual installation.

C.1.5.1.5 Dimmers



Dimmers shall be provided in accordance with the drawings. Provide all outgoing cables and control cables as required.

C.1.5.1.6 Emergency Low Voltage Halogen Light

Emergency low voltage halogen light shall be maintenance free type.

Each emergency low voltage halogen light shall be equipped with its own battery pack which shall include the following main accessories:

- A battery charger unit capable of re-charging the fully discharged battery within 12 hours.
- A sealed, rechargeable maintenance free battery unit providing full light output for minimum 2 hours during mains failure.
- A mains power failure detector with an automatic mains power/battery changeover static switch.
- An integral switch for 'normal', 'battery off' and 'test' position.
- Charger failure and battery discharge visual indicating lights.

C1.5.2 Electrical Accessories in General

The position of electrical accessories shown on the drawings are approximate, and variation of position up to 2 meters may be affected without variation if such alteration is made prior to the installation of conduit.

The Contractor shall be responsible for checking the lighting and power layouts against structural plans and other services prior to the installation of conduits, and lighting fixtures and accessories to avoid conflict.

The Contractor shall be responsible for measuring rooms and spacing outlets accurately and symmetrically and shall verify the positions of outlets against furniture layouts before commencing installation.

The Contractor shall follow the Engineer's detail drawing regarding the setting out of lighting fitting and the electrical accessories with respect to the finishes and interior decoration elements. Change of location within 2 metres compared with the Tender Drawing, prior to installation, shall not be regarded as a variation.

C.1.5.2.1 Socket Outlets

Socket outlets shall be 3 pin, 10A, 13A or 15A as shown on Drawings. All socket outlets shall be switched shuttered type complying with B.S. 1363, BS546 and to the Engineer's specific requirements.

C.1.5.2.2 Fuse Connection Units

Fuse connection units shall comply with BS 1363 and be provided with 2A to 13A cartridge fuse link as specified. Provide adequate earthing connection to appliances.

C.1.5.2.3 Appliance Control Switches

Appliance control switches shall be D.P. or T.P. flush pattern, with pilot light having the rating of 20A/32A/45A and shall comply with BS3676:Part 1. Proper words shall be engraved on the plate to designate the appliance served, such as 'air conditioner', 'exhaust fan' and 'heater' etc.

Appliance control switches of rating larger than 45A DP or 32A TP must be metal clad type and comply with requirements in Clause C1.1.4.

C.1.5.2.4 Cable Connection Units

Cable connection units shall be flush mounted type with terminal blocks suitable for fixing onto the BS 4662 box and from there change into pvc insulated and sheathed cable with circuit protective conductor to the appliance served.

C.1.5.2.5 Lighting Switches

Switches for controlling lighting circuits shall comply with BS 3676: Part 1 and be rated at 10 ampere. A.C. circuit load shall not exceed 8 ampere for tungsten type lighting fittings and 6 ampere for fluorescent type lighting fittings.

C.1.5.2.6 Switches

Switches mounted outdoors, or in positions where they may be exposed to rain or water, shall have watertight enclosures with IP54 in accordance with BS 5490. Alternatively they may be mounted inside watertight enclosures but shall be subject to the satisfaction of the Engineer.

C.1.5.2.7 Cover Plates for Electrical Accessories

All cover plates for switches, socket outlets and telephone outlets, etc. in the customer areas shall be Matt Chroma or metal clad as the approved equivalent. The cover plates for switches, socket outlet plates, etc. in the staff areas shall be white plastic or as specified on the Drawings. The electrical accessories to be used throughout the premises shall be the products of one manufacturer, as far as practicable.

C.1.6 Balancing of Circuits, Voltage Drop

The Contractor shall provide sufficient data to the Engineer for checking the load sharing among the three phases to ensure balancing of circuits can be achieved after energization. Regarding the voltage drop, the Contractor shall install equipment at its shortest distance from the source, if such criteria cannot be achieved on site, the Contractor shall report to the Engineer for necessary action.

C.1.7 Earthing Protection

C.1.7.1 Earthing Installation

All metal works associated with the electrical installation but not forming part of a live conductor, including exposed conductive parts and extraneous conductive parts, shall be solidly and effectively bonded and earthed in accordance with the latest edition of the I.E.E. Wiring Regulations and the British Standard Codes of Practice CP 1013.

C.1.7.2 Supplementary Bonding

Supplementary bonding of extraneous conductive parts shall be provided whenever such conductive parts are likely to be accessible simultaneously with other extraneous conductive parts or exposed conductive parts, and are not electrically connected to the main equipotential bonding by means of permanent and reliable metal-to-metal joints of negligible impedance.

The supplementary bonding conductor shall be copper and connected to the extraneous or exposed conductive parts by means of a copper connector-clamp of an approved type suitable for the application. All contact surfaces shall be clean and free from non-conducting materials, such as grease or paint, before the connector-clamp is installed.

For surface conduit installations, supplementary bonding conductor shall be terminated at the earthing terminal of the nearest conduit box forming an integral part of the conduit installation. For concealed conduit installations, supplementary bonding conductors shall be terminated at, via a telephone cord outlet plate, a copper earth terminal fitted inside a BS 4662 box forming an integral part of the conduit installation. The BS 4662 conduit box shall be located as near as possible to the bonding position and the exposed part of the supplementary bonding conductors shall be made as short as possible.

The cross-sectional area of a supplementary bonding conductor shall be determined in accordance with the IEE Wiring Regulations.

C.1.7.3 Circuit Protective Conductor

Circuit protective conductors may be formed by separate conductor/cable, the metallic sheath or armour of a cable, part of the same cable as the associated live conductor, trunking or ducting, or the metal enclosure of the wirings system. Flexible conduits, PVC conduits, the exposed conductive

parts of equipment shall not form part of the circuit protective conductors.

For every socket outlet, a separate circuit protective conductor shall be provided connecting the earth terminal of the socket outlet and that inside the enclosure accommodating the socket outlet.

For every length of flexible conduit, a separate circuit protective conductor shall be provided inside the conduit to ensure the earth continuity of the installation between the two ends of the conduit.

Provision shall be made in an accessible position for disconnecting a protective conductor from the main earthing terminal or the earth electrode to permit testing and measurements of earthing resistance. No switching device shall be inserted in a protective conductor.

All cables used a protective conductors, including earthing conductors, main equipotential bonding conductors, supplementary bonding conductors and circuit protective conductors shall be identified by the colour combination "green and yellow".

Bare conductors used as protective conductors shall be identified by the application of tapes, sleeves or disc, or by painting with the same colour combination.

The cross sectional area of protective conductor, excluding equipotential bonding conductors, shall be determined by the adiabatic equation given in the IEE Wiring Regulations. Where a protective conductor does not form part of a cable and is not formed by, or not contained in, steel conduit, trunking, ducting or other metallic enclosure of a wiring system the cross sectional area shall not be less than 4mm^2 . When a separate cable is used as a circuit protective conductor, the cable shall be insulated to BS 6004, Table (1a) or better unless its cross sectional area is greater than 6mm^2 . When metal enclosures for cables are used as protective conductors, they shall have cross sectional area equivalent to that of copper, not less than that resulting from the above mentioned adiabatic equation.

Where protective conductors are buried in the soil, they shall have minimum cross sectional area as given in the IEE Wiring Regulations

C.1.7.4 Ratings of Earthing Conductors and Bars

The earthing system shall be earthed with conductors able to carry maximum short-circuit currents.

C.1.8 Trunking and Conduit Provision for Extra Low Voltage Systems

The requirements of the trunking and conduit for all extra low voltage items shall be the same as those in the Clauses C1.3 and C1.4, unless otherwise specified on the Drawings.

Draw wires shall be provided inside all conduits for such purposes.

All conduits for the extra low voltage system shall be of minimum size of 025mm. Unless special permission is given by the Engineer, conduits of size 020mm shall not be used.

Prior to the installation of this trunking and conduit, the Contractor shall obtain the information of the signalling cable to be installed from the Engineer and submit working drawings for approval.

C.1.9 Painting, Labelling and Finishing

C.1.9.1 General

All sheet metal control cabinets, switchboards and distribution board enclosures and similar shall be painted internally and externally.

All exposed metal work including trunking, conduit, cable tray, bracket, support etc. shall be painted externally.

All surfaces to be painted shall be cleaned, prime coated, undercoated and then finished with two finishing coats. Each coating (including priming, undercoating and the first finishing coat) shall be



allowed to dry and shall be rubbed down before the next coat is applied. The minimum thickness of each layer of paint shall be 50µm.

C.1.9.2 Surfaces Not To Be Painted

Galvanised metalwork installed in false ceilings, bulkheads, vertical ducts and plant rooms.

Chrome plated and stainless steel surfaces.

Bearing surfaces, slides, adjusting screws and any surface that is required to be unpainted for the correct operation or adjustment of the equipment.

C.1.9.3 Paint Material

All paints and other preparations shall be non-poisonous, lead-free prepared synthetic products of approved brand.

Paint shall be selected to withstand the temperature on the surface to which it is applied, and shall be suitable in all respects for the environmental conditions in which it shall be located. In particular, painting for generator exhaust pipes shall be of heat resistant type capable of withstanding high temperatures.

C.1.9.4 Preparation of Surfaces and Prime Coating

Metal surfaces shall be wire-brushed to remove loose rust and scale. Casting shall either be ground smooth or alternatively filled with approved filling compound and then rubbed to a smooth finish.

Steel plate and rolled steel sections including brackets and supports not galvanized, shall be given an application of cold phosphating compound before being prime coated with red zinc chromate primer.

Steel pipes and conduits delivered to the site unpainted shall be prime coated as specified for steel plate.

All galvanized or zinc coated steel surfaces and all non-ferrous surfaces shall be given an application of zinc chromated self-etching primer before being primed or equivalent coated as specified above.

Machinery, apparatus, equipment and fittings delivered to the site already prime or finish painted shall be thoroughly cleaned.

C.1.9.5 Finishes

Each finishing coat shall be of a different shade. The final coat shall be left smooth, even and free from the visible brush marks and other defects.

Unless or otherwise specified, for surfaces which shall operate below 93°C, the finishing coat shall be high grade enamel.

Piping, cable enclosures and conduits shall be painted to a gloss finish in colour or colours to the satisfaction of the Engineer.

All piping, cable enclosures and conduits installed in ceilings and similar concealed spaces shall have the identification colour applied in bands spaced at 6 metre centres except that identifying colour bands shall be provided adjacent to branches, junctions, valves, floors and walls (both sides).

All supports, hangers and brackets, where associated piping or ductwork is to be finish-painted shall be painted to gloss finish of colour black.

Machinery, apparatus, equipment and fittings (including equipment delivered to site already painted but not accepted by the Engineer) shall be painted with a gloss finish.



C.1.9.6 Labels

Inscription of labels and engraving shall be in both English and Chinese characters.

Labels shall be made of sandwich plastic material with white outer layers and a black or red inner layer as required. Lettering shall be engraved on the plastic material by cutting away one of the outer layers to the outline of the required letters, exposing the inner layer underneath.

Labels shall be fixed to switchgear and distribution board by screws. Where drilling and tapping of the equipment is impracticable, approved adhesive means may be used subject to prior endorsement of the Engineer.

Front plate of socket of control switch feeding an essential circuit or a fixed electrical appliance, such as water heater, cooker, wall-mounted fan, exhaust fan, room cooler, etc., shall be engraved according to the appliance being controlled. Details of the inscription shall be submitted to the Engineer for approval.

All instruments, gauges, indicators, control equipments, contactors, circuit breakers, switches, starters, relays and cable terminals on switchboards, etc. shall be clearly labeled and identified with their associated function.

Lettering, shall not be less than 12mm high or otherwise required or approved.

Details of the exact lettering shall be as agreed with the Engineer prior to manufacture.

C.1.10 Spares Parts and Tools

C.1.10.1 Spares

The Contractor shall supply the following items as spares. These spares shall be handed over to the Engineer and will not be allowed to be used as replacement items on practical completion of the whole installation or during the Defects Liability Period.

C.1.10.1.1 Sub-main Distribution System

HRC fuses : 2 sets for each type of fused switch to be adopted in this project.

Miniature Circuit Breaker : 2 sets for each type of MCB to be adopted in this project including the combined MCB/RCD.

5% of total number of each type of socket outlet, lighting switch & fuse connection unit, with a minimum of 4 number for each type.

C.1.10.1.2 Lighting Fittings

Lamp bulbs : 10% of the total installed quantities of each type of lighting fitting for this project, with a minimum of 4 numbers for each type.

Each type of lighting fitting : 1 piece

C.1.10.1.3 The Contractor shall also propose a list of spare parts (and their unit prices) for all other major equipment as recommended by the manufacturer – sufficient for one year's operation. These spares may be wholly or partly purchased at the discretion of the Engineer.

C.1.10.2 Tools

The Contractor shall submit a comprehensive schedule with unit prices of all necessary tools to enable any erection, dismantling or testing to be carried out in any part of the plant by the Engineer after the Works have been taken over, whether of an electrical, mechanical or any other nature. The Contractor shall undertake that itemised prices will remain valid for a period of 12 months from the date of acceptance of submission.

The Engineer may instruct the Contractor to order all or part of the proposed list of tools.

The tools shall be used for the erection of the equipment being supplied and must be handed over to the Engineer in a completely new and unused condition.

All tools shall be supplied in suitable tool boxes complete with a list of parts contained in each box.

C.1.11 Testing and Commissioning

On completion of the installation work (part or whole where appropriate) the Contractor shall commission the equipment supplied and put it into operation in accordance with the intent of this Specification.

The Contractor shall provide all labour, necessary facilities and instruments to carry out such tests as may be necessary to demonstrate that the installation meets with the requirements of the Specification as well as the requirements of the local authorities.

In addition, the Contractor shall liaise with the other trades to carry out all adjustments necessary for the safe, reliable and satisfactory operation of all interfacing works.

The Contractor shall submit the testing and commissioning procedure for the Engineer's approval prior to exercise any test to be witnessed representative. All testing and commissioning records shall be properly completed and included in the O&M manual.

C1.12 Maintenance, Service and Training

C1.12.1 Maintenance

The Contractor shall carry out regular monthly inspections and shall fully service all plant installed under this Specification within the Defects Liability Period, and shall maintain all such plant in perfect operation during that period.

At each maintenance visit, the Contractor shall:

- Check all lighting and power circuits.
- Check all phase loading and phase balance the circuits if required.
- Service all circuit breaker, switches, socket outlets, switch panels starters, motors, transformers etc. and check their proper operation.
- Inspect all cables, conduits, trunking distribution boards, etc.
- Check the proper functioning of all control circuits, sensing and indicating devices, etc.
- Check the accuracy of all timers and reset if required.
- Test for the proper functioning of all protective devices.
- Check the battery charger and battery condition.
- Record all meter readings.
- Record all services and replacement carried out and report any work that needs rectification.

In addition to the monthly maintenance schedule, the Contractor shall at intervals not exceeding six months:

- Inspect and clean as necessary all items of plant and equipment;
- Clean and adjust all switchgear, protective devices, contactors and starters;

The Contractor shall also attend all emergency calls during the Defects Liability Period. Under normal situation, the Contractor shall arrive at the site within two hours upon receiving telephone calls or paging calls.

C.1.12.2 Training



The Contractor shall provide during the Contract period training facilities and training courses to ensure. That the Engineer's staff acquire full knowledge and appreciation of all aspects of the design, day-to-day operation, breakdown and routine maintenance, and fault diagnosis of the equipment provided.

C.2 FIRE SERVICES INSTALLATION

C.2.1 Pipework, Valves and Fittings

C.2.1.1 Piping

Inspect all pipes and fittings before fixing. Reject any which are defective.

Support and fix all piping with substantial hangers, anchors, brackets, saddles, guides etc.

Locate supports as near as possible to joints and changes of pipe run direction.

Vertical piping shall be supported with suitable brackets: do not use branches from risers as a means of support. Additional supports shall be provided for sprinkler pipes to meet the requirement of the current requirements of the Local Fire Department and Authorities having jurisdiction.

Dismantling facilities; Install and arrange all pipe runs for ease of dismantling and re-erection. Provide disconnecting flanges or screwed unions, as applicable, at suitable locations and at valves and equipment.

Pipe Brackets and Pipe Clips : Use galvanized iron brackets and galvanized steel saddle clips.

Bolts, Screws and Nuts : Hexagonal bolts, screws and nuts to be to BS 4190.

Steel Pipes : All water pipes up to and including 100mm dia. To be galvanized mild steel tubing with screwed joints to BS 1387 – medium grade.

Fitting for steel pipes : Malleable cast iron screwed fittings to BS 143 and 1256 and be galvanized.

C.2.1.2 Valves and Accessories

C.2.1.2.1 Working Pressures

All valves, flexible joints, check valves and accessories shall be capable to withstand the working pressure sustained and suitable for the medium conveyed. All valves and accessories shall have a working pressure not less than 16 bar.

C.2.1.2.2 Stop Valves

Stop cocks and valves not exceeding 50mm dia. to be bronze to BS 1010.

Stop valves exceeding 50mm dia. to be flanged cast iron globe valves to BS 5163 PN 16.

Gate valves exceeding 50mm dia. to be cast iron flanged to BS 5163 PN16.

C.2.1.2.3 Stamping of valves

Taps, valves and ball valves to be stamped with BSI certification trade mark.

C.2.1.2.4 Flexible Connection to be rubber bellows flexible connectors with flanged ends.

C.2.1.2.5 Isolating Valves

All valves and valve components supplied shall conform to the requirements of BS 5163 in every respect unless otherwise specified and be of the following British Standard Specifications where appropriate:-

BS 5150
BS 2494
BS 1400
BS 2872
BS 2874
BS 1452
BS 4504

Valves shall be suitable for use in normal water supply situations.

The nominal pressure for valves shall be 16 bar (PN16). The unbalanced pressure shall be equal to the nominal pressure.

Dimensions and tolerances shall be in accordance with BS5163 and BS5150 where appropriate.

Valves shall be supplied with flanged ends. Flanges shall comply with the relevant requirements of BS 4504 and shall be machined. However, drilling and diameter of flanges shall be to Table 16.11 even where nominal pressure rating lower than PN 16 is specified.

Valves shall be designed for manual operation by a removable key and shall be closed by turning the shaft in a clockwise direction.

Cast iron valve caps with arrows indicating clockwise closing direction shall be fitted and secured to valve stems by hexagonal headed setscrews unless otherwise specified.

Handwheels shall be provided and shall be manufactured from grey cast iron and marked with arrows indicating clockwise closing direction.

Either metal or resilient seating will be acceptable.

Stem sealing shall be of the stuffing box and gland form, toroidal sealing ring or other pressure actuated type of seal conforming to Clause 14 of BS 5163.

All cast iron parts shall be coated in accordance with BS 5163.

Pad lock shall be provided for all control and isolating valves.

C.2.1.2.6 Basic Materials

The materials used shall be in accordance with the following.

Body- Grey cast iron BS 1452, Grade 220

Wedge- Grey cast iron to BS 1452, Grade 220 with trim of gunmetal to BS 1400, Designation LG 2 or LG 4; or Grey cast iron to BS 1452, Grade 220 with wedge facing of rubber to BS 2494 NBR, SBR, IIR, CR, EMP, EPDM.

Stem- Aluminium bronze to BS 2872 or BS 2874, Designation CA 103 or CA 104.

Stem nut- Gunmetal to BS 1400, Designation LG 2 or LG4.

The alternative materials contained in Table 6(a) and 6(b) of BS 5163 shall not, except where expressly permitted, be used without the prior approval of the Engineer.

The Contractor may be required to provide at his own expense test pieces of aluminium bronze, gunmetal and their alternative material where approved for chemical analysis and mechanical property tests to provide the necessary evidence of suitability.

C.2.1.2.7 Testing requirements shall be in accordance with the 'open end test as specified in BS 5163 and BS 5150 where applicable unless otherwise specified.



C.2.1.2.8 The valves shall be prepared for dispatch in accordance with BS 5163. Wooden discs shall be securely bolted to the machined face of all flanges.

C.2.1.2.9 Marking Each valve shall be clearly cast on the body with the following information:-

- the nominal size (DZ.....);
- the nominal pressure rating (PN.....);
- the body material designation; and
- the manufacturer's name or trade mark.

In addition, the following information shall be marked integral with the body or on a plate of durable material

securely fixed to the body:-

- the type of seating;
- the number of British Standard, i.e. BS 5163;
- the identification number (a reference used by the manufacturer allowing identification for the supply of spares, etc);
- the year of manufacturer; and
- the mass of the valve in kg.

C.2.1.3 Workmanship

C.2.1.3.1 Adequate provision shall be made to allow and control thermal movement in the length of pipes.

C.2.1.3.2 Where pipes pass through walls:-

- . Fit G.1. pipe sleeves with 5mm (maximum) clearance.
- . Sleeves to finish flush with face of wall finish.
- . Where specified, provide cover flanges to ends of sleeves visible in completed work. Flanges to be 25mm larger than external diameter of pipe, and screwed or plugged and screwed.

C.2.1.3.3 Avoid contact in the completed work between the following metals:-

- . Aluminium alloy and copper alloys, nickel, lead or stainless steel.
- . Iron and steel and copper alloys.
- . Zinc (including galvanizing) and copper alloys or nickel.

C.2.1.3.4 Pipe fittings: Same size as the pipe work.

C.2.1.3.5 Bends: Long radius wherever possible.

C.2.1.3.6 Cutting: Tubes to be smoothed after cutting and to be free from burrs, rust, scale, and other defects and shall be thoroughly cleaned before erection.

C.2.1.3.7 Pipe runs: Follow the lines of walls and graded to ensure venting & draining.

C.2.1.3.8 Pipe joints

Steel pipes up to and including 65mm ψ shall be joined with screwed fittings, screwed flanges, or screwed unions. Screwed joints shall have tapered threads and shall be made with approved jointing material. Fittings shall be galvanized. Screwed fittings other than sockets shall be malleable iron.

Steel pipes from 80mm upward shall be jointed with flanges and flanged fittings, Flanges for mild steel pipework shall be wrought iron or annealed steel, machined full face, suitable for the system working pressures.

Jointing material must not project into bore of pipes or fittings. Caulk gasket firmly into sockets. Do not locate joints inside wall, floor/ceiling slab.

C2.1.3.9 Provide expansion joints in case of pipework crossing construction joints, and at points connecting to vibration sources.



C2.1.3.10 Pipes shall be connected to concrete tanks, retaining wall or external wall with brass flanged tank connectors or double nut tank connectors of suitable length and approved washers, all screwed together in red lead cement, and bedded and set in mastic.

C.2.2 Fire Hydrant and Hose Reel System

C.2.2.1 Drain Down and Refill

The Contractor shall be responsible to drain down and refill the system for the fitting-out work. Overnight protection to premises is necessary and essential.

C.2.2.2 System Equipment

All items of the FH/HR system shall be the products of manufacturers approved by the Fire Department and Authorities having jurisdiction.

C.2.2.3 Hydrant Outlet

The Contractor shall ensure the mounting height of hydrants comply with FSD's requirement.

C.2.2.4 Hose Reels Cabinet

Install recess mount type hose reels as shown on the Drawings.

Provide 30m length not less than 19mm dia. rubber hose wound round a metal drum of 200mm dia. with 25mm on-off valve at the inlet to the reel.

Hose reel tubing to be fitted with an approved type nozzle of 4.5mm orifice with a simple two way valve. The nozzle shall produce a jet of not less than 6m throw.

Simple on/off control valve shall be provided in the piping by the hose reel. The discharge nozzle and control valve shall not be fixed more than 1200mm above floor level.

The tubing of every hose reel must be capable of being readily wound round a drum without kinking and must not kink when led around sharp obstructions.

The tubing of every hose reel shall have a bursting pressure of not less than 2700 kPa and shall not be porous nor exhibit any signs of percolation below 2000kPa.

All hose reel outlets should be housed in glass boxes with lock and key.

The recess type hose reel to be clearly marked in English and Chinese "Hose-Reel Cabinet" on the outside. Operation instruction plate shall be provided as per local Authority's requirements.

C.2.3 Sprinkler System Installation

Where descriptions in this Specification are not shown on the Drawings, the Contractor shall also provide the Sprinkler System as described in this Specification.

C.2.3.1 Drain Down and Refill

The Contractor shall be responsible to drain down and refill the system for the fitting-out work as often as required to suit the phasing. Overnight protection to premises is necessary and essential. Claims for additional drain down will not be entertained.

C2.3.2 System Equipment

All item of the sprinkler system shall be products of manufacturers approved by the local authority and F.O.C. and/or LPC and Water Authority where applicable.

C2.3.3 Sprinkler Heads

Sprinkler heads shall be of conventional or spray pattern with deflectors suitable for the pendant position.

Unless otherwise shown on the Drawing, the sprinklers shall be designed for 68°C nominal temperature and shall have a red liquid in glass bulb as the heat sensitive element. All sprinklers installed at false ceiling level shall be complete with rosette base with finished colour to match the interior finishes.

Where concealed sprinkler heads are required they shall be provided with adjustable chromium plated metal rosette base with the heat sensitive bottom plate flush with the false ceiling line. Colour of heat sensitive bottom plate to be approved by the Engineer.

The sprinklers shall have orifice size of 15mm and K factor $80 \pm 5\%$.

In areas where there is no false ceiling, and the sprinkler heads are installed at less than 2 metres from the finished floor level, they are considered liable to damage. In these areas, an approved mechanical sprinkler protection guard as manufactured by the sprinkler head manufacturer shall be provided to the sprinkler head to prevent accidental damage to the heads.

C.2.3.4 Test and Drain Provision

At the end of the highest sprinkler pipe of the floor provide a test drain assembly complete with an approved device (such as orifice) to simulate the flow of a sprinkler which shall be terminated with a gate valve at a convenient drain point and be plugged off normally. The installed sprinkler flow switch shall be used for testing in accordance with local regulations.

All test and drain valves at the end of range pipes shall be of gate type and be blanked off with galvanized steel screwed-on caps or plugs. The test pipework shall be sized, and complete with suitable device, to simulate the operation of the sprinkler head.

C.2.3.5 Pipework

Where possible, sprinkler pipework shall be located above other service and installations in order to minimize the possibility of damage to the pipework due to falling materials. In no circumstances shall the sprinkler pipework be allowed to support other services or installations.

The Contractor shall co-ordinate with other trades and make minor adjustment to the sprinkler layout such that no sprinkler head shall be located directly above any luminaire, lamp holder, loudspeaker, a/c units etc..

Sprinklers shall be spaced in accordance with Local Codes. In particular, double layer sprinklers shall be installed above and below certain large air ducts and upright sprinklers shall be provided for the deep joist areas.

The Contractor shall be responsible for locating the sprinkler heads in the exact positions according to false ceiling layouts. The Contractor shall supply and install all necessary bends, tees, etc. to divert the pipework to avoid structural beams and any other mechanical and electrical services installations to reach the sprinkler heads in their locations as shown on the Drawings and as site conditions may dictate. Claims for any alteration to the work due to non-compliance with the Drawings shall not be entertained. Any deviation from the Drawings shall be reported to the Engineer prior to installation.

The Contractor shall allow for minor alteration of pipework to suit actual site conditions at no additional cost.

Remote pressure switches for individual sprinkler systems shall be wired to the sprinkler pump electrical board for starting of sprinkler pumps and jockey pumps.

C.2.4 Automatic Detection, Fire Alarm and Control System

C.2.4.1 Fire Detection and Alarm System

C.2.4.1.1 General

This Section specifies the automatic fire detection & alarm system equipment and installation which shall form part of the works as shown on the drawings.

The complete fire detection and alarm system shall meet with the current requirement of the Local Fire Department, and the Authorities having jurisdiction, and these Specification requirements. Provision of visual and audible alarm signals and appropriate control functions shall be made at the central display of the fire control system and/or the sub-station fire control panel.

Where descriptions in this Specification are not shown on the Drawing, the Contractor shall provide the Fire Alarm and Detection system as described in the Specification.

C.2.4.1.2 Manufacturer

All fire detection and alarm equipment and materials of the same type shall be supplied by a single manufacturer to ensure uniformity of standards and composition.

All equipment shall be approved by the Fire Offices' Committee (UK),

Underwriter's Laboratory (USA), or the other approved testing organization recognized by the Fire Services Department.

C.2.4.1.3 Equipment Description

The equipment for the fire detection and alarm system shall be acceptable to the Local Authority and shall comprise but not be limited to the following item:-

- Alarm bells, break glass units
- Smoke / Heat detectors
- Public Address System
- Electrical Installation for Fire Services
- Electronic Devices

C.2.4.2 Manual Fire Alarm System

C.2.4.2.1 Breakglass Unit

Fire alarm breakglass units conform to BS 5839 and shall be suitable for 24V D.C. operation. They shall have open circuit contacts arranged for surface fixing with the front cover finished in red. The contact shall close immediately after the glass is smashed.

The word "In Case of Fire Break Glass" shall be engraved in both English and Chinese.

The units shall be of the flush mounted type and shall generally be adjacent to the fire alarm cabinet and exit. Exact positions of break glass units shall be approved by the Engineer.

C.2.4.2.2 Alarm Bell

Alarm bells shall be ironclad, corrosion proof for 24V DC operation, 150mm round red gong pattern suitable for 20mm conduit entry.

Alarm bells shall be wired in a circuit such that any ground fault, open or short circuited condition shall be reported as trouble at the fire alarm central control panel. The Contractor shall allow for all labour and materials to provide this function.

Exact mounting locations for alarm bells to be approved by the Engineer.

C.2.4.2.3 Use concealed conduit system for the wiring work of manual alarm system.

C.2.4.2.4 The wiring system shall be normally energized fail safe alarm system with normally closed alarm contact.

C.2.4.3 Indicating Lamp & LED

In situations where the same lamps or LED's are required both for fire alarm/status indication and fault alarm indication, they shall be of twin-colour type, of suitable colour to BS 4099 and BS 5378 and be approved by the Engineer.

C.2.4.4 Wiring Installation

Wiring from/to the alarm control panels shall terminate at blocks inside the panels where a scheduled ferrule numbering system shall be provided, with clear

Indication on the Installations Drawings and neat fitting on site.

Conduit wiring system shall be of a type approved by the local Authorities. The size of cables shall not be less than 1.5mm².

Concealed conduits shall be used as far as possible. When exposed conduits cannot be avoided, the routing shall be approved by the Engineer before installation.

Installation of PVC cables and other electrical requirements shall conform to the "Electrical" Section of this Specification.

C.2.4.5 Visual Fire Alarm Indicator

Visual alarm indications in the form of flashing red lights, shall include a signaling strobe for 24V DC operation in accordance with the current FSD circular letter. Strobe lights shall consist of a xenon flash tubes and associated lens and reflector system.

The unit shall be suitable for surface or semi-flush mounting and labeled "FIRE ALARM" in both English and Chinese.

C.2.5 Portable Equipment

The Contractor shall supply and install all fire extinguishers, fire blankets and sand buckets as shown on the Drawings.

All fire services equipment shall be of type approved by the Fire Services Department.

The Contractor shall be responsible to protect all fire service equipment delivered to site until the complete installation is handed over to the Engineer.

Provide proper hangers or brackets for portable appliances. All hangers to be fixed properly to the wall at positions shown on the Drawings.

C.2.6 Miscellaneous Fire Services Installation and Provision

C.2.6.1 Provision of Dry-Contacts for the Building Monitoring System

Each F.S. local panel or sub-station panel shall have two pairs of voltage free signals back to the Landlord's central fire control system showing the common fire alarm signal and common fault signal.

The conduit & wiring shall be responsibility of the Contractor.

C.2.6.3 Painting

Paint all exposed Fire Services pipe in Red to BS 381C with primer undercoat unless specified otherwise by the Engineer.

C.2.6.4 Labelling



Label each metal clad switch, switchfuse, starter, busbar chamber, pump, control valve, sprinkler inlet, F.S. inlet and other F.S. equipment.

Labels to be made from sandwich type plastic material with black outer layers and white inner layers.

Labels to be engraved **in both English and Chinese**. Details of lettering to be approved by the Engineer.

Secure labels properly to individual equipment. Adhesive can only be used when drilling and tapping of equipment is impossible.

C.2.7 Testing and Commissioning

C.2.7.1 Compliance Test

Test the entire installation in compliance with all requirements and regulations and to the satisfaction of the Engineer, Water Authority, Local Fire Department, and Power Supply Company including all consumable items such as necessary gas, fuel, water, fusible link.

C.2.7.2 Testing Water Pipes & Fittings

Test at 1.5 times maximum working pressure for leakage for a period not less than 24 hours. The Contractor shall provide temporary plug and blanking plates for unfinished pipe sectioning each hydraulic test.

C.2.7.3 Electrical Test

Test all electrical installation, after completion but before connecting to supply Tests to comply with IEE Regulation.

C.2.7.4 Inspection and Test

Upon completion of the whole systems the Contractor shall inspect, test and set to operation the relevant portions of the sprinkler system to the satisfaction of the Engineer before the relevant local authorities and tests take place.

C.3 MVAC INSTALLATION

C.3.1 Commissioning and Testing

C.3.1.1 General

It is the intent of this Specification that all equipment components, including the ducting, piping and electrical installations be progressively and finally tested both individually and collectively to the satisfaction of the Engineer and the requirements of all authorities having jurisdiction over the project.

All testing shall be scheduled in accordance with the installation programme and the test schedule approved by the Engineer prior to carrying out the test procedures.

All tests shall be witnessed by the Engineer or his appointed deputy with at least seven day's notice given prior to any test.

The Contractor shall supply at his own expense all necessary meters, instruments, temporary wiring and labour to perform all required tests including adjustments of equipment, piping and wiring installed and connected under this Contract, any equipment supplied by others Instrumentation for measuring and adjusting water flow rates at regulating valves shall be provided by the Contractor and handed over to the Engineer on completion with all instruction/operating literature such that the Engineer can make future adjustments to the system.

All tests shall be recorded in an approved manner. Copies of test results shall be provided free



of charge to the Engineer.

For the purposes of this Contract the cost of correctly commissioning and balancing the systems shall be deemed to be not less than 1% of the contract value. The Engineer reserves the right to withhold an amount equivalent to 1% of the contract value until all commissioning and balancing is completed. Should the Contractor fail to satisfactorily complete the commissioning and balancing in compliance with this Specification and to the satisfaction of the Engineer then the Engineer may at his discretion appoint an independent firm or authority to properly carry out the commissioning and balancing. Appointment of such independent firm or authority shall not affect the Contractor's responsibilities under this Contract in relation to defects liability, warranty and performance guarantees.

Allow to balance the new and existing chilled water and condensing water systems to the flow rates indicated.

C.3.1.2 Testing of Pipework

All pipework shall be hydraulically tested to a pressure of 1 ½ times the maximum working pressure in the system. The test pressure shall be maintained without loss of pressure for a period of at least 24 hours. The maximum working pressure shall be deemed to be the static head plus the total pump head. All tests shall be carried out before the application of any insulation materials.

C.3.1.3 Pre-commissioning and Cleaning

Prior to connection of new pipework to existing systems and after satisfactory hydraulic testing, all pipework shall be flushed with clean water and run to waste until thoroughly free of all dirt, oil and cuttings, etc.

A final cleaning out shall be performed by circulation of an alkaline detergent solution.

The entire new pipework shall be filled with clean water and while filling, a non-foaming alkaline detergent shall be added. This shall comprise a mixture of sodium silicate and sodium phosphate plus a non-foaming wetting agent. Sufficient chemical shall be added to provide a phenolphthalein alkalinity in the range of 300 ppm to 500 ppm as CaCO₃.

At the end of the third day the system shall be drained and flushed through with clean water until the alkalinity is below 200 ppm. The system shall then be connected to the existing pipework system.

C.3.1.4 Testing of Air, Water and Refrigeration Systems

Tests of the chilled water system must be carried out during the summer months, when the outdoor wet bulb temperature is above 24°C. The chilled water system will not be accepted on the basis of tests made during mild or cool weather.

If the chiller water system is commissioned other than during summer, the system shall be checked and adjusted if necessary before the expected peak cooling demand is experienced.

Upon completion of adjustments, operate all systems at full capacity, for a period of not less than two days of 24 hours each, at a date approved by the Engineer. During this time make any corrections or adjustments required by the Engineer. All tests shall be carried out to the satisfaction of the Engineer.

During the testing and commissioning period a comprehensive record shall be maintained in the form of an approved log for all equipment items. The log shall show date of start-up and subsequent operations, tests and commissioning trials together with details of all readings, maintenance and/or remedial work undertaken. All entries shall be made legibly and countersigned by the inspecting authority in charge. Four copies of the final log shall be submitted for approval prior to hand over.

During the two day test period:

- Take readings at least four times daily for all temperature item and daily for other items.



- Note the general operation of all equipment.
- Certify as to the quietness and freedom from vibration of all system.
- Record the outdoor temperature and relative humidity.
- Record all water temperatures at flow and return connections at chiller unit and cooling towers.
- Note noise levels recorded during tests.
- Record flow rate handled by each water pump as measured by annubars and pump characteristics.
- Record all motor nameplate current ratings, and actual currents. Currents shall be measured in the field at starters or junction boxes.

No work will be approved without submission of satisfactory test data.

C.3.1.5 Testing of Electrical Services

C.3.1.5.1 Motors

Tests as specified in BS 4999 shall be carried out on all motors prior to delivery. Type tests on motors of equivalent ratings are acceptable. Certificates shall be supplied.

Site tests shall be performed as necessary to verify correct operation of motors.

C.3.1.5.2 Motor Control Centres

Type tests in accordance with the relevant specifications shall be carried out on switchboard and on all components and equipment therein where applicable. The Contractor shall provide evidence of compliance with the relevant specifications. Routine tests and Site tests shall be carried out as specified elsewhere in this document.

C.3.1.5.3 Wiring and Cabling

In general the entire electrical installation shall be tested as specified elsewhere in this document.



C.3.1.5.4 Controls Systems

All electric/electronic controls shall be tested as specified elsewhere in this document.

C.3.2 Painting & Identification

C.3.2.1 General

NO. exterior painting shall be done in rainy, damp or dusty weather, or on damp surfaces.

All surfaces external to the building, with the exception of copper, shall be coated with two coats of asphalt aluminium paint. All such surfaces shall be completely cleaned of all rust, oil, dirt, and the like before painting.

All galvanized surfaces shall be etch primed before painting. All non-galvanised surfaces shall have a prime coat of grey rust inhibitive paint.

Finish by painting all items except for factory finished equipment with two coats alkyd enamel gloss paint. Paint materials shall be delivered in their original labeled and sealed cans or containers with their label intact and seals unbroken. Brand names, colours, samples and types shall be submitted for approval before use. Where this specification refers to "exposed to weather" it means all areas whether roofed over or not where plant and materials are exposed to ambient temperatures and humidity and where driving rain could be expected to affect the plant and materials

C.3.2.2 Motor Control Centre

Before dispatch from the manufacture's works the whole of the exposed metal work of the equipment specified under these clauses shall be painted with materials of approved manufacture and composition.

All steelwork shall be new and be free from rust and scale. After degreasing, one coat of primer shall be applied, followed by one coat of compatible undercoat and two coat of synthetic enamel. All coats shall be stove baked to paint manufacturer's specification.

The finished colour of internal and external surfaces shall be the same and is to be as scheduled in this Specification.

The Contractor shall take the full responsibility for and is to make good at his own expense any defects which may occur during the maintenance period. In addition, any damage occurring during transit or erection is to be made to a standard equal to that of the equipment as originally manufactured.

The paint finish is to be repaired to its original condition using primer undercoat and top coats. Overall, the finish is to have a uniform appearance. Spot repainting which shows colour difference will not be accepted.

Protection covers shall be provided for the switchgear during the construction phase and up to Practical Completion.

Protection covers shall be to the approval of the Engineer and shall be removed after Practical Completion.

C.3.2.3 Equipment

Deliver all apparatus and equipment furnished under this Specification to the site with at least one coat of shop paint. This shall include but not be limited to motors, pumps, water chilling units. Equipment and apparatus delivered with one coat of shop paint shall be finish painted after installation. All items having a factory finish shall be touched up after installation.

C.3.2.4 Piping

Exposed piping in plantrooms, service areas and where exposed to view or to weather both bare and clad, shall be painted as specified and provided with identification marks and flow direction arrows.

All insulated black steel piping and fittings shall be painted with one priming coat at the joints after installation and prior to the application of the insulation.

All insulated pipework which require paint finish shall be clad with zinc annealed sheath in an approved manner prior to painting.

C.3.2.5 Miscellaneous items

All hangers, brackets and supports for all services shall be primer coated and shall be finish painted in all exposed locations, in the plantroom and in service areas.

C.3.2.6 Identification of Equipment

C.3.2.6.1 General

All items of equipment and all piping, sheet metal work and electrical wiring supplied and installed under this Specification shall be identified.

Supply and install laminated Traffolyte or similar approved nameplates, to be secured onto or close by every electric motor controller, motor starter, automatic valve, electric isolator, pilot light, thermometer, and each specialty item and controller supplied under this Specification. Nameplates shall clearly identify each item of equipment.

Nameplates shall be not less than 65 mm X 20mm wide, black cored letters on a white background with beveled edges and shall be secured with suitable screws.

Stencil with 75 mm high block lettering on all item of major equipment, where Traffolyte labels are not specified, and on all ducts and pipes, the function or service of each item. Submit lettering for approval, prior to application. Colours of labels and backgrounds shall be as specified in this Section.

No equipment shall be accepted without an identifying nameplate or stencil, and without all required charts.

All isolation valves to be provided with a permanently attached label indicating whether the valve is normally open or closed.

Identify flow direction in all piping and ducting with arrows of the same colour as the labeling.

Proprietary brand labeling systems will be considered for approval subject to compliance with the intent of this Section.

All labels shall be engraved in both English and Chinese.

C.3.2.6.2 Labeling of Electrical Components

All switchgear, apparatus and controls shall be labeled in accordance with the Supply Authority's requirements and in accordance with this Specification.

All labels shall have black lettering engraved on white traffolyte. The size of lettering and the wording shall be subject to approval. Label schedules shall be submitted prior to manufacture.

Each motor control centre shall be fitted with a main label and operating instructions mounted in a permanent position.

Labels shall be secured with brass screws or stainless steel screws.



Labels shall designate circuit number and equipment function.

With the exception of labels required for bus chamber panels, labels shall not be fastened to removable panels or doors. Labels shall be fitted to the front of all units and panels.

Labels engraved white on red traolyte and with the following wording shall be fastened to all covers or panels giving access to bus chambers – 'Danger – Live Bars Behind'.

Terminal strips shall be labeled to identify the circuit number, phase connection, terminal number and function – e.g. control, induction, protection, etc.

Control relays, timers, fuses and other items of switchgear located on common panels shall be clearly labeled to identify circuit number ,function and rating.

C.3.2.6.3 Colour and Identification Code

The colour schedule and identification lettering shall be the same as the existing installations.

C.3.3 Pipework

C.3.3.1 General

Pipework includes all pipes, valves, drains, tubes, fittings, nipples, reducers, hangers, brackets, anchors, expansion devices, sleeves, plates and all accessories required for the complete installation of the fully operational reticulations.

When preparing shop drawings and setting out the work, take full account of the layout and arrangement of all existing pipework and equipment. Make proper allowances for access and service clearances to all new existing installations.

C.3.3.2 Materials

Piped Service	Nominal Bore (mm)	Minimum Wall Thickness (mm)	Specification
Chilled water, Heating water	15-150 200 250 300 350 400 450 500	- 4.9 6.3 6.3 8.0 8.0 8.8 8.8	Black steel to B.S. 1387 Table 3. Black carbon steel, electric resistance welded (FRW 410) using 410 MPa grade steel B.S. 3600 and 3601.
Condensate drains	25 – 100	-	Galvanized mild steel pipe to B.S. 1387 medium grade.
Condensing Water Pipe	15-150	-	Galvanized mild steel pipe to B.S. 1387 heavy grade.

C.3.3.3 Service Duties

The entire pipework reticulation system shall be suitable for a minimum operating pressure of 1.0 MPa.

C.3.3.4 Installation

All piping shall generally be run parallel to the alignment of the adjacent building surfaces and as close to the ceiling or other construction as practical, at least 40mm away from insulation and free of unnecessary traps or bends. Piping shall be arranged to conform to the building requirements and to clear all other work and other trades.

Piping arrangements shown on the drawings are diagrammatic only and do not purport to show all bends, offsets and transitions necessary for the proper installation of the system within the confines of the building.



Fixing generally shall be by use of metal expansion bolts for concrete and masonry. Explosive fixings will not be accepted. Applied loads on fixings shall not exceed 80% of manufacturer's recommended maximum applied load.

The Contractor shall confirm with the Engineer the maximum depth allowable for securing bolts, etc. to slabs or other structure.

Reducers and expanders in horizontal piping shall be eccentric with top level and bottom offset.

All valves, air vents, unions and piping accessories shall be supplied and installed to the requirements of this Specification and accompanying drawings and where otherwise required for the proper valving and operation of the entire installation. Valves and other items requiring servicing shall be located in accessible positions.

All piping shall be installed at a slope either downwards towards a drain pint or upwards towards a vented high point to facilitate air venting and drainage of the systems. Chilled water lines shall be graded at a fall of 1:250 and condensate lines shall be graded at a minimum fall of 1:100. All condensate drains shall be at least 25mm diameter.

The design of complex piping arrangements and pipes unable to be concealed shall be referred to the Engineer before installation. Factory fabricated large radius elbows and bends shall be used. Mitred elbows and lobster back bends are not acceptable.

No pipes shall be installed so as to cause an unacceptable noise under normal operation. If such a noise does occur, then the Contractor shall alter the pipework as necessary at his expense and as directed by the Engineer.

Where immersion thermostats or thermometer bulbs are installed in piping, the pipe shall be at least one size larger than the main straight run in all pipes up to 100mm diameter.

All cut pipes shall be reamed and filed to remove burrs.

C.3.3.5 Joints

Piping connections under 65 mm to all pumps, valves, headers, coils, tanks and other apparatus or equipment shall be made with unions. All pipe connections of 65 mm diameter and over shall be flanged. Flanges and unions shall be located so that apparatus or equipment can be disconnected and removed from the piping system. Solid final connections will not be accepted. Screwed fittings shall be to BS 143 and 1256.

All joints on underground piping shall be welded.

Except where noted otherwise all joints and connections in steel piping shall be welded by approved certificated welders. Directional changes and branch connections in welded pipes shall be made in factory fabricated swept welding fitting to BS 1965. Field-fabricated fittings made of short length and shaped nipples will not be accepted. Change in piping size shall be made by the use of eccentric reducers and expanders. Butt welding of two different pipe size to form reducers or expanders will not be acceptable.

C.3.3.6 Hangers and Brackets

Supply and install sufficient hangers, supports, beam clamps, clips, inserts and mounting devices to support all piping installed drainage, and so located and arranged as to permit free expansion and contraction.

All supports shall be connected to the building structure, no pipes shall be supported from other services.

The Contractor shall design all supports and provide drawings showing reaction to the Engineer for inspection.

All steel support system where exposed to the weather and in damp areas shall be not dip galvanized.

Install all hangers straight and true, and in perfect alignment. Locate mp hangers near couplings, fitting or bends in piping without provision for expansion.

Hangers and brackets shall not be in contact with other items of equipment except with the approval of the Engineer.

Direct contact of dissimilar metals in the pipework/support system shall not be allowed.

Where lines of piping run as a common group, they shall be supported on a common hanger bar or pipe or channel section.

Branches up to 65 mm diameter from risers subject to movement due to expansion at the point of connection shall be flexibly supported by spring hangers for a distance of 5 metres from the riser. Larger branches shall be supported by constant load spring hangers for a distance of 10 metres.

Maximum spacing between supports on piping shall be as follows:

Piped Service	Nominal	Support Centre
Chilled water, condensate drains, condensing water	10 – 15	2.0
	20	2.4
	25 – 32	2.7
	40	3.0
	50	3.4
	62 – 80	3.7
	100	4.1
	125	4.4
	150	4.8
	200	5.1
	250	5.8
	300 - 1000	6.1

C.3.3.7 Expansion

The Contractor shall ensure that all necessary measures are taken to use loops or offsets either manufactured or site fabricated.

C.3.3.8 Sleeves and Cover Plates

Supply pipe sleeves for all piping passing through floor, walls partitions, furring, roof and ceilings. Sleeves shall be the full thickness of the construction finish to finish.

Installation of pipe sleeves shall be by the Contractor. Location, size and gauge of sleeves to be approved by the Engineer.

Sleeves through exterior brick and masonry walls and through fire partitions shall be of galvanized wrought iron pipe, at least two pipe size larger than the pipe passing through. Sleeves in partitions shall be of galvanized steel tube.

Sleeves shall pass through walls at right angles or as shown on the drawings.

Sleeves shall be large enough to accommodate piping movement due to expansion and also to accommodate insulation where required.

Where pipes pass through walls, floor, ceiling, partitions, and furred in finished spaces, furnish and install solid, close fitting steel plates or escutcheons, secured by set-screws or by other approved method.

Escutcheons in occupied spaces shall be satin chromium plated steel. Black steel or painted



escutcheons will not be accepted in occupied spaces.

Sleeves through roofs shall be of galvanized wrought iron pipe, and shall project 100mm above finished roof level and be properly flashed.

Sleeves through plantroom floors or areas subject to flooding shall be finished with a 75mm concrete curb.

Where such projecting sleeves are exposed, the sleeves shall be of chromium plated brass pipe. For all such projecting sleeves, the escutcheon plates shall be omitted.

Sleeves through fire rated shaft walls, floors and roofs shall be tightly packed with rockwool or other fire resistant material approved by the F.S.D. to maintain shaft integrity.

C.3.3.9 Valves

Supply and install all isolating, control and other valves required for the correct operation and control of the complete system.

Valve design working temperatures shall be 5 deg C for chilled water systems.

All valve handles shall be installed at common centres and common heights and shall be clear of head height and shall be easily accessible unless otherwise stated.

Valves and pipe connections shall comply with relevant current British Standards to suit the design working pressure and temperature of the fluid handled.

Valves shall comply with the requirements of all supply and statutory authorities having jurisdiction over the installation.

All valves used for isolating duty shall be suitable for “dead end” service. Unions shall be provided adjacent to screwed valves.

Valve working pressure for chilled water piping shall be 1,000kPa.

Valve bodies 50mm and smaller; Gunmetal to BS1400 or Bronze. Valve bodies 65mm and larger; Cast Iron body. All valve trim shall be bronze. Bronze valves shall have hand wheels of malleable iron or of high tensile strength alloy steel.

Butterfly valves shall be installed where shown on drawings. Butterfly valves shall be of the two flange type, hand multi-lock lever operated up to 150mm diameter, gear operated on valves greater than 150 mm. All butterfly valve shall be complete with position indicator.

Furnish and install Mission type “Duo-Check” check valves in the locations shown on the drawings. Valve body and plate shall be of aluminium-bronze construction with “Buna-N” type seal. The springs shall be type 316 stainless steel and suitable for the head pressure of the system.

C.3.3.10 Drain Points and Vents

On piped systems supply and install key operated air vents at all system high points, and drain points at all system low points and otherwise as shown on the drawings and as specified.

Manual vents shall be 6.5 mm plug cocks. All vents shall be fitted with a hose union. Drain points on water circulating system shall be fitted with 20 mm gate valves piped by means of copper tubing to physically accessible termination point in the system as appropriate.

Pumps – drip lines shall be provided from pump beds or pump structure of at least 25mm diameter copper pipe to tundishes which shall be connected to the building drainage system, sewer or storm water as required by the local Authority. Drip lines shall be expanded to 25mm diameter if necessary immediately after the bedplates or pump structure if the drain hole in the bedplate is less than 25mm diameter.

C.3.3.11 Strainers

For pipe lines of nominal bore between 15mm and 50mm, strainer shall be screwed gunmetal or bronze body 'Y' type with stainless steel screen.

For pipeline of 65mm and above, strainer shall be flanged to BS4504, with 'Y' type cast iron body and stainless steel screen.

The strainers shall be easily accessible and designed to allow blowing out of accumulated dirt without discontinuity of service and permit removal of the basket without disassembly of piping.

Supply and install blow-off gate valve with 15 mm hose union, the full size of the strainer outlet, but not larger than 50mm. Where a gate valve is less than full size the 50mm connection shall be made eccentrically at the bottom of the outlet. Keep space below such blow-off valve free of other piping or equipment.

Strainers shall be selected for the working pressure specified for the valves on the same piping system.

C.3.4 Ductwork

C.3.4.1 General

Manufacture, supply and install all ducts, casings, drain pans, plenum chambers and sheet metal work for air handling equipment and systems as specified under this Section of the work.

All insulated and uninsulated duct sizes shown shall be clear internal airway dimensions.

All ductwork, unless otherwise indicated to the contrary, shall be manufactured from hot dipped galvanized steel sheet complying with the requirements of BS 2989, 1975 Grade Z2 coating type 'C'.

All sheetmetal work design and construction methods and standards shall comply with the requirements of the latest edition of the HVCA DW/144 [specification for sheet metal ductwork]. Install externally and internally lined ductwork as specified and as shown on the drawings. Insulating materials used shall be as detailed under the Insulation section of this Specification.

All dampers, doors, casings shall be installed to minimize the generation of audible noise from vibration or leakage.

The Contractor shall submit shop drawings for examination. Show extent of acoustic lining, access doors, manways and turning vanes and all fittings, fixtures and accessories.

Use an approved duct sealant to seal all joints in air conditioning ductwork to ensure air tightness.

C.3.4.2. Low Pressure Ductwork

Low pressure ductwork shall refer to all systems with static pressure up to 750Pa.

All longitudinal seams shall be Pittsburgh or Acme Lock.

Transverse joints may be made with the Metu System with internal sealant or flanged angle frame connections.

Transverse joints may be made with standard Metu system or Labyrinth System with all drive cleats in place.

Transverse joints may be made with drive cleats up to 450 mm maximum duct size, with reinforced bar slip up to 900 mm and flanged angle frame connections over 900 mm.

All ducts over 450 mm either direction shall be cross-broken except those to which rigid board



insulation is attached or to which diffusers or branch ducts are connected.

All elbows shall be "Standard radius" or "square throat – double vane", unless the approval of the Engineer is obtained for a satisfactory alternative.

Steel not required to be galvanized shall be wire brushed after fabrication and coated with 2 coats of priming paint.

Angles shall not be fixed over cross breaks.

Round or oval spigots for connection of flexible ductwork to rigid sheet metal ductwork or plenums shall have a minimum length equal to one diameter of the flexible duct and shall have butterfly type volume control dampers.

All supply air plenum boxes at supply air fittings shall be constructed to the same standard as low pressure ductwork and shall be acoustically lined, as shown on the Drawings.

C.3.4.3 Flexible Ductwork

All flexible supply air ducts shall have 25mm thick glass-fibre insulation with a 0.075mm thick glass fiber reinforced aluminium foil bonded to the internal face by means of a solvent-based SBR adhesive. The internal face shall be supported with 1.3mm thick spring-steel wires bonded at 20mm centres by means of a solvent-based SBR adhesive. Ensure that flexible ducts comply with local fire department regulations. The maximum length of duct shall not be over 3 metres.

C.3.4.4 Installation

Lay out all work at the building site. Take all necessary measurements and construct the work to meet actual building conditions.

Supply and install crossovers, transitions, offsets and changes in duct shapes to avoid interference with beams, pipes, electrical conduits, lighting fixtures and other obstructions to maintain equal air flow resistance of all ducts.

Pleced or patented ducting systems have been approved, installation shall be in accordance with the manufacturer's recommendations.

Inspect all ductwork internally prior to erection and remove all dirt, dust and other foreign matter. Cover all open ends of ducts during construction with polythene sheeting taped in position.

No pipes shall pass through ducts, unless deemed necessary by the Engineer where pipes are shown to pass through ducts, provide teardrop sheet metal fairings, carefully shaped around piped, seal ducts at junction.

All joints shall be lapped, creased and secured for airtight connection. Lap all slip-joints in direction of air flow.

All flanged transverse joints shall be sealed with neoprene gasket around the entire perimeter.

Joints in air chambers and plenums shall be caulked airtight. Bottoms of all such air chambers resting on masonry floor shall be gasketted or caulked to prevent air leakage.

Connect the ducts, casings, plenums, rain baffles, bird screens and sheet metal work to all fresh air intakes as specified.

Where ductwork in Plant Rooms is specified or shown to be insulated, mount such ducts not less than 150 mm away from floors, walls, so that insulation may be installed.

Where floor slabs are of weatherproof construction do not pierce waterproofing with retaining bolts or inserts. Check with the Engineer for approved method of securing plenums, chambers and casings to a waterproof slab.

Supply and install hangers, brackets and supports for all sheet metal and ductwork suitable for the building construction.

Pop rivets shall be of the self sealing type.

All exhaust systems shall use flanged connections. Dive cleat construction or patented systems shall not be used. Proprietary system such as “Mez-Venolec” may be required where riser space is limited. All joints in kitchen exhaust ductwork shall be vapour tight by the application of an approved sealant.

For square elbows use long tail pattern turning vanes, spaced 37 mm on centres. The tangent portion of the tail of each vane shall be half as long again as the arc.

All turning vanes at every elbow in acoustically lined duct shall be acoustically lined.

Adequately protect all ductwork delivered to site. Any ductwork damaged in transit or storage shall be replaced at the direction of the Engineer.

C.3.4.5 Access Doors

Access doors shall be installed at every fitter section, fire damper, automatic damper, valves, temperature control equipment, fan bearings, electric duct heater etc. to permit inspection, operation and maintenance.

Access doors in ductwork, casings or sheet metal partitions shall be of double skin construction with minimum 25 mm insulation of the same general characteristic as adjacent sections of ductwork, of not less than 1.0 mm sheetmetal and shall have not less than 15 mm wide neoprene rubber gaskets around their entire perimeter.

Access doors in sheetmetal work shall be secured in the closed position by means of wedge type catches. Four latches will be used on doors 300 x 400 mm or above. In no case shall any access door require removal of nuts, bolts, screws, wing nuts, wedges or any other screwed or loose device.

Where access doors are specified or shown to be required, size shall be as shown on the drawings or as specified below. When the duct is of smaller dimensions than the access door specified, the door shall be the full width of the duct.

500 x 650mm into ducts having one dimension of 1200 mm or more.

370 x 500 mm at each supply fan discharge, at each single inlet centrifugal fan suction where the outward bearing is within the ductwork, and each automatic damper, fire damper and electric duct heater.

370 x 500 mm into ducts having dimensions 800 – 1200 mm.

240 x 370 mm into ducts having largest dimension less than 800 mm.

Access doors shall have a fire rating equivalent to that required for the adjacent construction when located in such construction.

C.3.4.6 Fire Dampers

Supply and install gravity operated fire dampers which comply with the local fire department requirements, wherever ducts pass through masonry or concrete walls and floors and fir partitions and wherever required by authorities having jurisdiction over the work. All fire dampers shall be construction and installed to provide a minimum fire rating at least equal to the construction rating in which it is to be installed. Fire dampers shall be gravity operated, with fusible link and shall be set to fuse at 60 deg°C or other such temperature as may be required by the local fir department.

All springs and catches shall be of non-ferrous and corrosion-resistant materials.



Manual Volume Dampers

C.3.4.7 Manual Volume Dampers

An adjustable deflector or damper with approved locking device shall be installed at each branch take off in supply and return systems and at each exhaust hood neck in exhaust systems. Dampers shall be not less than two metal gauges heavier than the duct, they shall have extended shafts and mounted lugs on the quadrant so that damper control can be located on the external surface of the insulation. Sheet metal stools shall be supplied as necessary. Dampers shall be adjusted and locked during the testing period.

Volume dampers shall be used as detailed below except where specified otherwise.

Opposed Blade – manually adjustable zone balancing damper branches and at registers, grilles for air conditioning supply and return.

Splitter Dampers – manually adjustable at main duct separation.

Stream Splitter Dampers – on direct duct mounted registers.

Rotating Butterfly – at all minor branch duct including flexible duct spigot connections.

Multileaf dampers shall be used where single leaf blades would be over 225 mm wide. Blades shall lock against each other and be provided with approved edge trim of neoprene or other approved material subject to F.S.D. approval to ensure an air tight seal.

C.3.4.8 Motorized Dampers

Motorized Dampers – for modulating of air flow rates shall be as Honeywell D641 low leakage, opposed blade type or an approved equal.

C.3.4.9 Duct Jointing Sealants

All sealants, adhesives, tapes, etc., used for jointing and sealing on ductwork systems shall comply with the requirements of DW/144, and be approved by F.S.D.

Jointing for flanged cross joints shall be formed from a gasket. Gaskets may be soft neoprene, armaflex tapes or other material to approval and gaskets shall have adhesive backing on both sides.

C.3.4.10 Air Fittings

All supply fittings shall have an opposed blade volume control device, the vanes for which shall be spring-loaded or otherwise arranged so that they remain permanently in their set position without vibration or noise. Where shown on the Drawings, return and exhaust air fittings shall also have opposed blade volume dampers.

All grilles, registers and diffusers shall be capable of being removed easily from the ductwork for access to dampers, etc., and construction in accordance with the best practice and free from sharp edges.

Except where otherwise shown on the Drawings, all air fittings shall have concealed fixing systems. Exposed screw fixings will not be accepted. All corners shall have mitred joints with no discernible gaps and all surfaces shall be completely smooth suitable for a painted finish.

Painting – All diffusers and registers shall be prime-coated with best quality rust-preventive primer and then painted flat-grey enamel. Final color enamel coat to be decided by the Engineer.

Return air grilles for fan coil units shall generally be arranged such that central core of the grilles is hinged and demountable for access to the filter for cleaning. Mounting frames for these grilles shall include provisions for fixing the filters in position. All filters installed shall comply in every respect with FSD's requirement.



Air fittings may be locally manufactured but it is a requirement that they comply as closely as possible with the quality and performance standards of imported products such as Anemostat, Barber Colman, Tempmaster etc. In preparing his tender, the Contractor shall satisfy himself that products of such a standard are locally obtainable as the Engineer's specific approval for the use of all fittings will be required.

Samples of every type of air boot grille, diffuser, etc., shall be submitted to the Engineer for approval before orders are placed.

Where a particular brand or model of air fitting is called for it is intended that the exact fitting specified is provided. Do not make substitutions without the Engineer's approval.

C.3.5 Thermal Insulation

C.3.5.1 General

All thermal insulation shall comply with the requirement of the FSD.

Thermal insulation shall be applied to all piping, equipment and ductwork as detailed in this specification, after completion and acceptance of all tests for leaks.

Flanges and unions for all piping as above shall be insulated except where making final connections to equipment.

All insulation shall be selected to have a thermal conductivity of less than 0.034 W/mK at 20°C mean temperature.

C.3.5.2 Installation

All piping and equipment shall be installed to permit the proper installation of the insulation material specified with, where possible, a 40mm gap between adjacent construction and insulation for pipework, and ducts. Makeshift patching or filling with loose or blown insulation because of lack of space will not be permitted. Adjacent and parallel pipes and ducts shall not be married together with insulation material.

All insulation shall be continuous through sleeves and hangers and as shown on the drawings. Samples shall be submitted for examination for all proposed insulation before acceptance and in addition be approved for the application by appropriate authorities having jurisdiction. The Contractor shall submit all approval or endorsement certificates relating to flame and smoke emission prior to application.

Where zinc annealed sheeting is applied to pipe, the seams shall be hidden from view wherever possible.

C.3.5.3 Chilled Water Pipework / Condensate Pipework / Condensing Water Pipework

All equipment and materials used shall be fire resistant and shall comply with the requirements of the Local Fire Services Department.

Insulation thickness shall be 40 mm thick fiberglass for chilled water pipe diameter up to 50mm and minimum 50mm thick for pipe diameter greater than 50mm. Insulation for condensate shall be 25mm thick.

Insulation facing and vapour barrier shall be factory applied aluminium foil (Sisalation 450) as an integral backing to the insulation.

In all plantrooms and where exposed to view or weather, pipes shall be insulated by rigid polystyrene of thermal conductivity not greater than 0.034w/mk at 20°C mean temperature. They shall be rendered with cement plaster to a thickness of not less than 15mm. Render shall be reinforced by a 15 mm mesh and 0.8mm wire netting and shall be brought to a true and fine finish. Then painted in accordance to this specification.



Pre-formed pipe sections shall be butted tightly and glued end to end on straight pipe, and at bends and tees the pre-formed sections shall be cut and mitred so as to fit neatly and tight when glued to the abutting insulation. Pre-formed sections shall be glued to the pipe surface to prevent vapour tracking. Vapour stops shall also be provided at bends, tees and each side of fittings such as valves, flanges, unions and fittings.

Vapour stops shall be made by glueing the last section of pipe insulation to the pipe over its full length and in any case not less than a length of 1m with an approved vapour stop glue.

On straight pipe, the longitudinal joints shall be staggered axially and shall not form a continuous straight line.

Insulating shall be stopped square at each side of valves, unions and flanges clear of bolts.

Pump casings, Valves, flanges, strainers, unions and other fittings requiring dismantling or removal for service shall be insulated, vapour sealed and finished with 0.8mm thick "Hammerclad" or equal hammered finish aluminium cladding firmly secured with toggle type suitcase clips to enclose the valve body, flange or fitting. The joints in the sheathing shall be sealed with Silverseal mastic or equal to form a vapour seal at all joints and where the removable sections join the sheathing on adjoining pipes.

The vapour barrier shall be completed by making a 50mm wide lap on longitudinal joints and glueing. Circumferential joints shall be sealed by means of 75mm wide tape lapped 38mm over each adjoining facing on pipe insulation and glued with an approved adhesive.

Alternatively, 75mm wide pressure sensitive pre-glued tape equal to Norton 415 Foil Tape may be used for longitudinal or circumferential joints in which case particular care shall be given to cleaning of the facing and proper pressing of the tape to achieve a satisfactory glued bond. Sisalation 450 facing on bends, tees, etc, shall be cut and shaped so that when glued it laps not less than 25mm over adjoining facing and provides a continuous and effective vapour seal.

Zinc annealed sheathing shall be held in position using not less than three galvanized steel bands on each section. Sheathing at bends shall be neatly cut and formed on "lobsterback" sections and pre-drilled and fastened using pop rivets or straps so that the vapour barrier underneath is not penetrated.

Pipe hangers shall be 'D' clamps or circumferential clamps over wood or cork blocks of the same diameter as the insulation. The insulation shall be butted up to each side and the vapour seal (and sheathing if exposed) shall be carried through between the clamp and the wood or cork block to give a continuous vapour barrier.

C.3.5.4 Air Conditioning Ducts

Air conditioning ducts shall be insulation with 25mm fiberglass blanket of 48kg/m³ density backed with Sisalation 450 vapour barrier except where internally acoustically lined.

Secure insulation to duct with stick-pins and clips to prevent sagging.

Provide galvanized sheet metal corner angles of 0.8mm thickness along the full length of all insulation ducts to protect insulation.

Insulation shall be cut so that longitudinal and circumferential seams are covered with a minimum of 75mm vapour barrier overlap. 150mm wide Sisalation 450 strips may be used in lieu of vapour barrier overlaps. Seal all joints and flaps with vapour barrier adhesive, Type EC-1128. Tying cord must be used until adhesive sets. Extreme care shall be taken at all joints to ensure a vapour tight installation. Any sections showing air pockets between duct and insulation will be rejected.

C.3.6 Air Handling Equipment

C.3.6.1 Fans - General

Values of resistance to air flow of items of equipment, ductwork and/or the total distribution system indicated in the contract documents are based on basic design assumptions and therefore must be re-assessed. It shall be the responsibility of the Contractor to verify these values based on the actual equipment offered and installed by him and to provide fans capable of delivering

The required air volume when operating against the actual total installed system resistance. Fan shall be 'type' tested in accordance with the requirements of BS 848 and shall be selected to give the air volume flow rates and sound power levels specified in the contract documents.

Unless otherwise Indicated, the requirements of Section shall not apply to Individual fans having a duty air flow rate of 1.0m³/s or less.

All fans should be constructed to a fully developed design and shall be capable of withstanding the pressures and stresses developed during continuous operation at the selected duty. Additionally, all belt driven fans shall be capable of running continuously at ten percent in excess of the selected duty speed.

The make and type of each fan shall be approved by the Engineer. Fan performance curves giving values of sound power levels and fan efficiency at the selected duty shall be submitted for approval.

All fans and associated motors should be able to run at any flow rate between 0.85 and 1.15 times the designed flow rate without affecting the stability of the fan operation.

Sound power rating curves shall be in accordance with BS 848/AMCA 210/AHSRAE 55, and in db measured at one meter from the fan at each of the octave band mid frequencies from 63 Hz to 8 kHz at the normal operating condition of the fan.

C.3.6.2 Centrifugal Fans

The shaft and impeller assembly of all fans shall be statically and dynamically balanced to G2.5 of BS 5625 Part 1 (1979).

Fan bearing shall be of a type suitable for the installed altitude of the fan. They shall be grease/oil ball and/or roller type or alternatively oil lubricated sleeve type. All bearing housings shall be precision located and arranged so that bearings may be replaced without the need for realignment. Bearing housings shall be protected against the ingress of dust and, where fitted with greasing points, they shall be designed to prevent damage from over-greasing. For grease lubricated systems the bearings shall be provided with grease as recommended by the bearing manufacturer. For oil lubricated systems the housings shall be provided with an adequate reservoir of oil and shall include a filling plug and be oil tight and dust proof. Systems other than total loss types shall include an accessible drain plug. All bearing lubricators shall be located to facilitate maintenance.

Fans shall be installed using bolts, nuts and washers with all 'as cast' bearing surfaces for bolt

heads and washers counterfaced. Holding-down bolts for fans and motors shall be provided with means to prevent the bolts turning when the nuts are tightened. Anti-vibration mountings shall be as specified elsewhere. Fans heavier than 50 kg shall be provided with eyebolts or other purpose made lifting facilities.

V-belt drives shall comply with BS 3790 and shall be capable of transmitting at least the rated wattage output of the motor with one belt removed; unless otherwise indicated not less than two belts per drive shall be used. Pulleys shall be exactly aligned. Motor pulleys shall be of adjustable type to enable operating speed to be varied within limits after installation. The Contractor shall ensure that any holding down bolts are grouted in and positioned to ensure correct alignment. Provision shall be made for positive adjustment of the tension in V-belt drives.

Centrifugal fans for high –velocity high-pressure systems as defined within HVCA Specification DW/144, shall be backward curved inclined type.

Unless otherwise indicated, centrifugal fans consuming more than 7.5KW at the fan shaft shall be of the backward biaded type having a fan total efficiency not less than 75% and those up to 7.5 KW shall have a minimum efficiency of 65%.

Fan casings shall be constructed to permit withdrawal of the fan impeller after fan installation. Fans other than those in factory constructed air handling units (AHUs) shall, unless otherwise indicated, be provided with flanged outlet connections and spigoted inlet connections suitable for flexible joint connections except that for negative pressures greater than 500 Pa inlet connections shall be flanged.

Impellers shall be of tube aerofoil and fabricated from galvanized mild steel of riveted or welded construction, with spiders of hubs of robust design, and shall be capable of running continuously at ten percent in excess of normal speed.

Impellers shall be keyed to a substantial mild steel shaft and the impeller complete with shaft shall be statically and dynamically balanced plus tested for satisfactory overspeed performance before leaving the maker's works.

Shaft bearings of belt driven single inlet fans shall be truly aligned and rigidly mounted on a pedestal common to both bearings. Fan bearings shall be ring oiling sleeve hearings, or bell or roller type. Where silence is important the bearings pedestal shall not be attached to the fan casing ring oiling type sleeve bearings shall be supplied.

Casings shall be of heavy gauge galvanized sheet steel construction adequately stiffened and braced and shall be entirely free from vibration or drumming during normal operation.

All surfaces of fan casings shall be galvanized after manufacture and all fans with an inlet eye diameter exceeding 300mm shall have a bolted access door on the scroll for access purposes.

The fan and motor assembly shall be mounted on a rigid dipped galvanized mild steel channel base.

C.3.6.3 Air Hanging Units (AHUs)

C.3.6.3.1 General

The specified construction standards set out in this section are intended to establish quality requirements. It is not intended that air handling units be custom built to this specification but rather it is a requirement that all air handling units be the standard developed product of experienced manufacturers., Only products manufactured in the U.S.A., Europe or Japan will be accepted unless the Engineer's express approval for an alternative has been given. Select equipment with due regard to available installation space, delivery deadlines and resultant noise levels.

Individual components forming part of packaged air handling plant shall, in addition to this section comply with the appropriate section contained elsewhere in the Specification.

All air handling units shall be provided with an identification plate and shall be securely fixed to the air handling unit casing in a prominent position.

In addition, each unit shall have a specification plate which shall show full details of the fan, coil, motor and filter media and any other information that may be required by the Engineer. This plate shall also be securely fixed to the air handling unit casing.

C.3.6.3.2 Construction

AHU unit assemblies shall be of rigid construction corrosion resistant and strengthened where necessary to prevent deflection and drumming even at 2500 Pa differential pressure. All individual components and sections shall be assembled using proprietary and approved fastening techniques. Locking devices shall be used with all fastenings which are subject to vibration. Material shall be not less than 2mm in thickness and methods of strengthening and fastening shall ensure that air handling assemblies are more rigid in operation than the distribution ductwork to which they are connected. All metal surfaces must be properly treated and suitably painted. The painting method and material used must be approved by the Engineer.

The air handling units shall be of modular construction by galvanized sheet, formed and reinforced to provide a rigid assembly. Formed panels shall be removeable to provide a rigid assembly. Formed panels shall be removeable to provide easy access.

Framework shall be constructed from galvanized steel sections of thickness no thinner than 2mm, welded or bolted to form a rigid box structure.

Jointing and sections shall be waterproof and air tight, a polyurethane gasket shall be installed between mating faces.

Infill panels of the air handling units shall be of single skin construction. The external casing shall be of a minimum thickness of 1.2mm. Internal flanges of the components shall be bolted together with cadmium plated, nuts, bolts and washers.

C.3.6.3.3 Panels

The panels shall fit within the framework and shall be sealed at the jointed edges with a waterproof and air tight gasket. All panels shall be removeable except those not required as quick access panels which may be bolted to the framework. Quick access panels may be lift off type with handles where they are below 1.0m², large sizes shall be hinged unless plant access is restricted. Quick access panels shall have a locking device which gives a secure seal between frame, gasket and plant.

Main access panels shall be provided for fan sections, filter sections and mixing boxes and elsewhere as indicated. The entire unit shall be mounted on a channel iron base frame. Main access panels for the fan sections shall allow the fan and motor to be removed from the casing. Pulley sections shall be located adjacent to the main release panels and motors shall be located on side rails for adjustment of belt tensioning and enclosed by the AHU casing.

C.3.6.3.4 Air Filters

Air filter types and required efficiencies shall be as indicated in the Contract Document and/or shall conform to the appropriate parts of this Specification.

All air handling units shall have High Efficiency Type Panel Filters as specified in the Air Cleaning Equipment section. Additionally, the Auditoria air handling units shall be complete with bag-type filters.

C.3.6.3.5 Air Cooling coils

Water shall not be carried over from a cooling coil into the remainder of the system and an eliminator section shall be provided, wherever necessary or indicated. The drip tray serving the cooling coil shall be extended or a separate tray be provided to collect water from the eliminator. Drip trays shall be sloped

Towards a drain connection and pipework shall be installed from each connection to the nearest sump or gully. The drain pipework shall include a water seal of adequate depth to prevent entry or exit of air to or from the system. A separate drip tray shall be provide for each 1.2 metre depth of coil. All drip trays shall be of galvanized steel construction insulated on the underside and coated on the topside with anti-mould coating. Drip trays shall be graded towards the drain connection to prevent ponding of stagnant condensate. Sealing devices shall be provided at tops and bottoms of coils to minimize air by-pass and water carry over.

Unless otherwise indicated, cooling coils shall be constructed of heavy gauge seamless copper tube with mechanically bonded aluminium fin.

Tube thickness shall be not less than 0.45mm. Fin thickness shall be not less than 0.24 mm with fin spacing 25.4mm maximum.

The resistance to air flow through a cooler battery shall not exceed 125 Pa taking into account of wet air condition and the face velocity shall not exceed 2.5m/s.

Air cooling coils shall be supported such that their weight is not transmitted to ductwork and they can be removed without disturbing adjacent ductwork. Access doors with air seals shall be provide on both the upstream and down stream of the cooling coils and shall be sized for the full height of the connecting ductwork but need not exceed 1800mm.

Before leaving the maker's works cooling coils shall be tested with air under water to 1 1/2 times the working pressure or to 2500 kPa whichever is the greater.

C.3.6.3.6 Chiller Water Connections to Cooling Coils.

These shall be arranged in a contra-flow pattern, with the flow of chilled water entering the leaving air end and leaving at the entering air end. The flow and return connections and headers shall be made of heavy gauge seamless copper tube and shall be so arranged to ensure an equal flow of water through all the tubes. Provision shall be made for thermal expansion of the tubes, for effective venting of the coils and their connections and for the draining of the headers and tubes.

Up to and including 50mm bore connections shall be made using ground-in spherical seated unions. Pipework 65mm bore and above shall be connected using flanged joints. Isolating valves shall be provided on flow and return connections and arranged so as to facilitate the easy removal of the coil. Each coil shall be fitted with an automatic air vent of suitable pressure rating at the highest point, and be provided with cocks for pressure gauge connection.

C.3.6.3.7 Electric Air Heater

Electric air heaters shall consist of a number of sheathed heating elements of the enclosed type mounted in a sheet steel casing. The elements shall be so installed that they can be removed for cleaning or renewal without dismantling ductwork. The surface temperature of the elements shall not exceed 400°C when measured in an air flow of 2.5 m/s at ambient temperature. A high temperature limit 'cut out' device with hand reset button shall be incorporated such that the limit device sensor is nearest to and above the heating elements which are energized by the first control step. The device shall operate within two minutes at a temperature of 68.5°C .

The control of electric air heaters, shall be interlocked with the fan motor starters and an air flow control of the pressure or sail switch type so that the heaters cannot operate unless the fan is running.

Electric air heaters which are installed as boosters I branch ducts remote from the fans shall have

an air flow control of the 'sail' or 'pressure' type which shall isolate the heating elements from the electricity supply in the event of the failure of air flow.

The number of elements in the heater shall be same as or a multiple of the number of step in the controller. All heaters and heater section of more than 3 kW loading shall be balanced over 3 phases and the complete heater bank shall be arranged for balanced operation on a 3-phase 4 wire system.

The connections from each element shall be taken to a readily accessible terminal box arranged for conduit entry. Each heater section shall be separately fused and the neutral point of all 3 phase star-connected sections shall be brought out to a link in the terminal box. Near hot areas the wiring insulation shall be of a quality suitable for the maximum working temperature. The total resistance of the heater to air flow shall not exceed 15 Pa and the face velocity shall not exceed 6 m/s.

The time delay device shall be so arranged that on switch off the fan motor to maintain the fan to run continuously for minimum three minutes after the heating element cut off to dissipate the residual heat inside the air duct.

Ensure that electric heaters and their controls comply with SD regulations.

C.3.6.3.8 Fan and Motor

All rotating components shall be mounted on a chassis fully isolated on spring/neoprene anti-vibration mountings from the framework and casing.

All fans shall be double inlet, double width backward curved air foil type mounted together with their motor on a base frame isolated from the main casing by means of 98% efficient spring/neoprene vibration isolators. The vibration isolators shall have a minimum deflection of 30 mm.

C.3.6.4 Fan Coil Units

C.3.6.4.1 General

All fan coil units and accessories shall be the product of the manufacturers named in the appropriate Clauses of this Section or an approved equal.

Generally, fan coil units shall be as manufactured by Sinko or an approved equal and shall be of Japanese or U.S.A. origin unless the Engineer has expressly approved an alternative.

C.3.6.4.2 Selection

The Contractor shall select all fan coil units and accessories suitable for the scheduled duties.

The Contractor shall correctly relate the manufacturer's information for fan coil selection to the requirements given on the Drawings.

In selecting the fan coil units, the Contractor shall allow for the actual resistance imposed on the air flow of the units due to ducts and grilles. The added resistance is to be applied to all fan coil units whether shown to have ducts connected or not, and is to be taken as a minimum of 50 Pa (external to the unit).

The fan coil unit shall be of the ceiling concealed type comprising cooling coil, direct electric motor driven centrifugal fan and condensate drain pan unless otherwise specified.

Select fan coil units to meet the specified duties at medium speed.

The maximum chilled water flow rates through coil as indicated on the Drawings will not be increased to permit manufacturers to offer "narrow" coils. Coils depth (number of rows) must be selected in accordance with the specified flow rates.

All fan coil units shall be of minimum vibration and noise level during operation; should these be excessive and not within normal acceptable standards, the Contractor shall be responsible of provision of adequate vibration isolation and sound attenuation as recommended and required by Engineer.

The Contractor shall allow for the inter-changeability of spare parts and accessories in the selection of each unit.

C.3.6.4.3 Standards

All fan coil units and accessories shall be of the highest commercial standard and shall be designed, constructed, rated and tested in accordance with approved authority such as the ARI of USA. Materials shall comply with the various British Standards, listed elsewhere in this Section of other approved international standards.

All factory applied acoustical and thermal insulation, including facing and adhesive, is to be fire-resistant and to conform to requirements of NFPA and Local Fire Service Department.

All locally fabricated casings and plenums shall be manufactured in accordance with the requirement of the 'Ductwork' Section of this Specification.

C.3.6.4.4 Equipment

Fan coil units shall be provided in the position shown on the Drawings, and shall comprise quiet running, direct-driven centrifugal fans, cooling coil. Heating coil (where specified), and filter as indicated on the Equipment Schedules. Use high-static type units where required to meet the specified air flow against the actual system static pressure.

Coils fans and fitters shall be mounted in a robust welded steel frame within a heavy gauge steel casing. The steel shall be galvanized after manufacture.

The fans shall be constructed with aluminium blades mounted to a solid steel shaft and shall be direct driven.

The duties of cooling coils are shown on the Drawing.

Air cooling coils shall be constructed with copper tubes, and unless otherwise specified, aluminium fins. All coils shall be a minimum of 3 rows.

All tubes shall be arranged horizontally and where there are more than one row, tubes shall be stiffened. Tubes shall have brazed copper return bends.

Fins shall have smooth drawn collars of length equal to fin spacing and mechanically bonded to tubes. Fins shall be plate type, corrugated to ensure maximum air contact area.

All coils shall have an air release valve at highest point and a drain valve.

Working pressure of coils shall be 1,030 kPa.

Fan motors shall be of the 'split-capacitor' type suitable for single phase power supply. The motor shall be resiliently mounted to the fan tray scrolls. The motor/fan tray assembly itself shall also resiliently mounted to the casing structure. The tray shall be easily withdrawable for inspection and cleaning after disconnecting from the mains supply and ancillaries with the plugs and sockets provided.

The motor shall be capable of providing at least three fan speeds (plug off) and shall be of adequate capacity to prevent overloading at any speeds and duty of the fans.

C.3.6.4.5 Filters

Filters shall be of the washable type with a minimum thickness of 25mm 'throwaway' type filters will not be accepted.



Filters shall be U.L. approved and fire-resistant to conform to the requirements N.F.P.A. and F.S.D.s requirement.

All filter shall have a minimum efficiency of 35% when tested against ASHRAE test standard 52-68.

C.3.6.4.6 Controls

Fan coil units shall be controlled as described I the 'Automatic Controls' Section of this Specification.

C.3.6.4.7 Installation

The Contractor shall note the limiting dimensions within false ceilings as shown On the Drawings. These dimensions cannot be increased under any circumstances.

All components of the fan coil units including casing shall be adequately protected during transportation and installation. Any unit which suffer excessive damage in the opinion of the Engineer shall be rejected and replaced with a new unit at no extra cost.

The fan coil units shall be located as indicated on the Drawings. The fan coil units shall either be bolted directly to the slab or shall be suspended on angle iron frames as shown on the Drawings.

All support angles, support legs, platforms, hangers and anchor bolts required for the proper installation of the units as recommended by the manufacturer shall be provided by the Contractor.

C.3.6.4.8 Electric Heaters for Fan Coils

Unless otherwise specified, these shall be of 2 kW capacity of the black heat sheathed element type, plain or finned, and shall be provided with a safety cut-out thermostat set to operate at 50°C.

A sail switch is to be fitted for each heater battery and is to be connected in series with the safety cut-out thermostat to switch off the heater in the event of reduced air flow.

C.3.6.5 Water Cooled Packaged Unit

C.3.6.5.1 General

- Unit shall be single-package horizontal type and shall include
- self-contained water-cooled condenser.
- Maximum water pressure drop for the condenser at these conditions shall be 100 kPa.

C.3.6.5.2 Cabinet

- Panels shall be galvanized metal finished.
- Unit sections shall be insulated with 25.4 mm of polyurethane insulations to prevent sweating and to muffle sound.
- A self contained filter frame for use with standard permanent/ throwaway filter shall be located at the back of the cabinet. Filter shall factory supplied.
- Additional acoustic enclosure shall be provided as reduce the sound generated by the water cooled packed unit.

C.3.6.5.3 Compressor

- Compressor shall be mounted with suitable vibration isolator, crankcase heater, refrigerant strainer, filter drier and shall be located in a sound attenuating compartment within the cabinet.

C.3.6.5.4 Condenser

- Water cooled condenser shall be brazed plate type with SUS 316 plate material.
- Threaded pipe connections shall be provide for water supply and return lines. Each unit shall contain full operation
- refrigerant R410A charge.

C.3.6.5.5 Evaporator Coil



- Evaporator coil shall be of non-ferrous construction with aluminium plate fins mechanically bonded to high performance cross hatched copper tubing.
- Coil shall be tested at 2760 kPag air pressure while submerged in water.

C.3.6.5.6 Evaporator Fan

- Evaporator fan shall be centrifugal forward curved and direct driven by a 3 Speed motor.
- Motor shall be factory supplied.

C.3.7 Air Cleaning Equipment

C.3.7.1 General

Provide all filtration equipment as specified and of the type indicated for each system on the Drawings or operate with at least the efficiencies specified in this Section.

Filters shall be complete with robust enclosure, holding frames and housing constructed of non corrosive metal, or of galvanized mild steel or rigid extruded aluminium.

The enclosure shall be constructed and assembled in such a manner that a rigid and durable enclosure for the filter pack is affected.

The periphery of the filter pack shall be continuously bonded to the inside of the enclosing frame thus eliminating the possibility of air bypass.

Holding frames shall be factory fabricated and shall be equipped with gaskets and a minimum of four heavy duty positive sealing fasteners. The gaskets shall be able to prevent air bypass between the filter and frame, between the adjacent frames and between the frames and housing. The fasteners shall be capable of being attached or removed without the use of tools.

The housing shall be factory fabricated and assembled. They shall incorporate access doors, extruded aluminium tracks and individual holding frames designed to accommodate standard size filter in efficiency and construction rating specified for the installation.

C.3.7.2 Standards

Filters shall conform, where applicable, to the following standards:

C.3.7.2.1 UL900-Standard for test performance of air filter units.

C.3.7.2.2 BS 6540 : Part 1- Methods of test for atmospheric dust spot efficiency and synthetic dust weight arrestance.

C.3.7.2.3 ASHRAE standard 52- 76- method of testing air cleaning devices used in general ventilation for removing particulate matter.

C.3.7.2.4 Local Fire Services Department approved type.

C.3.7.3 High Efficiency Type Panel Filters

The filter medium shall be glass, natural or synthetic fibre of fabric or of expanded aluminium foil. (Metal wool filters will not be accepted). Filters of this type shall have an average arrestance of less than 65% indicated when tested in accordance with BS6540 or ASHRAE 52 -76. Provide these in all air handling units.

C.3.7.4 Expanded Aluminium Foil Filter Panels

Panels constructed from multiple layers of expanded aluminium mesh with the layers being corrugated or plain and arranged alternately at right angles to one another. Filter media is to be supported on both sides with a rigid and thicker aluminium expanded metal mesh.

Filters shall be 25 mm minimum thick as indicated with a rolled or extruded aluminium frame. The frame section is to be ribbed for stiffness and its inner edges treated to prevent sharpness and increase strength. Corners shall be mitred and where secure riveted.

Folding handles shall be applied to the short side of all washable filter panels for ease of removal for cleaning.

The filters shall be washable type. The filter support frame provided shall be suitable for the installation of either type. Provide these on all fan coil units.

C.3.7.5 Filter Pressure Differential Measurement an indication

A filter-dirty indicator shall be provided for each filter banks of air handling units, fan coil units and fresh air fans. The indicator shall indicate whether the filter is clogged.

C.3.8 Variable Refrigerant Volume (VRV) Air Conditioning System

C.3.8.1 General

- C.3.8.1.1 The variable refrigerant volume (VRF) air-conditioning system shall be of multi-zone modular split type. Each zone shall consist of one air-cooled outdoor condensing unit with plural indoor units in one single refrigerant circuit. Each indoor unit shall be capable of independently serving and controlling the air conditioning load as required by the room space.
- C.3.8.1.2 The multi-split air conditioning system shall employ R-410A as refrigerant and shall be 'Inverter' type to allow variable refrigerant volume for energy saving capabilities.
- C.3.8.1.3 Compressor shall be equipped with inverter Controller, and capable of changing the rotating speed to follow variations in cooling load.
- C.3.8.1.4 The refrigerant piping shall be capable of extending up to 100m length with 40m level difference without any oil trap and with 30m level difference in the case where the outdoor unit is to be located below the level of the indoor unit. The total allowable refrigerant pipe length shall be up to a minimal of 80m.
- C.3.8.1.5 Outdoor unit shall be suitable for one type or even mix-match connection of different type of indoor units.
- C.3.8.1.6 The indoor unit shall be operational at least at two speeds.
- C.3.8.1.7 The indoor units shall have sufficient pressure to deliver the required amount of air into the air-conditioned spaces via delivery ducts, filters, coils and diffusers as specified.
- C.3.8.1.8 All necessary control circuits and associated wiring shall be provided and installed in concealed conduit system including fan selector switches, temperature sensors, controllers and respective metal enclosures as specified.
- C.3.8.1.9 Multi-split air conditioning system complete with all necessary accessories shall be supplied by a single proprietary manufacturer who has proven record for its products.
- C.3.8.1.10 Insulated drain pipes shall be connected from each indoor unit to the main drain system.

C.3.8.2 Centrifugal Fans

The shaft and impeller assembly of all fans shall be statically and dynamically balance to G2.5

of BS 5625 Part 1 (1979).

Fan bearings shall be of a type suitable for the installed altitude of the fan. They shall be grease/oil ball and/or roller type or alternatively oil lubricated sleeve type. All bearing housings shall be precision located and arranged so that bearings may be replaced without the need for realignment. Bearing housings shall be protected against the ingress of dust and, where fitted with greasing points, they shall be designed to prevent damage from over-greasing. For grease lubricated systems the bearings shall be provided with grease as recommended by the bearing manufacturer. For oil lubricated systems the housings shall be provided with an adequate reservoir of oil and shall include a filling plug and be oil tight and dust proof. Systems other than total loss types shall include an accessible drain plug. All bearing lubricators shall be located to facilitate maintenance.

Fans shall be installed using bolts, nuts and washers with all 'as cast' bearing surfaces for bolt heads and washers counterfaced. Holding-down bolts for fans and motors shall be provided with means to prevent the bolts turning when the nuts are tightened. Anti-vibration mountings shall be as specified elsewhere. Fans heavier than 50 kg shall be provided with eyebolts or other purpose made lifting facilities.

V-belt drives shall comply with BS 3790 and shall be capable of transmitting at least the rated wattage output of the motor with one belt removed; unless otherwise indicated not less than two belts per drive shall be used. Pulleys shall be exactly aligned. Motor pulleys shall be of adjustable type to enable operating speed to be varied within limits after installation. The Contractor shall ensure that any holding down bolts are grouted in and positioned to ensure correct alignment. Provision shall be made for positive adjustment of the tension in V-belt drives.

Centrifugal fans for high-velocity high-pressure systems as defined within HVCA Specification DW/144, shall be backward curved inclined type.

Unless otherwise indicated, centrifugal fans consuming more than 7.5 kW at the fan shaft shall be of the backward bladed type having a fan total efficiency not less than 75% and those up to 7.5 kW shall have a minimum efficiency of 65%.

Fan casings shall be constructed to permit withdrawal of the fan impeller after fan installation. Fans other than those in factory constructed air handling units (AHUs) shall, unless otherwise indicated, be provided with flanged outlet connections and spigoted inlet connections suitable for flexible joint connections except that for negative pressures greater than 500 Pa inlet connections shall be flanged.

Impellers shall be of true aerofoil and fabricated from galvanized mild steel of riveted or welded construction, with spiders or hubs of robust design, and shall be capable of running continuously at ten percent in excess of normal speed.

Impellers shall be keyed to a substantial mild steel shaft and the impeller complete with shaft shall be statically and dynamically balanced plus tested for satisfactory overspeed performance before leaving the maker's works.

Shaft bearings of belt driven single inlet fans shall be truly aligned and rigidly mounted on a pedestal common to both bearings. Fan bearings shall be ring oiling sleeve bearings, or ball or roller type. Where silence is important the bearing pedestal shall not be attached to the fan casing ring oiling type sleeve bearings shall be supplied.

Casings shall be of heavy gauge galvanized sheet steel construction adequately stiffened and braced and shall be entirely free from vibration or drumming during normal operation.

All surfaces of fan casings shall be galvanized after manufacture and all fans with an inlet eye diameter exceeding 300 mm shall have a bolted access door on the scroll for access purposes.

The fan and motor assembly shall be mounted on a rigid hot dipped galvanized mild steel channel base.

Automatic Controls

C.3.9.1 General

C.3.9.2 Control of Air Handling Units

Air handling unit for the supply of air to interior area shall be controlled by an electronic type PI controller. The controller shall regulate the two-way modulating control valve to achieve a constant supply air temperature. The supply temperature shall be monitored by a duct type temperature sensor.

C.3.9.3 Control of Fan Coil Units

Each fan coil unit shall be controlled by a two-way on/off control valve (Spring returned and normally closed). A duct type thermostat/temperature sensor shall be located at the return duct for temperature monitoring unless otherwise specified.

C.3.9.4 Remote Control Panels

All air handling units, fresh air fans and shall be operated via a dedicated remote control panel at the locations as indicated on the Drawings. This remote control panel shall allow the operator to switch on/off the equipment, adjust the temperature set points with temperature dials and indicate the status of running/stopped, motor fault, power on.

C.3.9.5 Equipment

Operation range of all duct type thermostats shall be fully proportioning with a temperature range of approximately 15° C to 30°C, and shall have adjustable throttling range, and adjustable set point. All temperature setpoint dials on the remote control panels shall also have similar range for adjustment. Thermostats which are employed for protection purposes shall be provided with manual reset mechanism to prevent cycling.

Temperature sensors shall be of resistance type with a high resistance change versus temperature change to ensure good resolution and accuracy. The sensing element shall be Resistance Temperature Detector (RTD) type of 500 ohm Balco, 100 or 3000 ohm platinum.

Differential pressure switches shall be of adjustable set point.

Valve actuators shall be electric motor driven type. They shall be proper size to provide smooth modulating control under design temperature and pressure conditions.

Positive positioning devices shall be furnished where specified or required. Positioners shall be furnished for all sequencing applications other than fan coil units.

All modulating straight through valves shall be single seat type with equal percentage characteristic. Valves 65mm and smaller shall be screwed type, valves 80mm and large shall be flanged. Valves shall be factory-rated to withstand the pressure encountered. Valves shall have stainless-steel stems and spring loaded teflon packing.

C.3.9.6 Allow for all necessary attendance, co-ordination, programming and management of the works carried out by the specialist supplier for system installation, start-up, testing, calibration, debugging, commissioning and hand-over of the DDC system.

C.3.9.7 The specialist supplier will provide all equipment, materials and engineering for the complete controls installation with the exception of pipe-fitting works required for the installation of valves, flow meters, temperature sensors, etc. which will be provided by the Contractor.

C.3.9.8 Select all automatic control equipment suitable for the scheduled duties.

C.3.9.9 The automatic control system shall be supplied and installed under this Contract.

The Contractor shall be responsible for the selection and provisions of all necessary control components, including control valves as necessary to achieve the desired level of temperature within the limits specified.



C.3.9.10 All equipment shall be constructed with materials suitable for the operating temperatures and pressures of these systems.

C.3.10 Noise and Vibration Isolation

C.3.10.1 General

All rotating or vibration emitting equipment shall be mounted on vibration eliminators so that a minimum of 90% of the vibrating sources are isolated from the supporting structure.

All vibration isolating equipment of similar type shall be supplied by one manufacturer. All isolator selections shall be subject to approval.

Rubber-in-Shear Isolators shall be properly housed and provided with adequate facilities for bolting.

Rubber shall be 35 durometer, with an area ratio of 0.54 and shall be selected to deflect by a maximum of 15% of its thickness.

Spring type vibration isolators shall preferably be constructed from suitable treated and finished steel or steel alloy.

Spring isolators shall be equipped with sound pads and levelling bolts and shall be free standing. The outside diameter of each spring shall be as follows, when floor mounted.

Load	Deflection			
	25mm	40mm	50mm	90mm
Up to 455 kg.	65	115	140	180
460 to 910 kg.	100	115	180	200
920 to 1360 kg.	140	180	200	200

Springs shall be designed to have equal spring constants in horizontal and vertical planes, to withstand solid compression without being overstressed and to operate at no greater than 65% solid deflection to the equipment when under load.

Control units shall be built into the spring isolators and flexible rubber pipe isolators where external forces could create damage or objectionable movement.

For all concrete inertia blocks, structural steel frames, equipped with reinforcing rods, mounting

templates, supporting lugs and steel spring isolators shall be provided.

C.3.10.2 Pipework Vibration Isolation

Flexible connections shall be fitted to all air handling unit connections.

The flexible connections shall be full line size of the equipment connection and fitted as close as practical to the source of vibration.

The flexible connection shall consist of a single convolution of reinforced rubber, wire reinforced cuffs at each end forming a raised face for sealing purposes. The cuffs shall be backed by removable steel flanges drilled to suit the mating pipework.

For water use the rubber type shall be EPDM, for other fluids a suitable rubber should be selected in accordance with manufacturers recommendation.

The rubber membrane shall have the date of manufacture moulded into the cover to ensure no units are used that have exceeded the recommended shelf life.

All rubber membranes shall have an indelible identification system as part of their design to clearly identify the model and hence suitability for the application and working conditions.



In general tied type flexible connections shall be fitted. The tie bars should incorporate large rubber isolating washers to prevent vibration transmission through the tie bar assembly.

For small bore sizes or for low pressures the manufacturers recommendations on whether tie bars should be fitted in these circumstances should be followed.

Unless otherwise indicated, all piping having connection to the air handling units shall be isolated from the building structure by means of noise and vibration isolation hangers for the first three pipe hangers from the air handling units.

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 piping, and maintain 10 to 15 mm clearance around the outside surfaces. This clearance space shall be tightly packed with kaowool and caulked airtight after installation of piping.

No rigid connections between equipment and building structure shall be made that degrade the noise and vibration isolation system herein specified.

C.3.10.3 Ductwork Vibration Isolation

All ducts between the AHU's and the duct flexible connectors shall have resilient mounts having the same static deflection as the AHU.

Hangers used for vibration control shall consist of a mild steel welded cage containing a helical spring, or neoprene/rubber/glass fibre isolator, (or both) and be suitable for suspension from drop rods.

The duct hanger cage shall be capable of carrying five times the maximum rated normal service load without permanent distortion. Arrangements shall allow 30 degrees movement without metal to metal contact.

Bends and bifurcations, 90 degree bends, shall either be of radiused type or fitted with equally spaced shortchord turning vanes.

Transitions are to be as gradual as possible within the physical limitations and it is preferred that one pair of sides remains parallel.

Where aspect ratios in main and branch rectangular duct runs exceed 3:1, stiffeners shall be employed.

Acoustically absorbent duct internal lining shall be polyester acoustic blanket such as DECIPOL P. NAP Acoustic or similar products. The product shall be 25mm thick 48kg/m³ density, rated to 30m/s surface velocity in prevention of air erosion. The lining shall be adhered to the casing using mechanical fasteners and approved adhesives.

C.3.10.4 Acoustic Treatment

The Noise Criteria level of the Office shall be NC 40 as measured at a level 1.5m above the floor level.

Select all equipment, provide equipment acoustic enclosures, attenuators, duct linings, acoustic treatment to ceilings, etc. as required to achieve this criteria.

The Contractor is responsible for providing acoustics products of the appropriate size and capacity to meet the dynamic insertion loss and self-noise requirements. The Contractor shall consult the schedule of silencers for the specified requirement. All certified test data on dynamic insertion loss, self-noise power levels and aerodynamic performance for reverse and forward flow test conditions shall be in accordance with ASTM E77 or equivalent.

Unless otherwise specified, all internal linings shall be covered with perforated galvanised steel sheet with 2.4mm diameter holes at 4.8mm staggered centers.

Sound attenuators shall consist of an outer casing, sound absorbing materials and internal baffles, splitters and supports. Casings shall be tested to 2 kPa and show no more than 2%



leakage or distortion in this condition. Seams shall be lock formed and mastic filled. End flanges shall be made from galvanised mild steel or rolled steel angle. Attenuators shall be fitted to ductwork using neoprene gaskets between bolted flanges.

Sound absorbing materials shall be fibreglass or mineral wool held in place with at least 5% compression to prevent voids due to settling. Absorbing material density shall be minimum 40 kg/m³ faced with minimum 0.5mm perforated galvanised steel sheets.

Materials within attenuators shall be inert, non-hygrosopic, incombustible, rot and vermin proof and must be capable of carrying passage velocities of at least 25m/sec without surface erosion or other forms of material migration. The infill shall be of a density sufficient to obtain the specified performance and packed under not less than 5% compression to eliminate voids due to settling. Splitters shall be faced with perforated galvanized steel sheet.

Where fan noise attenuators are located at a position not immediately adjacent to the noise source, ductwork between the fan and attenuator must be constructed from steel sheet of minimum thickness 1.2mm.

Where silencers are located outside of AHU rooms and above noise sensitive areas the duct, up to and including the silencer shall be externally insulated with 50mm thick rockwool, minimum density 60kg/m³ and lagged with a sound barrier material of adequate surface mass to resist the level of breakthrough envisaged. The wrapped duct shall be enclosed on all four sides by 12mm thick Medium Density Fibre (MDF) Board. 30mm minimum thickness fibre reinforced concrete (minimum density 2000kg/m³) shall be applied around the outside of the MDF board.

C.3.11 Electrical Installation

C.3.11.1 General

The Contractor shall supply, install, connect, test and commission the Main Low Voltage electrical system, MCCB board, Busbar, MCB board, motor control centre, motor starters, distribution cables, motors, wiring and accessories necessary for the satisfactory operation of the system as described hereinafter or as shown on the Drawings.

All general electrical devices shall comply with this specification in previous sections and clauses.

Painting, finishing and labelling of the entire installation shall be as specified elsewhere.

C.3.11.2 Motor Control Centres

Motor Control centres shall be of the wall mounted type as indicated and shall have switchgear and equipment in number, rating and arrangement as shown.

Motor Control Centres shall be supplied complete with copper busbars and earth links, and shall be installed in an approved manner, complete with all switchgear, fittings and accessories necessary for their proper functioning.

The motor control centres shall be provided complete with MCCB, isolators, contactors, starters and other electrical components necessary for the correct operation and protection of the installation as described in this Specification and shown on the Drawings.

C.3.11.3 Motor Starting Equipment

The type of motor starters shall be of the same manufacturer and rating as that of the motor or of the type and manufacture recommended by the motor manufacturer, in addition, the method of starting shall conform strictly to the requirements of the supply authority.

Direct-On-Line starters shall include the

following: Main isolator.

Main MCCB fuse, rated for the type of starting to be used.

Control circuit cartridge fuses.

Control circuit neutral link.

Heavy duty line contactor fitted with necessary auxiliary and spare contacts for monitoring and control.

Control circuit relays.

Single phasing protection and overload protection on all phases.

Motor sequencing controller, and all necessary auxiliary contacts to ensure the stability of the protective switchgear.

All necessary terminals of adequate rating and all necessary internal wiring. Provision for cable entries.

Star-Delta starters shall be provided with contactors, over-load protection, etc. as described for Direct-on-Line starters, arranged in a manner to ensure that the Star Contactor opens before the Delta Contactor closes. The period of running in Star shall be controlled by an adjustable automatic timing device. For motors exceeding 55kW, start-delta starters, if so used, shall be of the close-transition type.

The Contractor shall submit for approval full details of all motor starters before ordering the equipment, giving also time/current characteristics for each motor during the starting period.

C.3.11.4 L.V. Motors

The Contractor shall provide all motors required for driving fans, pumps etc. and for all items of equipment whatsoever provided under this Contract and requiring motor(s).

Motors in all cases shall be entirely suitable for the duty. A margin of not less than 10% shall be provided between the continuous rating of the motors (without overloading) and the maximum power absorbed by the item of equipment (as installed) under its most arduous characteristics of the driving machine.

All motors up to 30 kW shall have a full load efficiency of not less than 85% and power factor of not less than 0.85. Motors of rating greater than 30kW shall have full load efficiency of not less than 90% and power factor of not less than 0.85.

All motors shall be of the totally enclosed or totally enclosed fan cooled type (IP55). All motors shall be suitable for use in the temperature and atmospheric conditions that will exist in the plant rooms or roof top plant enclosures, it being assumed that the air temperature may rise to 43 C. All motors shall be continuously rated in accordance with BS 4999 or BS 5000 according to rating, and shall be insulated with Class B materials.

The Contractor shall also take note of the allowable fluctuations of the supply voltage, and ensure that all motors exhibit starting torque characteristics suitable to the load and type of starting.

Unless otherwise specified, Motors up to 2.2 kW shall be suitable for 220V single phase 50 Hz operations; motors above 2.2kW shall be 380/220V to 50 Hz.

Motors up to 3.5 kW shall be of the squirrel cage type suitable for D.O.L. starting. Starting current shall not exceed six (6) times full load current. Motors exceeding 3.5 kW shall be started in such a way that the starting current shall not exceed two (2) times full load current. Notwithstanding the details shown on the Drawings, motors exceeding 55kW shall be of a type approved in writing by the Supply Authority and shall have maximum starting current of two (2) times the full load current.

The make of motors shall be compatible with the equipment to be driven, and all motors shall be of a commercially silent type, having ball or roller bearings. Unless dictated by practical reasons, and approved by the Engineer, motor speeds shall not exceed 1500 rpm.

The Contractor shall provide isolating switches with padlocking facilities in the 'OFF' position

adjacent to all motors, irrespective of the position of the motor relative to the motor control panels.

All motors shall operate without vibration. The motors shall be mounted on a common bedplate with the machine being driven and the Contractor shall provide suitable anti-vibration mountings.

The Contractor shall provide holding down bolts required for the fixing of motors. The Contractor shall be responsible for the supply of all necessary concrete bases & cast-in bolts.

Motors above 5 kW shall be provided with an anti-condensation heater, and the control circuit shall be arranged such that the heater is off, when the starter is 'on' and vice versa. Heaters shall be wired from the motor control panel.

Drive types shall be generally as stated in the Specification for the relevant equipment or as indicated on the Drawings.

C.3.11.5 Variable Speed Drive Starters

- A. Where indicated on the Drawings, variable speed drive starter shall be provided specified hereafter.
- B. The starters shall include, but not be limited to, the following:
 - 1. Fused switchgear or MCCB as indicated on the Drawings.
 - 2. One set of variable speed drive (VSD) as specified below:
 - a. The variable speed drive (hereinafter referred to as VSD) shall be a solid-state converter to convert three phase mains supply of $380 \pm 10\%$ and $50\text{Hz} \pm 1\text{Hz}$ to an adjustable voltage and frequency output at its rated throughput power. VSD shall conform to BSEN 50081 or other similar recognized international standards on Electro-magnetic Compatibility (EMC) compliance for industrial or commercial applications and shall be manufactured to ISO 9001. Certificate of compliance shall be issued for each standard rating of VSD used in the Contract after being fully tested at the manufacturing facility.
 - b. The VSD shall be manufactured by a reputable manufacturer which has continuously manufactured VSDs for at least 5 years and the manufacturer shall have a local agent to provide full technical support with adequate spares holding and technical expertise in testing, commissioning and trouble-shooting. Training shall be provided by the manufacturer's representatives on operational and maintenance aspects including essential trouble-shooting techniques.
 - c. The VSD shall incorporate a 6-pulse full-wave uncontrolled diode bridge, fixed voltage fed DC link with inductors and capacitors to form a filter, a mains filter for EMC compliance. A pulse width modulation (PWM) inverter bridge utilizing insulated gate bipolar transistors (IGBTs) and output inductors in the motor lines. The inverter bridge shall be controlled by a microprocessor to produce a pulse width modulation (PWM) waveform or similar technique which would result in full motor voltage and sinusoidal current mains supply in the motor circuit. The VSD shall be equipped with build-in RS 485/232 serial communication ports.
 - d. The VSD shall be capable of continuously delivering rated output voltage even when the mains supply voltage is down to 6% of its nominal value and shall be able to control a standard BS 5000 3-phase squirrel cage induction motor over a speed range of 20% to 100% continuously and smoothly without de-rating the motor kW rating. The VSD shall provide total power factor of not less than 0.9 lagging, without external chokes or power factor correction capacitors, at all loads within the speed range. The inrush current shall be zero and during starting, the current shall start from zero and rises as the load accelerates with no danger of exceeding full load current.



- e. The VSD shall allow unlimited switching of the motor circuit, at any load and within the controlled speed range without damage and without the need of auxiliary control switching. The VSD shall be capable of automatically reconnecting to a spinning fan and run without tripping, following mains interruption and on transfer from backup source. The VSD shall be capable of running with no motor connected during functional testing. The VSD shall have voltage/frequency (V/f) ratio suitable for centrifugal pumps and fans control. Selectable V/f ratios shall be provided and it shall not be possible to set a constant V/f ratio, to prevent damage to connected equipment and to optimize energy usage.
- f. The complete VSD unit shall be housed in the MCC with front-access door. It shall be suitable for continuous operation without de-rating under ambient temperature of up to 40°C and relative humidity of up to 95% unless otherwise specified. The manufacturer shall arrange their equipment to be fully tested including motor loading at their manufacturing facility or by an approved testing authority to certify that their equipment conforms to the aforesaid standard. Certificate of compliance shall be issued for each standard rating of VSD used in the Contract after being fully tested at the manufacturing facility or by the testing authority.
- g. The VSD shall be fully rated to provide the performance as follows:-
 - i. minimum efficiency of 95% at 100% load and not less than 90% at any other operating loads;
 - ii. output torque shall be limited to 105% of full load torque;
 - iii. no facility for reversing the motor rotation shall be incorporated;
 - iv. the maximum allowable fifth harmonic current distortion expressed in percent of the fundamental input current at the VSD input terminals during operation within the variable speed range shall be less than 35%.
 - v. the electromagnetic compatibility shall be to BS EN50081 or similar international standards.
 - vi. the harmonic distortion shall comply with the Supply Rules issued by the power supply company.
- h. The following minimum features shall be incorporated in the VSD unit complete with and integral control panel:-
 - i. it shall accept digital and analogue 0-10 V, 4-20 mA control signals;
 - ii. integral measurement and selectable display of:
 - output current
 - output voltage
 - output frequency
 - output speed
 - output power
 - motor temperature
 - iii. display of warning/fault/alarm status;
 - iv. data can be transmitted on the RS 485/232 output for remote interrogating and reprogramming;



- v. it shall have programmable relay output (220V 2A) and programmable analogue output of 4-20mA or 0-10V DC suitable for the application.
 - vi. 5 programmable preset speeds (including at least 2 skip frequencies of adjustable bandwidth to overcome mechanical or air system resonance);
 - vii. selectable local or remote control;
 - viii. it shall have the following integral protection against;
 - loss of mains and motor phase
 - motor shortcircuit
 - motor circuit earth fault
 - motor overheat
 - overvoltage
 - VSD overheat
 - Under voltage
 - Input transients
 - VSD and motor overload
 - Mains input accidentally couples to motor output terminals
 - ix. it shall have an integral full 3-term PID control to provide closed loop control direct from a signal transmitter without need for external signal conditioning;
 - x. it shall have a facility for controlling motor anti- condensation heater for heater operation when the motor is idle.
- C. One set of appropriate type starter for manually changeover operation in case of VSD failure. The type of starter shall be direct-on-line or star-delta or reduced voltage and shall be selected according to the motor rating.
 - D. No-volt release device of automatic resetting type.
 - E. Local/off/remote control selector switch lockable in each position.
 - F. Set of start and stop pushbutton.
 - G. Set of indicating lamps for motor running, off and tripped on fault.
 - H. Set of dry contracts wired to terminals for remote indication of motor running, off, tripped on fault and summary alarm to the Central Control and Monitoring System (CCMS).
 - I. One set of terminals wired to provide for connection to the following:
 - J. Emergency stop pushbutton, effective in all positions of the local/remote switch, if any.
 - K. Lamp test button.
 - L. Any other items required to effect satisfactory motor starting and control as specified elsewhere in the Specification.

The quality of materials and workmanship of the electrical work for HVAC installation shall be in accordance with the 'Electrical Installation' section of the Specification.

C.3.11.7 Testing and Commissioning

The testing and commissioning procedures and standards of the electrical work for MVAC installation shall be in accordance with the 'Electrical Installation' section of the Specification.

C.4. LUMBING AND DRAINAGE INSTALLATION

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C.4.1 Potable Cold and Hot Water Supply System

All material used for cold and hot water system shall comply with the local Water Authority's requirements and suitable for drinking purpose.

C4.1.1 Pipes and Fittings

Copper pipe to BS / EN 1057 shall be used for the entire potable and hot water supply system. The copper pipes if laid under the ground shall be installed in such a manner that it does not come into contact with concrete, cement mortar, lime mortar or plaster and shall be protected against such contact by wrapping it with hessian or other suitable material and coating it with bitumen or where such pipe passes through a wall or suspended floor it may be protected against such contact by being carried through a sleeve or by some other suitable means.

Copper pipes for cold water: copper pipes to BS EN 1057 with plastic cover.

Copper pipes for hot water: half hard light gauge copper pipes to BS EN 1057 with corrugated plastic cover.

Fittings for copper pipes to be of copper or copper alloy type A, capillary fitting to BS EN 1254 Part 1 and working pressure not less than 16 bar.

C.4.1.2 Jointing Materials

The use of jointing materials based on red lead will not be permitted for fresh water pipework.

C.4.1.3 Valves and Accessories

Valves : Draw off taps and stop valves not exceeding 50mm dia. to be bronze to B.S. 1010PN-16.

Copper alloy swing type check valves to be to B.S. 5154-PN10.

Cast bronze gate valves to B.S. 5154-PN10.

Ball valves : Ball valves generally to be brass to B.S. 1212, Pt. 1 or 2, suitable for working pressure of 16 bar. Copper floats: to B.S. 1968:1953.

The expansion joint shall be precision moulded under high pressure to ensure joint integrity and shall be multi-layer corrugation type with a life of 2000 full cycles capable to handle at least 110°C fluid.

Flexible Joint: Stainless steel single bellow joint with flanged ends suitable for a working pressure of 16 bar.

Strainer: to be Y pattern bronze body with screwed connection up to 50mm and cast iron body flanged for 65mm and over, with removable stainless steel mesh baskets and of such design as to permit blowing out of accumulated dirt.

All valve selected shall be of the non-rising stem type.



C.4.1.4 Water heaters

Water heater shall be of the approved type by the Local Authority. The whole heater and electrical accessories shall be factory assembled and tested. Fully illustrated operating and maintenance instruction manual shall be included. The instantaneous type electric water heater shall be of 6kW rating and capable to withstand a working pressure of 10 bar. Soil and Waste Disposal System

C.4.2.1 Pipes and Fittings

UPVC pipes and fittings to BS 5255 (white color) shall be used for sizes 50mm dia. and below. It shall also be used for connection between the water closet and the cast iron soil pipe before passing through the floor slab.

Hot dip zinc coated steel pipe to BS 1387 heavy grade and fitting to BS143 and BS 1256, thread joint for pumped delivery pipe of sizes 32 to 50mm diameter, and 40mm diameter or below for waste pipe within pantry.

Epoxy Coated Cast iron pipe and fitting with socketless joint to B.S. EN877 : ISO 6594 with internal epoxy resin lining shall be used for pipe sizes 50mm dia. and above. It should be used whenever necessary to pass through the compartment wall/ floor slab.

Ductile iron pipe and fitting to B.S. EN598, class K12 flanged joint to B.S. 4504, PN16 shall be used for pump delivery pipe of sizes 80mm dia. and above.

C.4.3 Valves and Accessories

C.4.3.1 Draw off taps and stop valves shall be brass material, dezincification resistant (DZR) metal or UPVC conforming to BS 1010 PN-16 for sizes up to 50mm diameter.

C.4.3.2 Gate valves of size 50mm diameter and below shall be zinc free bronze conforming to BS 5154, PN10 and BS1400. Gate valves for sizes above 50mm diameter shall be high grade cast iron, flange joint, stainless steel 316 stem conforming to BS5150/5151/5163, PN16 and BS 1452 grade 220 minimum.

C.4.3.3 Swing type check valves of size 50mm diameter and below shall be zinc free bronze body and stainless steel 316 swing conform to BS 5154 PN-10 and BS 1400. High grade cast iron silent check valve exceeding 50mm diameter shall be flange joint, stainless steel 316 trim, conforming to BS5153, PN16 and BS 1452 grade 220 minimum.

C.4.3.4 Globe valve of size up to 50mm diameter and below shall be of zinc free bronze with screwed joints conforming to BS 5154 PN-10 and BS 1400. Globe valve exceeding 50mm diameter shall be high grade cast iron, flange joint, stainless steel 316 trim conforming to BS 5152, PN16 and BS 1452 grade 220 minimum.

C.4.3.5 Metal parts of valves to be zinc free bronze or other suitable material, to prevent corrosion.

C.4.3.6 Flexible joints shall be of reinforced arch-filled rubber bellow type with flanged ends suitable for a working pressure of 16 bars.

C.4.3.7 Minimum working pressure of all valves and accessories shall be rated for a working pressure of not less than 16 bars or 1.5 times the system pressure (whichever is greater).

C4.3.8 All valves selected shall be of the non-rising stem type.

C.4.4 Submersible Pumps

C.4.4.1 Submersible pumps shall be jacket cooled for pumping water from the pantry and alike.

C.4.4.2 Motor shall be integral with the pumps. Motor protection shall be IP68 with insulation to Class F.

C.4.4.3 The pump shall be light weight to enable easy operation.

C.4.5 Control Panels

C.4.5.1 Control panels shall be low voltage and shall have indicators/controls including, but not limited to, the following:-

- Indication of power healthy.
- Indication and audible signals for pump faults (each pump).
- Indication and audible signals for high level / low level of each water tank.
- Indication for pump running {each pump}.
- Indication of running current (each pump).
- Indication of voltage (each pump).
- Alarm reset button.
- Auto / manual selector switches.
- Lamp test button.
- On / off push buttons.

C.4.5.2 Internal components for control panels shall include, but not be limited to:-

- Ammeter, voltmeter, main switch
- Main Contactor
- Overload Protection
- Phase failure protection
- Undervoltage protection
- Terminals for termination of external wiring
- Provisions for cable entry
- Auxiliary contacts for sequence control

C.4.6 Pump Operation

C.4.6.1 Starters for pumps shall be arranged so that the standby pump shall be started automatically upon failure of the duty pump.

C.4.6.2 The status of the standby and duty pump shall be swapped after each duty cycle.

C.4.6.3 The pumps shall be arranged to have automatic sequential start.

C.4.6.4 Manual lead-lag switching shall be provided.

C.4.7 Electrical Installation

C.4.7.1 Material and Workmanship

The quality of materials and workmanship of the electrical work for Plumbing and Drainage installation shall be in accordance with the 'Electrical Installation' section of the Specification.

C4.7.2 Testing and Commissioning

The testing and commissioning procedures and standards of the electrical work for Plumbing and Drainage installation shall be in accordance with the 'Electrical Installation' section of the Specification.

C4.8 Sanitary Fixtures and Fittings

All sanitary fixtures and fittings inside pantry including fixing brackets, traps, cisterns, taps, wastes, flush pipes, etc. will be supplied and installed by the Contractor and shall be comply with all local requirements.

The Contractor shall submit the sanitary fixtures proposal together with the return Tender.

C.4.9 Workmanship

C.4.9.1 General Requirement

All plumbing and drainage work to be carried out by a contractor who must have a licence approved by the local authority.

C.4.9.2 Installation of Pipework

C.4.9.2.1 Generally

Manufacturer's recommendations on installation of pipework to be strictly followed.

Thermal Movement : make adequate provision to allow and control thermal movement in the length of pipes and gutters.

Expansion joints : Provide expansion joints wherever pipings traverse building expansion joints.

Sealing off : Prevent entry of foreign matter into any system by sealing off openings during construction. Fit access covers and cleaning eyes as the work proceeds.

Cutting : cut ends of pipes and gutters clean and square using equipment appropriate to the material.

Protection : wrap all pipes passing through walls or slabs with a layer of inert material.

Protection : sleeve pipes shall be at least the total thickness of walls or slabs through which pipes are passed and should exceed the thickness by 50mm.

C.4.9.2.2 Fixing

Fix pipes and fittings securely with bracketry and fastenings appropriate to the location and the material.

Pipes are to be installed with correct falls for venting and draining and attention must be paid to neatness of installation.

Suspended pipework must be positioned as close to slab soffits as possible, whilst maintaining required falls.

The Contractor should note the restricted space available in certain pipe ducts and care must be taken to ensure that all pipework is installed in the correct sequence manner and position such that maintenance and operation of all valves possible.

Pipes requiring protection against corrosion to be fixed with 30mm (minimum) clearance between pipe and structure. Avoid fixing such pipes in internal angles.

The fixing of valves or accessories to pipes shall be installed so that they can be disconnected and re-jointed easily.

Welding or soldering valves and accessories to pipes directly will not be accepted.

Spacing of pipe fixings and supports: according to the following table:

Pipes	Maximum Spacing (m)		
	Nominal Size (mm)	Vertical Pipes	Horizontal Pipes
Cast iron & Ductile Cast iron	All	3.00	1.75
Steel	Up to 25	3.00	2.50
	32	3.75	2.75
	40-50	4.50	3.00
	65-80		3.75
	100		4.00
	100-150		4.00
Copper	Up to 28	2.50	1.75
	35-42	3.50	2.50
	54	3.75	2.75
	76-108		3.00
UPVC	AS recommended by Manufacturer		

NOTE : in all cases not less than one fixing to be used per length of pipe

Hangers for pipe runs shall be of adjustable steel type, or other approved design hung on round steel rods. Brackets or clamps may be used where pipelines run along walls, columns or ceilings. Hangers shall be placed not more than 0.6m from each change of pipe direction.

Steel hanger rods minimum sizes or equivalent shall not be less than the following:

Rod Size (mm)	Pipe Diameter (mm)
12	Up to 100
19	100-200
22	200 - 250
25	250 - 350
28	over 350

Where electrolytic corrosion may occur, the steel supports, shall be fixed to the piping or tubing using an insulating material (e.g. neoprene) to avoid direct metal contact.

All pipes supports shall be of such design and type to allow the removal of any pipe section without the necessity of disconnecting adjacent pipes.

C.4.9.2.3 Jointing

Jointing material must not project into bore of pipes, fittings or appliances.

The contractor must be skilled in jointing the pipes and fittings specified. Protection : Pipes laid through holes or notches may not be subject to differential friction due to movement.

All joints to be airtight and watertight.

Contact of dissimilar materials : Avoid contact work between the following metal:

- Aluminium alloys and copper alloys, nickel, lead or stainless steel.
- Iron and steel and copper alloys.
- Zinc (including galvanize) and copper alloys or nickel.

However, if jointing of dissimilar materials is unavoidable, special flanged connections with insulating gaskets plus insulating sleeves for flange bolts must be provided.

Jointing cast iron pipe : Joint cast iron pipes with cold culking compound or molten lead of sufficient quantity.

Jointing steel pipes : Joint steel pipes with screwed sockets to B.S. 21 with jointing compound or pipe thread tape.

C.4.9.2.4 Pipes Through Slab, Wall etc.

All galvanized steel pipes that come into direct contact with concrete shall be wrapped with Hessian or other approved materials, painted with three coats Aulux coal tar epoxy F431-2076 (ICI) and such pipe work shall be tested and inspected by the Water Authority before concrete is poured.

Pipes through floors : Where pipes pass through concrete floors they must be wrapped with strips of bituminous felt before casting in.

Cast-in pipes through concrete balcony floors must be provided with sealed joints.

Pipes through walls : Where pipes pass through walls:

- Fit loose plastics pipe sleeves with 5mm (maximum) clearance.
- Sleeves to extend 25mm either side of face of wall finish.
- Where specified, provide loose plastic cover flanges to ends of sleeves visible in completed work. Flanges to be 25mm larger than external diameter of pipe, and screwed or plugged and screwed.

Pipes passing through external walls : For cast iron, galvanized steel or cement pipes passing through external walls, the pipe section shall be coated with cold applied bitumen while the aperture shall be sealed with hot applied rock asphalt. Where PVC pipes pass through external walls, the apertures shall be sealed with mastic compound

Pipes passing through compartment walls or slabs : The gap between pipe and its sleeve must be firmly sealed with soft packings giving a fire resistance period equal to the compartment wall or slabs. The ends of sleeves shall be caulked with non-hardening mastic to the Engineer's approval.

Pipes passing through flat roofs : Where pipes pass through flat roofs covered with asphalt.

- Pipe sleeves of cast iron, galvanized steel or 1.6mm galvanized sheet steel must be fitted.
- Sleeves to project 150mm above finished roof level or top of concrete surrounds.
- Sleeves must be covered with collars.

Where pipes pass through flat roofs covered with other than asphalt, similar pipe sleeves of plastic pipe may be fitted.

Internal pipes passing through outdoor slab or to ground floor where exposed to weather, drain or covered with soil shall be complete brass puddle flange section.

C.4.9.3 Sanitary Fixtures and Fittings and Equipment



C.4.9.3.1 Requirement

The Contractor shall examine, inspect and ensure the sanitary fixtures, fittings and faucets in good condition before installation.

The Contractor shall supply all red lead cement, mortar, lead plugs and other accessory materials, and install the sanitary fixtures, fittings and faucets, cut and pin or rawplug brackets, and make all connections to water supply services, overflows and wastes.

The Contractor shall also supply and install all drainage accessories to enable completion of a drainage installation as shown on the drainage diagrams and drawings.

C.4.9.3.2 General

Protection :

- ° Retain protective coverings, when practical, during and after fixing.
- ° Do not stand in or on any appliance.
- ° Do not use appliances for preparing or soaking materials or for washing tools.
- ° Replace any appliances which are chipped or scratched.

Fix appliances in accordance with manufacturer's recommendations. Use fastenings supplied by manufacturer wherever possible.

Corbelled Appliances : Rigidly support built in and cast in appliances until walls are complete.

Jointing : Seal joints between the appliances and adjacent surfaces with synthetic rubber based sealant in accordance with manufacturer's recommendations.

Install all accessories as recommended by the manufacturers and to the satisfaction of the Engineer / Project Manager.

Supply and installation of UPVC outlet connection for water closet outlet pipes shall be included.

Any materials, accessories or fixing fixture not listed in the sanitary fixture and fittings schedule shall be supplied in good time and installed within this contract.

Concrete supports to wash basin shall be supplied and installed within this contract, but waterproof finishes to floors shall be provided by the Contractor and priced in the Main Contract.

C.4.9.3.3 Connecting to Pipes

Taps : Fix in accordance with manufacturer's recommendations making watertight seals with the appliance. Place cold tap at on right hand side as viewed by user.

Waste : bed in waterproof, jointing compound and fix with lock washers between appliance and backnut.

Waste outlets to floor drains to be bedded in red lead cement.

C.4.9.3.5 Fixing Appliances

Outlets are to be bedded in red lead cement.

C.4.10 Painting and Labeling



C.4.10.1 Painting

General:

All pipes exposed to view shall be painted in primary colours with central band.

For pipes in false ceilings and ducts and all PVC pipes, three colours bands (two outer bands and one central band) shall be used to ensure ease of identification of pipes.

Colors bands shall be approximately 50mm wide and paint stencilled to pipe at intervals not exceeding 3m. Additional bands shall be provided adjacent to valves, crossovers and elsewhere where additional identification is required.

At reasonable intervals on straight pipes and adjacent to all valves, (including in valve pits) coloured arrows shall be stencilled to the pipework to indicate direction of flow.

C.4.10.2 Schedule of Colours

All pipes and plant etc. shall be painted or provided with colour band (3m or equivalent) with colours as described below or as directed by the Engineer:-

DESCRIPTION OF SERVICES	PRIMER COLOURS AND OUTER BANDS		CENTRAL BAND	
	COLOUR	NO.	COLOUR	NO.
Pipework:				
Mains supply-potable	Light French Blue	175	White	-
Drains and Vents	Black		Black	-
Equipment and Plant	Opaline Green	275	-	-

Note : Colour numbers quoted are to B.S. 381C: 1948 for ready mixed paints.

C.4.10.3 Painting Procedure (for metal pipes without coating)

All metallic surfaces shall be wire-brushed and cleaned from rust, scale, dirt and grease.

Prepare, prime with zinc chromate primer before fixing and paint three coats of synthetic paint.

Apply one coat of bituminous paint of approved quality before fixing and one coat after fixing on all cast iron pipes, holdfasts and other iron work enclosed in ducts.

Rainwater heads : to be painted both sides.

C.4.10.4 Labeling and Identification

All piping, plant and equipment provided under this contract is to be labelled in both English and Vietnamese to duty or services, all such labelling to correspond to schedules, diagrams, etc. to be provided as part of the Record Drawings. Labels generally to be of black Traffolite engraved with white lettering, (or as otherwise required by the Architect).

The following refers to specific items (but not by way of limitation) requiring labeling/identification.

- (a) Valves
- (b) Plant items, e.g. Pumps, Tanks



- (c) Distribution Boards/control panels
- (d) Starters
- (e) Isolators

For items (c), (d) & (e), circuit numbers, phase and control circuits shall be clearly labelled.

Valve labels

All valves handwheels throughout the installation shall be fitted with labels of black Traffolite, not less than 50mm dia x 1.5mm thick, with engraved numerals and/or lettering filled in with white composition.

Labels shall either be secured under the handwheel nut or fixed to the body of the valve by means of linked brass chain.

Identification Boards

Where exposed to view, all pipes shall be painted in the primary colours with colour bands approved by the Engineer/ Project Manager.

Where concealed in false ceilings, pipe ducts, etc., three bands one central band and two outer bands in primary colours - shall be painted on all pipe work. The width of each band shall be equal to the external diameter, including insulation where applied, but not less than 50mm.

Pipes of not less than 50mm all colour bands shall be spaced 3m apart.

Directional Arrows and Identification labels

Directional arrows shall be painted on all visible sizes of ducting on 3m centres and at equipment.

At all valves

On 3m centres for piping painted in one colour. Adjacent to the colour bands on piping which is colour banded.

Arrow size shall be aesthetically proportioned to the size of the pipe. Arrows shall be painted black on all piping where the background colour is other than black and white on black backgrounds.

For main distribution pipes, they shall be painted stencilled with letters to indicate the circuit or systems.

Where the finish is bituminous, colour band (3m or equivalent) shall be provided, as specified above.

C.4.11 Testing, Cleaning and Protection

C.4.11.1 Testing

Notify the Engineer / Project Manager before carrying out tests. Ample notice shall be given to all Local Authorities concerned.

All systems are to be tested in accordance with all the relevant rules and regulations at the contractor's expense.

Testing to be carried out as soon as practicable after completion. All concealed work to be tested and witness by all relevant parties and local authority before being finally enclosed.



Provide clean water and apparatus for testing as required.

Should a pipe section fail to meet the test pressure, the Contractor shall, without additional charge, replace the defective pipe and joints as may be required in order that the test pressure requirements can be satisfied.

Testing shall be repeated until the Architect and all concerned Local Authorities are fully satisfied.

C4.11.2 Cleaning and Protection

At the times, all pipes, sanitary fixtures, fittings accessories and plumbing equipment shall be properly protected from damage and shall be cleaned upon completion. All chromium plated surfaces shall be cleaned and polished. Any damaged equipment or fittings shall be immediately replaced at the Contractors expense.

C.4.12 Operation of Plant, Equipment etc.

The Contractor shall ensure that the installation or portion thereof which has been set to work complies with all requirements including the following:-

That the plant is of robust construction and of adequate capacity for the duty specified.

That all valves, switches, controls, etc. are regulated and capable of proper operation and all isolating valves are capable of tight shut-off.

That all apparatus operates smoothly and quietly in accordance with the requirements of this specification.

That all instruments are accurate and correctly calibrated.

Should the results show that the pumps etc. or any other items of equipment fail to perform to the efficiencies or other performance figures as specified, then the Contractor shall adjust, modify, rectify and if necessary replace the equipment without further payment until the required performance is obtained. Should it be necessary the Contractor shall be entirely responsible for cost of any damage or deterioration to the Building or contents or any other services consequent on such attendance.

C.4.13 Spare parts and tools

C.4.13.1 Spare parts

The Contractor shall provide the following spare parts before practical completion of the project:-

1. ϕ 20 cold water gate valve - 2 sets
2. ϕ 32 bottle trap - 2 sets

C.4.13.2 Tools

The Contractor shall submit a comprehensive schedule with unit prices of all necessary tools to enable any erection, dismantling or testing to be carried out in any part of the plant by the Engineer after the Works have been taken over, whether of an electrical, mechanical or any other nature. The Contractor shall undertake that the itemized prices shall remain valid for a period of 12 months from the date of submission.

The tools specified may be ordered in part or not at all. The tools shall not be used for the erection of the equipment being supplied and must be handed over to the Engineer in a completely new and unused condition.

C.4.14 Testing and Commissioning

C.4.14.1 Air Testing:

- a) Fully charge water seals of all sanitary appliances.
- b) Insert test plugs into open ends of pipework.
- c) Connect tee piece to installation by a flexible tube passed through a water



- d) seal, or by fitting to a test plug.
- d) Tee piece to have cock on each branch, one branch connected to manometer.
- e) Allow a period for temperature stabilization, after which pressure to be maintained without loss for not less than three minutes.

C.4.14.2 Water Testing

- a) Insert a test plug in the lower end of the pipe below the lowest sanitary appliance.
- b) Fill pipe with water up to flood level of lowest sanitary appliance.
- c) Static head should not exceed 6m.

C.4.14.3 Hydraulic Testing: (for water supply and pump delivery pipe)

- a) Slowly fill the installation with water, with the highest draw-off tap open to allow air to be expelled from the system.
- b) Pressurize the system to a test pressure of 1.5 times the maximum working pressure or 1000kPa whichever is greater.
- c) The pressure maintain for at least one hour.

On completion of the installation work (part or whole where appropriate) the Contractor shall commission the equipment supplied and put it into operation in accordance with the intent of the Specification.

The Contractor shall provide all labor, necessary facilities and instruments to carry out such tests as may be necessary to demonstrate that the installation meets with the requirements of the Specification as well as the requirements of the local authorities.

In addition, the Contractor shall liaise with the other trades to carry out all adjustments necessary for the safe, reliable and satisfactory operation of the interfacing works.

The Contractor shall submit the testing and commissioning procedure for the Architect's approval prior to exercise any test to be witnessed.

All testing and commissioning record shall be properly compiled and included in the O&M manual.

C.4.15 Training

C.4.15.1 Training

The Contractor shall provide during the Contract period training facilities and training course to ensure the Engineer's staff acquire full knowledge and appreciation of all aspects of the design day-to-day operation and routine maintenance requirement of the system.

