

SECTION 6: SPECIFICATIONS

PART 3: TECHNICAL SPECIFICATIONS - ELECTRICAL, ACMV & FIRE PROTECTION

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General Requirements

1. Where the following terms are used, the definitions given below shall apply:-

Contractor	shall mean the Main Contractor or Building Contractor
Sub-Contractor	shall mean the Sub-Contractor whose tender for this Contract is awarded following acceptance of their Tender.
Authority	Government or statutory bodies who have any jurisdiction with regard to the Works or to whose system
Works	All plant, equipment, material and labour to be provided and work to be done by the Sub-Contractor as required and shown, indicated and/or described in the Sub-Contract Documents including all utilities required for the work at the Sub-Contractor's expense.
Site	The area within which the Works are to be executed and any other area provided or designated by the Employer for the purpose of executing this Sub-Contract.
Contract	shall mean the documents forming the tender and acceptance thereof, together with the documents referred to therein including the Conditions of Sub-Contract, Standard and Supplementary Specifications, Drawings and Schedules of Rates.
Drawing	shall mean the Drawings referred to in the Schedule of Drawings and any modification of such drawings approved by the Architect and such other drawings as may from time to time be furnished or approved by the Architect.

General Requirements

2. DESCRIPTION

This Specification describes the standards, performance, materials, manufacture, supply, installation, testing, commissioning, operation and maintenance of all systems described in this document and as shown on the Sub-Contract Drawings.

The Sub-Contractor shall furnish all labour, superintendent, materials, tools, equipment, storage, permits, certificates, drawings, temporary work, inspection, testing and all accessories, auxiliaries and incidentals necessary to complete the Sub-Contract Works in a proper, safe thorough and skilful manner to the satisfaction of the Architect.

All details and requirements specified in this Section are to be read as being additional to the requirements of the relevant sections of the Main Contract Preliminaries and the Sub-Contract Preambles. In the case of any conflict/ contradiction between the requirements of this Specification and the Main Contract Preliminaries and Sub-Contract Preambles, the requirements of the Main Contract Preliminaries and Sub-Contract Preambles shall take precedence.

In the case of any conflict/contradiction between the requirements of this Specification and the Sub-Contract Drawings, the Sub-Contractor shall be obliged to comply with the decision of the Architect with NO financial adjustment to the Sub-Contract value.

3. SCOPE OF WORK

The Sub-Contract Works consist of the supply, delivery to site, installation, testing and commissioning of the complete works, all as fully described in the Specifications and as shown on the Sub-Contract Drawings of this Sub-Contract.

The Sub-Contractor shall carry out everything necessary for the proper execution of the Sub-Contract Works, whether or not shown on the Sub-Contract Drawings or described in the Specification, provided same may reasonably be inferred therefrom.

The Sub-Contract Works shall include all installation for hoisting of the equipment from ground level and supply and installation of all cables, cable trays, trunking, etc. necessary for the installation of the cables.

The specification and drawings fundamentally show the design intent and the performance specification to be met by the Sub-Contractor using makes and types of equipment and materials selected by him.

4. COORDINATION

Attendance and services for carrying out the works shall be provided by the Sub-Contractor to the extent indicated in the Preliminaries. The Sub-Contractor shall also co-ordinate with the Fire Alarm/BAS Sub-Contractor on alarm signals related to Fire Protection Services, including attendance at testing, etc.

Overall coordination of the works shall be carried out by the Main Contractor however it is the responsibility of the Sub-Contractor to ensure that the Contractor is afforded all necessary drawings, details and information in a timely manner to enable them to perform their coordination prior to the construction or installation of any items affected by the coordination process.

General Requirements

In particular, it is the responsibility of the Sub-Contractor to ensure that they are in possession of all information, directly related to their works or to other trades to enable them to design and set out their works in a manner which takes full account of the works being undertaken by the Contractor, Direct Contractors and other Sub-Contractors.

5. LIAISON WITH OTHER TRADES

It shall be necessary for the Sub-Contractor to work in close cooperation with other trades prior to and during the installation of this work and the work of others. In designing the work the Sub-Contractor shall take account of other trades and installations to avoid interference with the work of other trades either during the installation or in the operation of the Systems. The Sub-Contractor shall also be responsible for moving around his equipment as required so as not to be in the way of the construction or any other works.

6. SETTING OUT

The arrangement of the various equipment and associated services shall follow closely that set out on the Drawings except where modification is required to suit the specific materials and equipment to be provided, to fit in with the latest available information on the building construction details, to meet the requirements of other services and equipment or to incorporate improvements proposed by the Contractor, and such other modifications as directed by the Architect.

The Sub-Contractor shall be responsible for the setting out of the equipment and associated services to meet the requirements of the specification.

The setting out and design shall be in accordance with best engineering and trade practice and that of the various equipment and systems shall be such as to allow for proper operation and ease in servicing and maintenance of the installation. All controls and operating devices shall be readily accessible; and indicating and warning devices visible. Where unavoidable, access platforms shall be provided.

All services run (pipes, conduits, ducting, etc.) shall be fixed clear of each other and shall be arranged so far as is reasonably possible to afford easy access for maintenance and repair. No service run shall be installed or fixed behind other services run and shall be readily replaceable along its full length. Where difficulty is experienced in setting out to meet these requirements, the problems shall be brought to the Architect for his decision.

7. CLIMATIC CONDITIONS

All equipment and materials supplied and forming part of the works shall be capable of achieving the specified performance under, and be capable of withstanding the following conditions:

Maximum ambient air temperature -	35°C db
Minimum ambient air temperature -	21°C db
	(shade)
Maximum ambient wet bulb	- 30°C wb
Rainfall intensity	- 50mm in 15 minutes
Wind velocity and pressures	- Test results available for review at Project Architect office
Peak solar radiation	- 1,100 W/m ²
	(horizontal surface)

General Requirements

The Sub-Contractor shall take account of the close proximity of the site to the sea and the presence of salinity within the atmosphere in the design & choice of materials for the works.

8. TROPICALISATION, FUNGUS AND RUST PROOFING

All equipment shall be protected against the formation of fungus and rust from the time it is delivered to the time it is put into operation. Fungus & rust proofing shall be accomplished in a recognised & approved manner which could be by means of protective varnishes manufactured specially for the purpose & applied at the factory prior to the delivery, whichever method is adapted. The system will have total protective qualities. All equipment supplied shall be tropicalized & suitable for the most onerous condition to be encountered.

9. MATERIAL AND WORKMANSHIP

All materials and equipment supplied for this Sub-Contract shall be new and un-used. All such materials and equipment shall be of the best type for each particular purpose and of the best quality as regards design, manufacture and performance. All works shall be carried out in accordance with best engineering practice by fully competent tradesmen of appropriate grades.

10. WELDING AND CUTTING

All welding work undertaken as part of the works shall be carried out by welders who have, within six months of the performance of the welding work, undertaken a welding test and obtained a welding certificate from a testing agency acceptable to the Architect.

Where more than one welder is engaged in the works then each weld shall be capable of being identified as the work of an individual welder.

Under no circumstances shall the welding or flame cutting of galvanised steel be permitted.

No welding or flame cutting shall be undertaken without the prior authorization of the Sub-Contractor and unless satisfactory fire protection and safety measures are in force.

11. GALVANISING AND STAINLESS STEEL

Unless otherwise stated all references to galvanising shall be hot dipped galvanization in accordance with BS EN ISO 1461.

All references to stainless steel shall be 316 Grade Stainless Steel.

12. PROTECTION

The Sub-Contractor shall be responsible for the protection of all equipment and materials both in storage and installed on site. Damaged or deteriorated equipment and materials shall not be permitted to be used as part of the installation it being the responsibility of the Sub-Contractor to remove from site and replace such items at no additional cost to the owner.

General Requirements

The Sub-Contractor shall ensure that all necessary measures are taken to avoid damaging other construction and installation works during the course of their installation, testing commissioning or operation of the systems forming part of the works. The cost of repairing or replacing any damage caused to other works shall be the Sub-Contractor's responsibility.

13. STANDARDISATION

Materials, equipment and fittings shall be standardised as far as possible throughout the installation. In particular, every attempt shall be made to achieve standardisation in the following respects:

- All major units of equipment shall be supplied by a single manufacturer and other equipment shall be supplied by the smallest possible number of manufacturers.
- All electric motors shall be of the same make and have the maximum interchangeability of components.
- All items which are of a similar nature shall be obtained in each case from a single manufacturer or from the smallest possible number of manufacturers.
- All items for similar duties shall be the same make and model.

14. EQUIPMENT

Each item of equipment shall generally be a standard proprietary design manufactured in quantity by an established manufacturer of such equipment and shall incorporate all the features customarily accepted as being essential to equipment of its type and for the service intended where such features are not inconsistent with the provisions of this Specification.

15. ELECTRICAL

The Sub-Contractor shall provide electricity supply to all Mechanical equipment. All cables are to be terminated in isolators or control panel with control panel to be provided by others.

16. METRIC UNITS

The Sub-Contractor shall provide all information, manufacturer's data and materials in metric (S.I.) units and dimensions.

17. SHOP DRAWINGS

The Sub-Contractor shall, at times specified and well before the relevant work proceeds, prepare and submit for review, detailed, fully co-ordinated shop drawings based on the Sub-Contract Drawings, taking into account any modification either to the works or to the installation which may have taken place and correctly related to the details of the actual items of plant and equipment to be installed.

The required sets of shop drawings shall be submitted to the Architect and shall be constantly updated to reflect modifications and changes agreed/accepted by the Architect and to reflect design changes issued by Architect's instructions.

General Requirements

The Sub-Contractor shall similarly prepare all necessary schedules of equipment, etc., and also all necessary wiring diagrams for items of electrical equipment and diagrams showing the interconnections between different items.

To assist the Sub-Contractor in the preparation of his shop drawings, one set of Sub-Contract Drawings shall be provided after the award of the Sub-Contract. The Sub-Contractor shall be fully responsible for updating his shop drawings based on any changes to the Sub-Contract Drawings which may from time to time be required.

Shop drawings (i.e. installation drawings) for each system shall be provided as specified, on the same scales as for the as-built drawings.

Shop drawings shall be submitted within two months of the award of the Sub-Contract or less than twelve months prior to the commencement of the Sub-Contract Works on Site, whichever is the sooner.

In particular before beginning fabrication of the equipment, the submission of scaled shop drawings shall be required of all work and equipment showing the equipment working positions, the general arrangement of all plant and tank rooms, electrical equipment and electrical installations.

All shop drawing shall be submitted through the Main Contractors and shall contain the Sub-Contractor's endorsement thereon as required by the Main Contract Documents.

Shop drawings shall be prepared in the following metric scales:

Floor plans & section	1 : 50
Plantroom layout, sections & elevations	1 : 20
Details	1 : 20 or 1 : 1

The Sub-Contractor shall produce elevation drawings of all services recessed in walls and / or floors where these services are embedded within apartment unit walls. These drawings shall also include dimensions of these cable route and or pipe routes against prominent references / gridlines.

18. BUILDER'S WORK DRAWING

The Sub-Contractor shall review and subsequently distribute builder's work drawings and schedules showing details of builder's work required in connection with the installation of the Works.

In cases where preliminary builder's work information has already been given on the Sub-Contract Drawings, such information is to be checked by the Sub-Contractor and incorporated in his own builder's work drawings.

It is the intention that all holes chases, etc. shall be left in the structural building work as it proceeds and not cut out subsequently, except in so far as may be necessary due to subsequent authorised variations to the Sub-Contract Works.

The Sub-Contractor shall acquaint himself throughout the period of the Works, with the Sub-Contractor's detailed construction programme, and shall prepare the builder's work drawings in such order and at such times as to enable them to be reviewed and subsequently issued.

General Requirements

No claims will be entertained in respect of additional holes, chases, etc., required after the structure has been constructed unless these are necessary due to authorised variations to the Works.

19. "AS-NEW" CONDITION

At the time of handover of the Sub-Contract Works prior to the issue of the completion certificate, the whole installation shall be in "as-new" condition. The Sub-Contractor shall, in accordance with the Contractor's conditions during the course of the Contract, protect all plant and equipment, and shall restore/repaint as necessary before completion of the Contract.

20. AS-BUILT DRAWINGS

Before the Date of Completion of the Contract, the Sub-Contractor shall provide As-built drawings duly endorsed by their respective trade's Professional Engineers (to be engaged separately), as specified for all equipment and systems for the complete installation, incorporating all amendments made during the course of the Sub-Contract.

During the preparation of working drawings, the Sub-Contractor shall liaise closely with other Contractors and Sub-Contractors to ensure complete co-ordination of services installed by all parties.

As-built drawings shall be developed by competent draughtsmen throughout the installation programme and shall form a continuously updated record of the Sub-Contract Works installed.

The Sub-Contractor shall produce elevation drawings of all services recessed in walls where these services are embedded within apartment unit walls. These drawings shall also include dimensions of these cables / pipe routes against prominent references / gridlines.

Four (4) bound sets of all As-built drawings together with three (3) sets of computer softcopy in CD of each drawing in the latest AutoCad format, shall be submitted to the Architect prior to the date of issue of the Certificate of Completion.

As-fitted schematic system diagrams, properly framed, shall also be provided and mounted on the wall inside each plant room.

In addition, the Sub-Contractor shall obtain and provide the requisite number of sets of Manufacturer's Operation, Maintenance Manuals and detailed working drawings of all plant, equipment, pumps appliances, systems, refrigeration, motors, switch gears, internal wiring diagrams, etc., as may be appropriate and with suitable titles and reference numbers added on.

The exact scope and details of all Instructions and Record Drawings shall be agreed with the Architect. All operating Instructions and Record Drawings are subjected to the written confirmation of the Architect.

The Sub-Contractor shall note that retention monies will not be released after the satisfactory completion of the Period of maintenance until the "As-built Drawings" together with the operation and maintenance manuals have been submitted and approved by the Architect. The Sub-Contractor shall fully comply with all requirements of the Specification in this respect.

General Requirements

21. AS-BUILT DRAWINGS FOR AUTHORITIES' EXAMINATION AND CERTIFICATION

The Sub-Contractor shall prepare the required sets of As-Built Drawings and certify on these drawings that the drawings reflect the actual works installed. These drawings shall be submitted to the Authorities, through the Architect, for examination by the Authorities (BCA, FSSD, NEA, PUB) or by Registered Inspectors.

The Sub-Contractor shall ensure that the As-Built Drawings to be submitted for examination and certification by the Authorities shall conform in layout to the latest Architectural Plans.

The As-Built Drawings shall be submitted to the Architect for checking before submission.

The Sub-Contractor shall ensure that this submission of As-Built Drawings will not delay subsequent Authorities' inspections and tests, otherwise the Sub-Contractor shall be fully responsible for any consequence due to his delay. These drawings shall be submitted at least two months before scheduled Authorities/RI inspection.

22. SAMPLES

The Sub-Contractor shall on request or where specified elsewhere submit to the Architect through the Sub-Contractor, samples of materials and/or workmanship and such samples shall be reviewed and commented on in writing before the appropriate equipment or installation work is carried out.

Such samples are subsequently to be retained by the Architect as the criteria of the standard of the workmanship or material to be supplied and any items not so complying may forthwith be rejected by the Architect and shall be replaced by the Sub-Contractor without increase to the Sub-Contract Sum.

23. LOADING CALCULATION

The Sub-Contractor shall submit loading calculations including any and all loads imposed on the building structure. The calculations shall be prepared and certified by a Singapore Registered Professional Engineer.

24. SUBMISSIONS

All submissions by the Sub-Contractor shall be full and complete in all details and shall be checked and verified prior to his submission of the material to the Architect for review.

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

25. GUARANTEE

The Sub-Contractor in providing a specific piece of equipment or apparatus, whether specified herein by name or whether of a make selected by the Sub-Contractor, shall be deemed to warrant its satisfactory performance under all working conditions which may be encountered.

General Requirements

Unless otherwise stated in this Specification, the Sub-Contractor's guarantee for the Sub-Contract Works shall extend for the entire Maintenance Period from the Date of issuance of the Certificate of Completion of the Sub-Contract Works. The guarantee, in an agreed form, shall be vested in the name of the Employer.

In the event that any manufacturers' guarantees are still within their term of validity at the Date of Completion for the Works, then all such manufacturers' guarantees shall automatically be assigned to the Employer. All subsequent rights and liabilities under the manufacturers' guarantees shall be the Employer's.

In the event of anything described in the specification or shown in the Sub-Contract Drawings, being, in the Sub-Contractor's opinion, unsuitable or inconsistent with his guarantee or responsibilities, the Sub-Contract shall draw attention thereto at the time of tendering.

Neither the time limit imposed on the Sub- Contractor's guarantee, nor the final completion Certificate issued by the Architect, nor the acceptance of the installation by the Employer, nor the checking for compliance with the design intent of any material or method shall in any way absolve the Sub-Contractor from his responsibility for any latent defects in the Contract Works which may become apparent in the future and which are, in the opinion of the Architect, due to the Sub-Contractor's failure to use materials and methods which comply to this Specification and the Sub-Contract Drawings.

26. 1.26 OPERATION AND MAINTENANCE MANUALS

The Sub-Contractor shall, prepare the complete Maintenance and Operating Instructions which are to be printed in English for the installation. When these instructions have been agreed in detail with the Architect, the Sub-Contractor shall submit to the Architect, four (4) copies thereof suitably bound. The Operating Instructions must be handed over before the Date for Completion of the Contract.

The Sub-Contractor shall allow for operating all plant on behalf of the Employer up to the date of issuance of the Completion Certificate.

The Sub-Contractor shall have allowed in his tender for providing the services of a sufficient number of English speaking skilled men to cover each trade engaged on the building services installation for the purpose of instructing the Employer's staff, for 6 months after the issue of Completion Certificate.

Before Completion of the Works, about 2 months before commencement of the Maintenance Period, four sets of maintenance and operating manuals are to be provided by the Sub-Contractor, bound in suitable hard covers, properly labelled and identified; they shall contain the following (Properly ordered and indexed) in a form completed and to submit and approved by the Architect.

a) Index

Comprehensively list all elements and sub-elements of the subject matter.

b) Description of all systems and equipment

Shall comprehensively describe

General Requirements

- introduction and general description
- scope of work executed
- description of each system, including function and composition

c) Method of Operation of all system

Shall comprehensively describe

- the correct method of operating all manually controlled items of plant for all specified modes of operation, including start-up, shutdown and emergency procedures.
- the operation of all automatic control systems.

d) Method of Maintenance and Overhauling all Equipment

Shall comprehensively describe all procedures necessary to undertake the operational, cyclic and breakdown maintenance of all items of plant. Such instructions shall include exploded diagrams of the components of each plant items. Manufacturer's recommendation of frequency and method of overhauling shall be included.

e) Equipment Schedules

Shall comprehensively list details of all items of equipment installed and the equipment suppliers and/or agents, such details shall include the original purchase orders and/or invoices numbers of each item of plant, having a manufacturer's warranty period extending beyond the expiry of this Contract's Liability Period.

f) Manufacturer's Literature and Performance Data on all equipment

Original copies of all technical literature shall be supplied with performance data/curves (e.g. pressure against flow rates, etc. for pumps) and each shall have appropriate operating point indicated thereon.

g) List of Spares

Shall comprehensively list any spare parts to be provided under the Contract and any special tools to be provided, together with a description of their use.

h) Commissioning and Capacity Test Result

Shall include the following information, such information having been accepted by the Architect :

- commissioning and capacity test result
- factory test result
- air and water balancing results
- calculations verifying achievement of specified performance requirements

General Requirements

- Schedules of control set points and balancing settings.

Where capacity tests have not been undertaken at the time of Completion, provision shall be allowed in the manual to include these results after the tests have been carried out.

i) List of As-Built Drawings

Shall contain a full list of all “As-Built” Drawings.

27. DUTIES AND SIZES OF PLANT AND EQUIPMENT

The duties of plant and equipment described in the Sub-Contract are minimum duties and Sub-Contractor shall confirm them with the Architect taking into account any variations which may be made to the systems during the progress of the Sub-Contract Works.

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

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

Before ordering equipment, the Sub-Contractor shall provide the Architect with full details of the weights of equipment for purposes of determining floor loadings, etc.

28. MAINTENANCE PERIOD

The Sub-Contractor shall provide, without charge, labour and materials to properly maintain and operate all the Works included under the Sub-Contract for a period specified under the Main Contract after the issue of the Certificate of Completion of the Works as a whole. The Sub-Contractor shall provide competent technicians to take responsibility for maintaining the Works. Foremen, electricians, labourers shall be put at the disposal of the Principal for use during maintenance and repair.

Should the Employer feel that the staff on the site are too few to carry out specific works, then the Sub-Contractor shall despatch to site immediately the staff so instructed by the Employer.

Such work shall include, but not limited to the following, to satisfy this requirement of the Sub-Contract :-

- a) Repair or replace switchgear, fuse, cable, electronic components, etc. as necessary, including the provision of all equipment.
- b) Provide and replace all malfunction or burnt out panel lamps, and control gear assuming normal office hours in office area, all computer centre related areas to be working 24 hours a day every day of the year.
- c) Repair of water leak & malfunction of water services.

General Requirements

Inspect conditions of equipment operating in site on a daily basis, or as otherwise directed.

- d) Shutdown inspect, clean and test all services at least twice during the period, once at the end of six months and the second time, close to the end of the twelve months period. Any parts required to be replaced during these inspections, and during any other period of the Maintenance Period are to be met at the Sub-Contractor's expense.
- e) Prepare a daily log of all maintenance repairs, replacements, inspections carried out, including a status report of all equipment. The daily log shall be kept up-to-date and located in such a place that the Employer can inspect it at any time.
- f) The Sub-Contractor shall provide labour and materials to properly maintain and rectify all the works both within normal working hours and outside working hours included under this Sub-Contract for the Period commencing after the date of completion of the Whole of the Contract Works.
- g) Upon instruction by the Employer, whether face to face, or over telecommunication devices etc., in case of fire or when there are operation defects discovered in any of the systems, the Sub-Contractor shall provide qualified engineers and technicians on 24-hour-on-call basis to take responsibility for the maintenance/rectification and operation of the fire services installation works. This 24 hour on call service shall include weekends and Public Holidays.

The Sub-Contractor shall at time of tender provide information as may be required in respect of the proposed staffing levels and grades for the maintenance work.

Up to and including the date of Completion the Sub-Contractor shall be responsible for both maintaining and operating the building services installation.

During the maintenance period the Sub-Contractor shall provide as a minimum the staff levels and equipment and materials including consumable necessary to maintain, operate, repair and overhaul the plant on a routine basis. The materials provided shall be in addition to the spares provided as specified elsewhere within this document.

During the maintenance Period provide a call out service which shall:

- a) Be available and able to be contacted by telephone 24 hours per day, 7 days a week; and
- b) Attend to call out service within 2 hours
- c) immediately investigate on site the cause of equipment failures, breakdowns, an alarm, false alarm or fault from the installation when informed of such an occurrence; notify the Employer in writing on the circumstances surrounding each call out on the first working day after the call out.

At the end of the Maintenance Period, carry out tests as per Acceptance Tests.

General Requirements

29. STATUTORY OBLIGATIONS AND OTHER REGULATIONS

The Sub-Contract Works shall fully comply with all statutory obligations and regulations together with any amendments made thereof as required by the following bodies:

- Fire Safety & Shelter Department (FSSD)
- Public Utilities Board (PUB)
- National Environment Agency (NEA)
- Building and Construction Authority (BCA)
- Ministry of Manpower (MOM)
- Land Transport Authority (LTA)
- Infocomm Development Authority of Singapore (IDA)
- Energy Market Authority (EMA)
- SP Services Ltd (SPSL)
- SP PowerGrid Ltd (SPPG)
- City Gas Pte Ltd (CITYGAS)
- National Parks Board (NParks)
- SPRING Singapore (SPRING)
- Any other authority having jurisdiction over any part of the Sub-Contract Works.

The Sub-Contractor shall arrange for all submissions and pay the cost of statutory inspections and certificates.

The M&E Services Installations shall comply with the following statutory obligations and regulations:

- Fire Safety Act and subsidiary legislation made under the Act.
- Electricity Act and subsidiary legislation made under the Act.
- Building Control Act and subsidiary legislation made under the Act.
- Energy Conservation Act and subsidiary legislation made under the Act.
- Public Utilities Act and subsidiary legislation made under the Act.
- Sewerage and Drainage Act and subsidiary legislation made under the Act.
- Gas Act and subsidiary legislation made under the Act.
- Environmental Protection and Management Act and subsidiary legislation made under the Act.
- Environmental Public Health Act and subsidiary legislation made under the Act.
- Environmental Pollution Control Act and subsidiary legislation made under the Act.
- Telecommunication Act and subsidiary legislation made under the Act.
- Workplace Safety and Health Act and subsidiary legislation made under the Act.

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All equipment and installations shall comply with the latest Acts, Regulations, Codes and requirements of relevant Authorities currently in force. British / IEC Standards shall also be adopted if the local standards do not exist. In case of conflict between the supply authority and the specification requirements, the supply authority shall apply.

30. REJECTION OF UNSUITABLE MATERIALS

The Architect shall be at liberty to 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 Sub-Contract Sum.

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

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

31. CONTRACTOR'S PROGRAMME

The Sub-Contractor shall conform to the construction programme and shall include everything necessary to complete the Works in a sequential and acceptable manner.

32. SILENCE OF OPERATION

The Sub-Contract works as installed shall be reasonably silent in operation having regard to the conditions under and locations in which they will be called upon to operate.

The Sub-Contract shall take all necessary steps to ensure that the equipment supplied by him is silent as specified and shall include for such sound absorbing, or anti-vibration, material or devices as are necessary to ensure a satisfactory degree of silence and absence of vibration in the structure of the Works.

The Architect's decision as to what constitutes satisfaction in this respect shall be final.

If on completion the system is not, in the Architect's opinion, sufficiently silent, the Sub-Contractor shall, without additional charge, carry out such modifications or additions as may be required, until the system is made silent to the Architect's satisfaction.

33. LIMITED ACCESS

The Sub-Contractor shall note the limited access available on site for storage of materials and installation work and of the need to arrange suitable off-site storage, if required and at the Sub-Contractor's expense.

All materials and equipment are to be installed in the correct sequence to ensure that all services may be accommodated. Where works by other trades are to occupy the same pipe, duct or plant space the Sub-Contractor shall take care to leave clear access for sequential on future provision of these services within shafts, plant rooms and voids.

General Requirements

34. INSPECTION OF CONDITIONS

The Sub-Contractor shall examine related work and surfaces before starting their work and report to the Architect, in writing, conditions which prevent the proper execution of their work.

Starting the work of this Sub-Contract without reporting unsuitable conditions to the Sub-Contractor and the Architect constitutes acceptance of conditions by the Sub-Contractor.

Any required removal, repair or replacement of defective work caused by existing conditions and not reported shall be done at no additional cost to the employer.

35. VERMIN PROOFING AND CLEANING

On completion of the Sub-Contract Works, the Sub-Contractor shall check and ensure that all cable entries, pipe entries, openings, coreholes, etc. are properly sealed with fire rated material and rendered vermin proof and water tight. The floors, trenches and surroundings shall be cleaned, mopped, and left in a clean, dust-free state on completion. Building works and paint work of equipment damaged during the installation works shall be made good to the satisfaction of the Architect.

All costs involved in the above shall be deemed to be included in the Sub-Contract.

36. POWER SYSTEM HARMONICS

For the purpose of this provision, "PCC" means the point of common coupling being the terminals of the mechanical equipment power interfacing units at the point where they connect to the electrical distribution system. The installation is designed with the intent of complying with current international and European Community electrical immunity and emission standards. In order to continue an interference free service to others' installation, the Sub-Contract must comply with each of the following:

- 1) The sub-contractor shall provide adequate measures including active harmonic filters to limit the total harmonic distortion at the PCC to 5% for voltage and less than 12% for current for all phases, in accordance with the requirements of the Institution of Electrical and Electronic Engineers Standard IEEE 519. The Sub-Contractor shall take particular care in the selection of equipment that may produce harmonics including without limitation electronic ballasts, UPS, soft-starters and variable speed drives, to ensure that these limits are met at all times. Upon completion of the project, the sub-contractor shall be required to submit a full-load test of the total harmonic distortion level of the system in compliance of the requirements and duly endorsed by his Licensed Electrical Engineer.
- 2) The Sub-Contractor shall ensure that the power factor at the PCC is equal to or better than 0.85 lagging.
- 3) The Sub-Contractor shall complete the installation to meet all current international and European Community emission standards for electrical interference for light commercial buildings, including without limitation EN50082, IEC1547, CISPR11, CISPR15, CISPR16, EN55015, EN55011, EN50081, EN60555, EN61000, IEC801, IEC1000 and EN61800.

General Requirements

37. ELECTROMAGNETIC COMPATIBILITY (EMC)

The Sub-contractor shall be responsible for ensuring that all equipment supplied conforms with the requirements of relevant international standards in terms of their electromagnetic compatibility with the environment and with all equipment to be installed in the Project. All equipment used shall comply with the prevailing generic EMC requirements and EMC requirements applicable to general, scientific and industrial equipment specified but not limited to the following standards, or their equivalents:

IEC	–	International Electrotechnical Commission
CISPR	–	International Special Committee on Radio Interference Document
EN	–	European Norm
BSI	–	British Standards Institution
VDE	–	Verband Deutscher Elektrotechniker

All signal and control cabling installed shall be correctly screened and earth to prevent noise and electric shock. Operation of all equipment shall not be adversely affected by radiated energy from hand held communication equipment.

All equipment that is likely to be touched by personnel and contains sensitive electronic equipment shall be protected against electrostatic discharge.

The Sub-contractor shall ensure that any static or alternating magnetic fields, generated in the environment, do not adversely affect the operation of the equipment.

Bonding shall be provided for all exposed metallic parts of the equipment and connecting them to the earthing network for meeting safety requirements and minimize noise voltage due to potential differences.

Equipment shall be designed so as to minimize radio interference in the frequency range 0.15 MHz to 30 MHz by means of suppression at source.

All equipment supplies, prefabricated and installed shall be designed, manufactured and installed to fully comply with the European Electromagnetic Compatibility Directive 2004/108/EC, Low Voltage Directive 2006/95/EC and Machinery Directive 2006/42/EC.

All equipment supplied to the site shall be either electromagnetically benign or carry the “CE” mark and be provided with copies of the relevant test certificates.

The Sub-Contractor shall ensure that the entire installation shall not be a source of radio interference and whenever necessary suppression devices shall be installed.

38. MOTOR CONTROL PANEL AT EXPOSED LOCATIONS

For all motor control panels outside plant rooms and at exposed locations such as carpark, services area, public space, etc. shall be provided with a lockable front door with viewing glass panel.

General Requirements

39. INTERFACING WITH THE OTHER SERVICES AND SYSTEMS

39.1. General

The Sub-contractor shall provide all necessary provisions for interfacing with other trades, services, and equipment not under this Sub-contract. All necessary sensors, current/voltage transformers, voltage-free contacts, relays, auxiliary contacts, terminals, transducers, etc. for interfacing with other works shall be provided by the Sub-contractor.

All control/monitoring wiring from sensors, equipment, and components for the interfacing shall be terminated at a separate interfacing compartment located at the respective equipment/system's switchboard or control panel provided under the Sub-contract. The interfacing compartment shall be completed with all necessary connectors, terminals, and with proper identifications to allow interfacing works to be easily carried out. The compartment shall clearly indicate "Extra Low Voltage Cable Only. No Power Cable Connection". Where there is no equipment/system switchboard or control panel involved, the Sub-contractor shall provide separate interfacing panels with provisions same as the interfacing compartment as described above. The locations of the switchboard/control panels and the interfacing panels shall be co-ordinated with the Main Contractor and other sub-contractors.

For every control panel and each module of the switchboard, at least five (5) spare terminals shall be provided for future interfacing works.

Wiring and cables for interfacing with the Fire Alarm System and other fire protection and life safety systems shall be fire rated to comply with Fire Authority's requirements. Unless otherwise specified or shown on the Drawings, interfacing wiring from Fire Alarm and Building Management systems shall be provided and terminated at the terminals of the interfacing compartments or panels by the Fire Alarm System and Building Management System sub-contractor respectively. The Sub-contractor shall co-ordinate with the Fire Alarm System and Building Management System sub-contractor on the current and voltage requirements for the interfacing works/provisions. The type of provisions for interfacing signals shall be as follows, unless otherwise specified:

- Digital inputs and outputs : voltage-free dry contact
- Analog inputs and outputs : 4 – 20 mA or 0 – 10 mV

All the interface provisions shall be DC operated and rated not more than 50 mA.

For interfacing works between Fire Alarm System and Building Management System, the Fire alarm System sub-contractor shall provide interface wiring and terminate them at the Building Management System's interfacing compartments or panels.

The Sub-contractor shall provide and make all power cable connections from their equipment, local control panels, and switchboards to the electrical isolators or power points (including cable termination) provided by the Electrical sub-contractor. Location of power supply isolators and power points shall be co-ordinated and agreed between the Sub-contractor and the Electrical sub-contractor.

In addition to the interfacing requirements shown on the Drawings, interfacing provisions as described below shall also be made by each respective sub-contractor.

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39.2. Electrical Sub-Contractor

The Electrical sub-contractor shall provide the following for other trades and all other equipment as specified in the Tender Documents:

- 1) Isolators and power points (fused spur units) for equipment and systems of other sub-contractors as shown on the Drawings. The other sub-contractors shall be responsible for connection and extending the power supply to their equipment and control panels. Where shown on the Drawings, the Electrical sub-contractor shall make direct power cable connections to the mechanical system's main motor control centres.
- 2) Earthing terminal in the Fire Command Centre and all other plantrooms for supplementary equipotential bonding of other equipment and systems.
- 3) Power failure signal to the Lift System (including wiring terminations into the Lift interfacing panel in the Lift Motor Room), Fire Alarm System and the Building Management System.
- 4) Electrical bonding of all roof equipment and external metal cladding including provisions and connection of bonding cables.
- 5) Fuel main storage tank and day tank High/Low level alarm signals to the Building Management System.
- 6) Emergency power supplies to Building Management System (including all field panels), Fire Alarm System, carparking system, and all security systems.
- 7) Emergency power supplies to all fire shutters, smoke shutters/curtains, and automatic doors.
- 8) Power points in each toilet for the plumbing trade (for connection to automatic sanitary sensors and flush valve by the Plumbing and Sanitary Sub-contractor).

Power supply to variable air volume (VAV) boxes and the ACMV system's control components/sensors shall however be provided by the ACMV Sub-contractor from the corresponding equipment motor control panel.

39.3. ACMV Sub-contractor

The ACMV sub-contractor shall provide the following for the other trades:

- 1) Smoke signal from the air-handling unit return air smoke detector to the Fire Alarm System.
- 2) On/Off control and status indications at the Fire Command Centre's Ventilation Panel (to be provided by the ACMV sub-contractor) including switches and indication lights for the following equipment and systems:
 - Entire smoke extraction system including individual fans (and associated motorized dampers), smoke shutters/curtains, smoke damper, etc.

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- Staircase pressurization fans
 - Smoke Lobby ventilation fans
 - Basement carpark ventilation fans
 - All automatic fire/smoke dampers
 - Other emergency fans for fire and life safety operations
- 3) High level interface between the chiller control panels and the Building Management system.
 - 4) Shut down control of air-handling units by the Fire Alarm System on floor-by-floor basis.
 - 5) High/Low level signals to the Building Management System for all water tanks including feed and expansion tanks.

39.4. Plumbing and Sanitary Sub-contractor

The Plumbing and Sanitary sub-contractor shall provide the following for other trades:

- 1) Water supply connections to water tanks under other sub-contracts including isolation valve.
- 2) Drainage facilities for pressure relief/parity valves and condensate drain from air-handling units and fan coil units. Insulation of drainage pipe receiving condensate drain shall also be provided by the Plumbing and Sanitary sub-contractor.
- 3) Gas leakage signals to the Fire Alarm System, Building Management System, and the kitchen ventilation fan's motor control panel (including wiring and termination into the fan motor control panel).
- 4) High / Low level alarm signals to the Building Management System for all water tanks.

39.5. Fire Alarm System Sub-contractor

The Fire Alarm System Sub-contractor shall provide the following for the other trades:

- 1) All control and monitoring modules for interfacing with all other trades.
- 2) Control signals and modules for all fire shutters, smoke shutters/curtains, automatic doors and all emergency ventilation systems.
- 3) High level interface with the Building Management System
- 4) Signal to the Lift Motor Room for lift homing operation.
- 5) Signal to all electronic security systems.
- 6) Signal to shut down air-handling units on floor-by-floor basis and all gas supply systems.

General Requirements

39.6. Building Management System (BMS) Sub-contractor

The BMS sub-contractor shall provide the following for the other trades:

- 1) All control and monitoring modules for interfacing with other trades (with the exception of those for interfacing with the Fire Alarm System).
- 2) High level interface with the Fire Alarm System and the chiller control panels.

40. STRUCTURAL EXPANSION JOINTS AND SETTLEMENT JOINTS

The Sub-Contractor shall make adequate provisions of flexible joints/connectors and/or expansion loops where services pass through structural expansion joints. The locations of these expansion joints are shown on the architectural/structural drawings. The provisions of flexible joints/connections shall take into account the movement allowance. Detailed calculations shall be submitted by the Sub-Contractor to justify the selection of these flexible joints/connectors.

For settlement joints shown on the structural drawings or required by the Main Contractor for the construction of structural works, the Sub-Contractor shall co-ordinate with the Main Contractor such that any installation which passes through settlement joints shall be executed after the respective settlement joints are cast and the expected structural differential settlement has significantly taken place.

The Sub-Contractor shall co-ordinate with the Main Contractor to ensure that all services installed under metal roof and skylight shall have adequate provisions to take into account the movement and deflection of the roof structure and the cladding.

41. TESTING AND COMMISSIONING

All plant, materials and systems shall be tested, and commissioned as specified in the "Commissioning and Testing" Section of this specification.

All testing, and commissioning procedures and documentation shall be reviewed by the Architect prior to commencement. One set of all documents shall be provided for record purposes within each copy of the operating and maintenance manuals.

Prior to commencing the testing and commissioning of the works the Sub-Contractor shall submit to the Architect for review five (5) sets of a report containing documentation and procedures forming part of the testing and commissioning

On completion seven sets of the record documents shall be submitted to the Architect, through the Sub-Contractor for review. Once agreed to by the Architect one set of record documents shall be incorporated into each set of Operating and Maintenance Manuals.

42. SUPERVISION

An EMA Licensed Electrical Worker (LEW) of the appropriate grade shall be employed by the Sub-Contractor to supervise the entire electrical installation works to ensure compliance with SS CP 5 – Code of Practice for Electrical Installations and the relevant Electricity Regulations.

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A PUB Licensed Plumber shall be employed by the Sub-Contractor to supervise and submit plans/obtain approvals for the water supply works consociated with the water supply installation.

An EMA Licensed Gas Service Worker (LGSW) shall be employed by the Sub-Contractor to supervise, submit plans and obtain approval for the gas pipe installation works.

43. ATTENDANCE DURING AUTHORITIES INSPECTIONS

The Sub-Contractor is required to attend to all inspections carried out by Registered Inspectors and Authorities for the purpose of applications of Temporary Fire Permit (TFP), Temporary Occupation Permit (TOP), Fire Safety Certificate (FSC) and Certificate of Statutory Completion (CSC).

The Sub-Contractor is to provide manpower and equipment, tools and instruments for testing and inspections by the above departments.

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1. STANDARDS

All equipment, materials and workmanship shall comply with the appropriate Singapore Codes of Practices, British Standards or an acceptable equivalent international standard.

All equipment, materials and workmanship shall comply with the local authority requirements.

2. L.V. SWITCHBOARD CONSTRUCTION

The main normal and emergency L.V. switchboard shall be ASTA / KEMA type-tested assemblies complete with ASTA / KEMA type-test certificates complying with IEC 61439-2 with minimum Form 3 construction, unless otherwise specified. The switchboards shall be of the metal-clad floor standing type and shall be built up from enclosed units housing the circuit breakers, contactors, fuse switches, relays and other items of equipment shown in the Sub-Contract Drawings.

The L.V. switchboards shall be suitable for indoor service on a 400V/230V 3-phase 4-wire 50Hz system with solidly earthed neutral and capable as a whole of withstanding the prospective electrical and mechanical stresses produced by fault conditions equivalent to 50 kA at 415V for three seconds, or otherwise specified.

Surge arresters shall be incorporated to each main incoming feeder of the main switchboard. All switchboards and associated equipment (switchgear, busbar assemblies, etc.) shall be certified for the category of duty specified.

The sheet metal for the build-up of the various items shall be specially selected, deadflat mild steel not less than 2mm thick. The panel shall be built up on substantial framing with all necessary stiffeners and supports. The entire panel shall be vermin proof.

Front access doors shall be provided and for floor standing cubicles, back of the panels shall be removable. Removable gland plates shall be provided at the top and at the bottom of the switchboard with knockouts or blanked off openings for incoming and outgoing circuit cables. Wherever applicable, non-ferrous entry plates shall be provided for the MICS cables.

The insulation level of the switchboards shall be minimum 660V.

All doors shall be removable with concealed hinges and earthing leads. All doors shall be provided with dust-excluding gasket of neoprene or other equal and acceptable material.

Labels shall be made of "TRAFFOLITE" laminated white/black/white pattern with suitably engraved black lettering for non-essential power supply and red "TRAFFOLITE" laminated red/white/red pattern with white lettering for essential and vital circuits.

Labels shall be securely fixed with a minimum of two cadmium 6BA screws which shall be inserted into tapped holes in the equipment and secured by locking nuts at the rear. Exact details of lettering and legends shall be agreed with the Contractor prior to manufacture.

All paint finishes shall be of high quality epoxy powder coating. A minimum of two undercoats shall be applied and each built-up and flattened separately. The final coat shall be agreed light colour gloss finish and sufficient body shall be given to the paint films so that the final appearance of the finished units is entirely free from blemishes,

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undulations, foreign inclusions, scratches, patterning or any defects whatsoever. All coats of paint shall be oven-baked and dried.

Ventilating louvers where required shall be provided on the sides and backs of panels and shall be of approved design. All louvers shall be screened.

All panels and cubicles shall be fitted with internal sheet metal dividers to separate low voltage instruments and components.

All terminals shall be shrouded, and those terminals which remain live with switchboard isolated shall be adequately labelled with cautionary signs. All circuits shall be provided with removable links/fuses to facilitate isolation, checking and maintenance.

3. AIR CIRCUIT BREAKERS (ACB)

ACB shall be triple or four poles as shown on the Sub-Contract Drawings. The ACB shall be rated at 415V to carry the full load current continuously and type-tested to 50 kA short-circuit breaking capacity for 3 seconds, unless otherwise specified.

The circuit breakers shall be of the air break horizontal withdrawable pattern and comply with IEC 60947-2. Insulating materials shall be suitable for the ambient conditions specified and for the board design but shall in any case be rated for not less than Class B temperature rise.

The design shall be such that the main contact pressure increases with heavy through-fault currents. Auxiliary arcing contacts shall be provided to protect the main contacts from burning during the switching operations. All contact parts shall be readily replaceable.

A mechanically operated visual ON/OFF/ISOLATED indicating device shall be provided to indicate the circuit breaker position. A local push button shall be provided for manual tripping.

Circuit breakers shall be provided with independent manual operation with spring-assisting closing mechanism.

With hand charged spring mechanism, the springs shall not be discharged until the spring has been fully charged and until the means of charging has been removed or disconnected.

The operating mechanism shall be trip-free.

Mechanical interlocks shall be provided to cater for the following functions:-

- a) The circuit breaker cannot be inserted or withdrawn when in the closed position. Attempted withdrawal shall not trip a closed circuit breaker.
- b) The circuit breaker cannot be closed until it is fully engaged or completely isolated and withdrawn.
- c) Covers or door giving access to the circuit breaker cannot be removed or opened unless the circuit breaker is fully isolated and withdrawn.
- d) Safety shutters shall be provided to all ACB so that no live parts will be exposed

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when the ACB is drawn out.

Facilities shall be provided for testing the circuit breaker operation in the isolated and withdrawn position using the normal control functions. Where control circuits are supplied and interlock circuits are broken via plugs on withdrawal of the circuit breakers, a minimum of two jumper lead and socket and plug assembly of each size and type shall be provided to facilitate testing in the withdrawn position.

The ACB shall have Test Certificates for:

- i) Temperature Test
- ii) Mechanical Endurance Test
- iii) Dielectric Test

4. BUSBARS

Busbars and busbar connections shall be constructed in accordance with the requirements of B.S. 158 and 159.

Busbars shall be of rectangular section hard drawn high conductivity copper, adequately rated and supported on non-hygroscopic, anti-tracking insulators spaced at suitable intervals, the complete assembly being capable of withstanding the maximum mechanical stresses set up either by any thermal expansion within the bars under normal operating conditions or under short-circuit fault conditions.

Full size neutral bars shall be provided.

Busbars installed in switchboards shall be so arranged that all conductors can be brought onto the bars without undue bending. Busbars shall be coloured to B.S. Colour Code at strategic locations for phase identification.

Connections shall be made with double split case brass clamps. Drilling of the bars will not be permitted, unless approved by the Contractor.

Notwithstanding the above, all conductors between the busbars and the fuse switches / MCCB above 200A per phase shall be high conductivity copper bars, having a current rating of not less than that of the fuse switches/MCCB to which they are connected.

Busbars shall be tinned copper to B.S. 1432.

A tinned copper earthing strip of dimension not less than 25 x 3mm shall be provided for the full length of the switchboards and sufficient provisions made for earthing connections of all electrical circuits. It shall be effectively connected to all metal parts other than current carrying conductors.

5. FUSE SWITCHGEAR AND ISOLATORS

All fuse switchgear and isolators shall conform to the requirements of B.S. 861, B.S. 3185 and B.S. 2510. All contacts shall be fully shrouded and have a breaking capacity on manual operation as required by the relevant British Standard.

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Isolators and fuse switchgear shall have mechanical interlocks between the panel door and the switch operating mechanism so arranged that the panel door may not be opened with the switch in the 'ON' position. Similarly, it shall not be possible to close the switch with the cubicle door open; except that provision shall be made within the cubicle for authorized persons to defeat the mechanical interlock and close the switch with the door in the open position for test purposes.

All switchgear shall be flush mounting and be fitted with mechanical ON/OFF indicators with operating handles of the semi-flush or telescopic pattern.

In TP&N fuse switch and switch-fuse units bolted neutral links shall be fitted. For single pole and neutral switch-fuse and isolating switches, the neutral conductor shall be taken through a bolted link. Where specified on the Sub-Contract Drawings castell interlock shall be supplied.

6. FUSES, BARRIERS AND BASES

Cartridge fuses to B.S. 88 : Part 2, Class Q1 shall be provided.

The voltage rating shall be 415V 50 Hz to 500V D.C. The rated breaking capacity of fuses shall be 100 kA at 415V 50 Hz or 40 kA 500V D.C.

Fuse bases and carriers shall be of plastic moulded insulating material of an approved make. Ceramic materials will not be accepted.

All live terminals and contacts shall be effectively shrouded and it shall be possible to change fuses with the circuit alive, without danger of contact with live metal.

Fuse bases and carriers shall be colour coded, white for isolating link, light green for control and black for all other fuses, with phase indication.

Fuses and links in the same circuit shall be mounted in the adjacent positions in the same row. Fuses for control and voltmeter shall be mounted on the front of the panel by back-connected fuse holders.

7. MOULDED-CASE CIRCUIT BREAKERS (MCCB)

All MCCB shall conform to IEC 60947-2. The A.C. rated short-circuit breaking capacity for MCCB installed in the L.V. switchboards shall not be less than 50kA, or otherwise specified.

Except for the terminals and toggle, the entire current carrying and operating mechanism of circuit breakers shall be contained within a moulded plastic case.

The operating mechanism shall be of the quick-make, quick-break type, with the speed of operation independent of the operator and mechanically trip free from the operating handle, so as to prevent the contacts being held closed against a short circuit or overload condition. The operating mechanism shall be constructed to operate all poles in a multi-pole breaker, simultaneously during opening, closing and tripping operations.

MCCB shall have an inverse current/time characteristic (tripping shall be inversely proportional to the magnitude of the load current). Circuit protection against overload and

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

'ON' and 'OFF' indications shall be incorporated in the MCCB to show whether the contacts of the circuit breaker are in the open or closed position. The breaking and extinction of the arc created during switching shall be achieved by the means of non-welding contacts and arc chutes surrounding these contacts. The breakers shall be complete with positive contact indication.

The overload trip-setting indication shall be incorporated in the MCCB or displayed permanently on the panel adjacent to the MCCB.

Triple pole circuit breakers shall be interlocked internally so that an overload on any one phase shall trip all three phases of the breaker simultaneously.

The Sub-Contractor shall supply, on request, full current discrimination tables showing overload and short circuit discrimination and a full set of transparency characteristics curves to enable discrimination systems to be checked.

8. AUTOMATIC CHANGEOVER SWITCHES (MAINS FAILURE)

The automatic changeover switches shall be 4-pole and suitably rated for heavy-duty applications in a wide range of temperature from 0°C to 40°C. They shall be manufactured and tested to the relevant British Standards Specification.

The automatic changeover switches shall consist of the following basic elements:-

- a) Main contacts to connect and disconnect the load to and from the sources of power.
- b) Sensing/Supervisory circuits to constantly monitor the condition of power sources and thus provide the signal necessary for the contactors and related circuit operation.
- c) Transfer mechanism to effect changeover of the main contacts from source to source.
- d) Status indication to show which source of power the load is connected.
- e) Command signals to start and stop the standby diesel generator.

Three-phase sensing circuits shall be provided. Failure of one or more phases of the incoming supply or a reduction in voltage to less than 60% of normal, shall initiate a timing device adjustable in the range 0 to 15 seconds. If the failure persists at the expiry of this pre-set time delay, a signal shall be initiated to start the engine of the standby generator and the load shall be automatically disconnected from the main supply and connected to the generator supply.

After restoration of the normal supply, the automatic changeover switches shall automatically be restored to its normal position after an adjustable preset period from 10-180 seconds. A signal shall be initiated to stop the engine of the standby generator after a further five minutes running to ensure security of mains supply.

The automatic changeover switch shall be electrically and mechanically interlocked to

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ensure that the two sources of supply will not be paralleled.

A manual override switch shall be provided to allow for manual switching of power supplies in the event the automatic transfer mechanism fails to operate.

9. AUTOMATIC TRANSFER SWITCHES (MAINS FAILURE)

Clause 3.8 is also applicable to Automatic Transfer Switches (ATS) complying with IEC 60947-6-1. Automatic Transfer Switches shall be four-pole with either a pair of Moulded-Case Circuit Breakers (MCCB) or a pair of withdrawable four-pole Air Circuit Breakers (ACB) as indicated in the Sub-Contract Drawings.

A motorized mechanical linkage shall be provided in MCCB or ACB whichever is applicable, for preventing simultaneous operation of the other breakers when one of the breakers is in its 'ON' position.

Automatic Transfer Switches shall be provided with facilities for manual operation.

10. CURRENT TRANSFORMER

Current transformers shall be the straight-through type with suitable ratio, output and class of accuracy for their function and shall comply with IEC 60044-1. Measuring current transformers shall have accuracy of Class 1 and protective transformers shall have an accuracy of 5P10, unless otherwise specified.

Current transformers shall be rated for Class B temperature rise and a primary voltage of 660V.

Current transformers shall be of the epoxy resin encapsulated type and shall be capable of providing the necessary output to operate the connected protective devices or instruments.

Current transformers with adjustable primary turns will not be accepted.

For dual ratio current transformers, all ratio terminals shall be terminated at a terminal board and be clearly marked with connections corresponding to the wiring diagrams.

The secondary circuit of each set (L1-L2-L3) of current transformers shall be earthed at one point only. Means shall be provided for these earth connections to be disconnected by accessible position for testing.

Current transformers provided in plastic casings and of the split core type will not be accepted.

Measuring current transformers shall be connected to test terminal blocks. The test blocks shall be provided with easily removable links and designed to facilitate automatic shorting when the links are removed.

Where current transformers are used for measuring line currents via a common ammeter and a selector switch, current transformers shall be shorted out when not being used for indication.

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11. PROTECTION RELAY

Except where otherwise specified, protection relays shall comply with IEC 60255.

Where plug selection is specified, the design shall be such that the plug setting can be changed on load without open-circuiting the current transformer, and the highest current tapping point will automatically be selected when the plug is removed.

For protection, under/over-voltage, trip monitor and trip supervisory relays, draw-out cases shall be provided for flush mounting and finished in phenolic black. A contact shall be fitted which shall short circuit the associated current transformer on withdrawal of the relay.

For mains incoming Inverse Definitely Minimum Time Lag (IDMTL) protection relays, three single-phase units in one horizontal plane and accommodated in a common casing shall be provided. Earth fault relay shall be separately accommodated. The IDMTL relays shall be electro-mechanical type of approved make, or otherwise specified.

Earth fault relays shall have settings which are adjustable between 10% to 40% of current rating of circuit under protection. Overcurrent relays shall have adjustable settings between 50% to 200%. The range shall be adjustable in seven equal steps. Both types of relays shall have adjustable time setting range of 0.1 to 1 sec.

Relays shall be housed in dust and vermin-proof accessible cases.

Operation indicators shall be provided for each protective element and installed within the same relay. The relay shall have a common hand-reset device operable without opening the relay case. A sealing device permitting the use of sealing wire shall be provided preventing opening of the case.

Dust filters shall be provided in metal cases attached to the relays by screwed bezels and supplied with removable filter elements.

The relay contacts shall be capable of making and breaking the maximum current which may occur under fault conditions in the circuit in which they are connected.

12. DISCRIMINATION

Where earth fault detection is provided, sufficient adjustment shall be allowed to maintain discrimination between outgoing and incoming circuits, and prevent spurious tripping due to inherent leakage on long cable runs or remote equipment.

Where circuit breakers are not provided with earth leakage detection, they shall be arranged to trip on earth fault by ensuring a low earth loop impedance.

Outgoing circuit breakers shall have suitable characteristics to give discrimination with submain circuit breakers.

13. AMMETERS

Ammeters shall be current transformer operated type and of accuracy Class 1 (unless otherwise specified) complying with IEC 60051-2 and be capable of carrying their full load current without undue heating and shall not be damaged by the maximum fault levels of

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the switchgear.

All ammeters shall have a continuous overload capability of 120% of the upper limit of the scale for two hours. The scale shall be 100mm in total length.

Mechanical zero adjustment shall be provided and accessible from the front without dismantling.

14. VOLTMETER

Voltmeters shall be of accuracy Class 1 (unless otherwise specified) complying with IEC 60051-2 and have expanded scales of 100mm in total length. The range shall be 0V to 500V for all 400V 3-phase supply and the zero shall be marked.

Voltmeters shall be connected to the incoming side of the power supply through 6 amp. HRC fuses and links. Mechanical zero adjustment shall be provided.

15. AMMETER SELECTOR SWITCH

The ammeter selector switch shall be mounted on the front of the panel and shall be of the rotary type with make-before-break contacts for selection to read red-yellow-blue neutral currents with L1-L2-L3-N marked clearly on the switch.

Contacts shall be rated for a thermal current of 6 amperes at 230V 50Hz.

16. VOLTMETER SELECTOR SWITCH

The voltmeter selector switch shall be mounted on the front of the panel and shall be of the rotary type with break-before-make contacts for selection to measure L1-L2, L2-L3, L3-L1 and L1, L2 and L3 phase voltages with L1-L2, L2-L3, L3-L1, L1-L2-L3 marked clearly on the switch.

17. CONTROL AND AUXILIARY RELAYS

Control and auxiliary relays shall be plug-in type, rack-mounted, provided with cable connection sockets and anchored by quick fastening vibration-proof devices.

All contacts shall be double breaking type. Relay coils shall be rated at 230V single phase A.C. supply, and they shall operate when the voltage is reduced to 85% of nominal. Drop out voltage shall not occur at voltages exceeding 65% of nominal.

Contact elements and operating coils shall be replaceable and be enclosed in transparent dust-proof plastic case or available for easy inspection.

Each relay shall have a minimum of one pair of normally open and one pair of normally closed spare contacts.

18. LATCH RELAYS

Latch relays shall be provided for essential circuits and shall be suitably rated for 230V A.C. single phase supply. They shall be able to close when subject to a voltage reduction

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of 85% of nominal.

When the operating coil of the relay is energised, a spring loaded latch closed position. The contact shall remain closed even after the power is removed from the operating coil. A manually operated relay coil shall be provided to release the contact and allow the relay to drop out.

19. VOLT-FREE CONTACTS (DRY CONTACTS)

Where interface is required, "volt-free" contacts shall be provided for use by the other Sub-Contractor. They shall comprise a pair of contacts operated directly by the equipment but electrically separated such that no potential derived from the equipment appears at the contacts. Volt-free contacts shall also be used to complete external control, alarm or indication circuits.

20. SEQUENCE TIMERS

Delay timers shall be of the motorized type, suitable for $230V \pm 10\%$ single phase application. When the motor is fed, a built-in electro magnetic clutch shall pull in a mobile arm, and run for the preset time, before closing the associated microswitch contacts. The mobile arm shall be spring loaded so that when the timer motor is de-energized, the timer unit resets by itself. Unless otherwise stated, all timers shall have adjustable timing between 0 to 10 seconds.

21. SWITCHBOARD HEATERS

Each panel of the switchboard shall have bus wiring supplies and anti-condensation heaters. The buswire shall be energized from a 230V 50 Hz single phase supply.

Each segregated panel section and each vertical panel section in a multi-tier cubicle shall be fitted with panel heaters, isolating switch and HRC fuses. Panels for circuit breakers shall be fitted with suitably positioned adjustable thermostats for temperature control.

22. INTERNAL AND CONTROL WIRING

All instruments and equipment shall be securely mounted and all internal wiring runs shall be included and shall be so positioned as to ensure complete accessibility for servicing purposes.

All internal wiring shall be PVC insulated, neatly bunched, run on supporting cleats or insulators and shall be coloured and adequately labelled or sleeved for identification. All control wiring shall be 1.5mm^2 multi-strand copper and shall terminate on the "Klippon" system, and shall incorporate loops to permit the opening of doors and removal of components for inspection without disconnecting the cables.

All internal and control wirings shall be labelled.

23. SPPG METERS AND CURRENT TRANSFORMERS

Provision shall be made, where specified and/or as shown on the Sub-Contract Drawings, for accommodation of the Authority's supply metering equipment on the L.V. switchboards. The Sub-Contractor is responsible for liaising with SPPG for testing and

Electrical Installation Low Voltage Switchgear

installing the meters and current transformers.

24. TESTING

Factory Acceptance Test and on-site testing shall include, but not be limited to, the following:

- a) Mechanical tests including checking of all mechanical and electrical connections, interlocks, etc.
- b) High voltage dielectric test.
- c) Primary injection test of protective device, wherever applicable.
- d) Functional checks of all control circuits.
- e) Calibration of metering instruments, current transformer, etc.
- f) Secondary injection test of protective devices.
- g) Insulation resistance test.
- h) Contact resistance test.
- h) Any other tests as recommended by manufacturer and/or required by SPPG. All fees for testing are deemed to be included in this Sub-Contract.

Electrical Installation

Distribution Boards and Fused Switchgear

1. DESCRIPTION

The Sub-Contractor shall provide, install, test, commission and set to work all sub-circuit distribution switchgear and enclosures as indicated on the Sub-Contract Drawings and specified in this Section.

2. STANDARDS

All fused switchgear, switches, MCB and distribution boards shall fully comply with this Section.

All equipment, materials and workmanship shall comply with the appropriate Singapore or British Standards.

The short circuit ratings of the switchgears shall be certified by the independent and recognised testing authority.

3. DISTRIBUTION BOARDS

Distribution boards complying with IEC 61439-3 shall be provided to serve lighting circuits, small power outlets and/or as otherwise specified on the Sub-Contract Drawings. The number of "ways" shown on the Sub-Contract Drawings shall be provided.

All wiring, busbars, etc., within the distribution boards shall be screened behind a 2.5mm thick flame retardant insulating shield. Only the MCB operating dolly and insulated body shall project through the shield.

Neutral bars shall be of adequate cross section, mounted on insulators and drilled to receive circuit wiring. Two clamping screws shall be provided per neutral way. Screws shall be cheese head brass not less than 2 B.A. Where neutral and earth terminal connectors are installed, they shall have equal numbers of terminal ways as the numbers of MCB provided in the board. Under no circumstances shall the neutral cables be short-circuited with the earth continuity conductors.

Enclosure doors shall be fitted with chromium plated handle and closing latch device. The sheet metal for the board shall be not less than 1.6mm thick.

Cable entry knockouts shall be provided at top, bottom or both sides of the enclosure as required or removable gland plates used. Where single cable entered the enclosure, the entry plate shall be non-ferrous type.

All boards and outgoing circuits shall be clearly labelled, and marked with phase identification. All labels shall be of laminated plastic, black graved with white words.

Inside each distribution board door, a single-line diagram, enclosed in a perspex envelope shall be provided to provide details on the total number of points served by each MCB, total load per way and the area served.

Distribution boards shall be finished with rust resistant primer and sprayed overall with enamel paint.

Electrical Installation

Distribution Boards and Fused Switchgear

Polystyrene distribution boards with high quality may also be acceptable in lieu of sheet metal enclosure.

Surface mounting insulated distribution board shall be double insulated type and the index of protection shall be at least IP 40. The distance between DIN rails shall not be less than 150mm for ease of wiring and maintenance.

The enclosure shall withstand the glow wire test at 750 degree Celsius. in accordance to IEC 60695-2-1. The colour of material shall be RAL 9016.

Top and bottom cable entry plates shall be removable and interchangeable for easy installation. Sufficient numbers of earth and neutral terminals shall be provided for each outgoing circuits. All hinged doors shall have an earth braid connected to the cubicle. They shall be fitted to the frame from the outside with captive, hand tightened screw.

Distribution boards shall be of a modular design in 1, 2 or 3 rows. An optional key lock shall be provided when specified to prevent unauthorised access to the switchgears. Full access shall be provided to service and maintain all equipment inside each cubicle by means of a suitable hinged door that shall open a minimum of 120 degrees. Panels longer than 1.2 metres shall be provided with 3 point locking system.

4. FUSED SWITCHGEAR

Fused switchgear and switches shall be suitable for surface mounting, with enclosures fabricated from sheet steel, finished in grey or other agreed colour, stoved enamel, removable top and bottom end plates and gasketed door.

Chromium plated front operated handles with visible 'ON', 'OFF' indication shall be provided.

Front access doors shall be detachable and shall be interlocked to prevent opening when the isolator is 'ON'. Padlocking or key locking with key trapped when fuse/isolator is in closed position shall be provided. Provisions shall be made for the interlock to be defeated by a competent person for maintenance purposes.

The interiors of the switches and fused switchgear shall comprise porcelain bases fitted with plated non-ferrous conducting components.

Switches shall be quick make and break type, and shall have removable shields over the fixed contacts, and removable moving contact bars.

The fused switchgear and switches shall have a positive contact indicator to show the contact position with the door open.

All fused switchgear and switches shall be capable of withstanding the electrical and mechanical stresses produced by interrupting prospective fault currents of up to and including 50 kA r.m.s. symmetrical at 433V for 3 seconds, or otherwise specified.

All switching devices shall be rated for 660V, designed for heavy duty applications. They shall be fully tested to conform to IEC 60947-3, Cartridge fuses to IEC 60269 / B.S. 88 shall be supplied.

Where mounted externally or otherwise specified, weatherproof enclosure with IP55

Electrical Installation

Distribution Boards and Fused Switchgear

degree of protection shall be provided with hot-dipped galvanized finish.

5. MINIATURE CIRCUIT BREAKERS (MCB)

Single pole MCB shall be used for sub-circuit control and protection on all lighting and small power final circuits. Double pole MCB shall be used for sub-mains circuits and as means of isolation for single phase supply, or otherwise specified. Three pole breakers shall be used for three phase equipment, and four pole MCB shall be used as and when specified in the drawings.

The body and base of the units shall be moulded Bakelite or similar material which are non-flammable and comply with IEC 60695-2-10 and units shall be sealed after assembly.

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

The breaker operating mechanism shall be the tripped-free type so designed as to prevent the load handling contacts from closing on a fault.

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

Positions of the breaker operating dolly shall be clearly indicated. A window contact position indicator shall be incorporated on all 10kA MCB.

MCB shall comply with IEC 60898-1 and be independently type-tested by a recognised testing authority. Full type-test report shall be submitted when required.

MCB shall be approved by SP Services Ltd with breaking capacities as indicated on the single-line drawings. The tripping characteristics shall be suitable for the type of load connected.

All MCB shall be DIN-rail mounted type. The terminations shall be so designed to accept either prong- or fork-type busbars. The MCB shall be fed either from the top or bottom terminations without any deterioration of the MCB performance.

All cable and busbar terminations shall be sweated and tinned prior to connection to MCB terminals.

6. RESIDUAL CURRENT CIRCUIT BREAKERS (RCCB)

RCCB shall comply fully with SS 97 and shall be batch-tested by PSB and bear the approved Safety Mark label.

RCCB shall be either two or four pole and current-operated type with a tripping time not exceeding 0.1 sec.

The RCCB shall be rated for operation at 400/230V, 50Hz and shall have a tripping sensitivity current as specified in the Sub-Contract Drawings.

All RCCB shall be voltage-independent type complete with tripped-free mechanism. A

Electrical Installation

Distribution Boards and Fused Switchgear

test button shall be provided for testing of the RCCB.

A window contact position indicator shall be provided on the front face of the RCCB to show the true status of the contacts.

An anti-nuisance tripping device shall be incorporated in the RCCB to prevent undesired tripping due to transient voltages or currents.

Electrical Installation Cables

1. GENERAL

The Sub Contractor shall include for the supply, installation, testing and commissioning of all cables and accessories as specified herein and shown on the Sub-Contract Drawings.

The current carrying capacity shall be in accordance with SS CP5 with rating adjusted to suit local conditions.

2. STANDARDS

All cables shall be manufactured to the appropriate Singapore or British Standards Specification.

All PVC shall be flame retardant.

3. PVC INSULATED CABLES

All PVC insulated cables shall consist of annealed copper conductor complying with SS 358-1 unless indicated otherwise on the Sub-Contract Drawings. The rated voltage of the PVC cables shall be 600/1000 Volts.

Current carrying capacity of the cables shall be in accordance with the current SS CP5.

All cables shall pass PSB type tests and batch tests or approved under PSB quality certification scheme and have SPPG'S and SPSL's approval.

4. FLEXIBLE CORDS

Flexible cords shall be multi stranded copper conductors, high temperature, PVC insulated with flame retardant white circular PVC sheath 300V/500V grade to SS 358-3.

Minimum size of conductor shall be 1.5mm² (30/0.25mm²).

5. PVC INSULATED ARMOURED CABLES

PVC insulated, PVC sheathed, steel wire armoured, PVC sheathed cables (PVC/SWA/PVC), shall be to B.S. 6346, 600V/1000V grade with stranded, shaped, copper conductor cores of equal cross section and colour coded insulation.

PVC insulated cores shall be sheathed with flame retardant PVC which shall serve as a bedding for galvanized single steel wire armouring. The armouring shall be covered with an outer flame retardant PVC sheath.

Cables shall be terminated in a gland fitted with an armour clamp. The gland body shall be provided with an internal conical sealing to receive the armour clamping cone and a clamping nut which shall secure the armour clamping cone and conical armour seating. A flame retardant PVC shroud shall be fitted to cover the gland body.

Cable conductor terminations shall be by means of heavy duty compression cable lugs. The lugs shall be of high conductivity copper electro tinned and applied to the conductor by means of a hydraulic crimping tool unless otherwise specified.

Electrical Installation Cables

6. MINERAL INSULATED COPPER SHEATHED (MICS) CABLES (IF APPLICABLE)

MICS cables shall be provided with a flame retardant PVC sheath and shall be installed in accordance with the requirements of the SS CP 5.

The current carrying capacity of these cables shall be in accordance with CP5 and limited to the volt drop specified.

All MICS cables and cable accessories, glands, etc., shall be 1000V grade to BS 6207 and fittings to BS 6081 suitable for heavy duty industrial applications. All MICS cable fittings and accessories shall be manufactured by the appropriate cable manufacturer and only one make of cable shall be used.

7. FIRE RESISTANT CABLES

Fire resistant (FR) cables shall be either single-core or multi-core as specified. The conductors shall be of high conductivity annealed copper wire stranded and of 600/1000V grade at 50Hz.

The cables shall be insulated with fire resistant materials and glass mica flame barrier designed to maintain circuit integrity under fire conditions. The FR cables shall be of low smoke and non-toxic gas emission with flame retardance halogen free. The insulation of cables shall be manufactured in complying with the latest edition of Singapore Standard SS 299 and bear the PSB Product Listing Scheme labels as required by the Fire Safety and Shelter Department. It shall also be tested in accordance to the following Standards:-

B.S. 6387	-	Cat. C (Resistant to Fire Alone) Cat. W (Resistant to Fire with Water) Cat. Z (Resistant to Fire with Mechanical Shock)
IEC 60331	-	Flame Resistance Characteristic of Cables.
IEC 60332-3	-	Flame Retardance (Cat. A, B & C)
IEC 60754	-	Halogen Content & Toxicity

All relevant test certificates on the FR cables shall be submitted to the Architect / Consultant for acceptance prior to the ordering of the cables.

8. CROSS LINKED POLYETHYLENE ARMoured AND PVC INSULATED CABLES (XLPE/SWA/PVC or XLPE/AWA/PVC)

Cross-linked polyethylene insulated steel wired armoured and PVC sheathed cables (XPLE/SWA/PVC) shall be to IEC 60502-1 with insulation grade to suit the operating voltage and cores of equal cross section.

Conductors shall be formed from high conductivity full annealed stranded copper.

Conductor screening shall be non-metallic and consist of either a semi-conducting tape or a layer of extruded semi-conducting compound, or a combination of the two, having a total nominal thickness of 0.5mm.

Insulation shall consist of cross-linked polyethylene which is applied by extrusion to form a compact homogeneous body. The average thickness of the insulation shall be not less than 3.4mm.

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Core screen shall consist of either a semi-conducting compound or a combination of the two. A metallic screen consisting of either plain or tinned copper tape shall be applied over the semi-conducting screen except where rendered unnecessary by wire armouring.

The cores of multi-core cables shall be laid up with suitable fillers to form a compact circular assembly. Multi-core cables shall have steel wire (SWA) or steel tape armour and single core cables shall have aluminium wire armour (AWA).

The bedding for multi-core wire armoured cable shall consist of layers of semi conducting non vulcanisable rubber link tape having a nominal thickness of 0.8mm. Alternatively, three-core cable may be armoured with two layers of galvanized steel tapes of 0.6mm thick with a bedding of an extruded layer of heat resisting PVC complying with B.S. 6746, Type 5.

Cables shall be armoured with galvanised steel wires to give the cable strength and also act as a low resistance earth return conductor. Electrical contact shall be maintained between the core screen and the earthed armour wires through the conductive bedding tapes.

The oversheath shall consist of an extruded layer of black PVC compound complying with B.S. 6746 Type 1 compound.

9. Armoured Cables

Where multi-core cables are for indication, protection and control applications, each core shall have an identification number and engraved ferrules over the cable tails. The ferrules shall be numbered to correspond to a wiring diagram agreed by the Architect / Consultant. All wires shall be terminated with an acceptable type of clamp connector. Pinching screw type connectors shall not be acceptable.

All cables shall be installed in accordance with the Code of Practice SS : CP5, the cables being run between their source and termination points installed on cable trays, in ducts, clipped to ceilings and wall or as otherwise specified on the Sub-Contract Drawings.

10. INSTALLATION

10.1. Armoured Cables

Cables shall in general be supported by perforated cable trays. This tray shall be not less than 2mm thick mild steel, hot dipped galvanised or electro galvanised finished, and with returned edges of minimum 20mm high. It shall be supported from the rib of structural slab, beams, etc., by mild steel rods, galvanized, and not less than 15mm in diameter, with underslung steel angle supports. Sample of the supporting bracket shall be submitted for comment.

The tray design and strength and/or the tray supports shall be spaced at such intervals to ensure that tray sag shall be not more than 1/500 when installed with all cables, otherwise corrective measures shall be carried out to the Architect's satisfaction.

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

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cables are run in other exposed areas, they shall be protected with metal trunking. The cable tray and metal trunking shall be supported with rigid metal brackets.

Where cables are clipped to wall or ceilings, they shall be secured by means of spacer saddles. The spacer saddles shall be of the hot dip galvanized steel deep spacer type fixed to the surface by means of "rawl/plugs" or other equal manner. Each cable shall be fixed by a saddle at each point and fixed to its base by two cadmium plated fixing screws.

The Sub Contractor shall be responsible for the off loading and handling of the cables on site and shall ensure that cables are delivered to site on drums and properly protected against mechanical damage.

Cables shall be installed within cable ducts and draw pit systems by means of normal hand running off the cable drum. It shall enter the draw pit protected by roller guides and be drawn through by hand.

Unless agreed by the Architect / Consultant, straight through joints in cables shall not be allowed.

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

Unless otherwise specified, all cable ducts and draw pits shall be provided by the Sub Contractor.

10.2. Cable Bushings, Transits and Fire Stopping

In certain places, where cables pass through floors, walls or other partitions, bushing of an acceptable type shall be supplied and set in position by the Sub Contractor; where necessary, split bushings may be used for convenience in running out cables.

After running and cleating the cables, the bushing must be thoroughly grouted in or otherwise securely fixed in position and the space between the cables and the bushing completely filled in with a fire resisting material, acceptable to the Fire Service Bureau Department, and which has no deleterious effect on the cable sheathing or serving.

Every cable entry from exterior into the building shall be sealed by a Multi Cable Transit System as Brattberg MCT or equal.

The system shall consist of a mild steel frame with compression "tecron" insert blocks, as Brattberg RGB system or equal, to ensure that a gas and liquid tight seal is achieved. Compression shall be achieved by either compression plate and end packing device or by use of a press wedge.

All unused openings in the frame shall be fully sealed by 'blind' inserts.

Where cables pass through interior walls or floors of the building, all openings and spaces remaining after installation shall be sealed by a fire resisting and stopping system, approved by the Fire Service Bureau, which has no deleterious effect on the cable sheathing and which remains easy to remove after installation to allow for future

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alterations. The fire stopping system shall be as Hitachi Flamemastic or equal and shall be installed by the electrical Sub-Contractor.

10.3. Mineral Insulated Copper Sheathed Cables (If Applicable)

MICS cables shall be sealed immediately after cutting. All cable shall give a minimum of 10 megohm when tested on a 1000 V D.C. megger immediately and 48 hours after sealing. The Architect reserves the right to test all cables during installation and up to the end of the maintenance period. Any cables not giving a satisfactory insulation level shall be resealed or if considered necessary by the Architect, replaced by the Sub Contractor to obtain a satisfactory test reading.

Cables terminations at distribution boards, switchgear and apparatus generally shall be made by means of cold screw on pot type seals with ring type universal glands. Brass locknuts with serrated washers shall be used where cables terminate at apparatus not provided with screwed entry. For termination of single core cables to equipment, a piece of NON FERROUS PLATE shall be provided. Screw on cable lugs shall be provided for the cable connections to equipment.

Through joints, if required, shall be of the brass sleeve type. The sleeve shall be internally threaded at each end to receive a ring type universal gland, fitted to each of the cable ends. An ebonite spreader shall be used within the sleeve to hold the cores in position. Solder type connections shall be used on all cables up to and including 16mm². Above this size, mechanical type connections shall be used.

All joints shall be of acceptable manufacture and carried out fully in accordance with manufacturer's installation recommendations.

All terminations and seals shall be made in accordance with agreed methods, care being taken to exclude moisture and foreign matter. Compound used in the making of seals shall be capable of withstanding a temperature of 1500C with plastic sleeving to copper cores.

Where M.I.C.S. cables are installed during building construction, and may be liable to mechanical damage, they shall be provided with adequate temporary protection in the form of sheet steel troughs or by other acceptable method. Damaged cables not so protected shall be replaced by the Sub Contractor at his own cost.

Where M.I.C.S. cables pass through walls, they shall be protected with a piece of conduit bushed at each end and built into the wall.

MICS cables fixed directly to the structures, shall be provided with copper spacer clips for multiple runs (up to four cables) fixed directly to the structure. Brass round head screws of minimum length of 25mm employing rawlplugs shall be provided as necessary. Copper spacer clips securing single cables shall be of one fixing screw pattern. Two screw patterns shall be used for multiple cable runs. Spacing of cable fixing shall be to manufacturer's recommendations or SS CP5 whichever is the smaller.

All cables shall be routed entirely separate from pipework associated with other services. Where M.I.C.S. cables pass through floors, they shall be protected for a distance of not less than 300mm from floor level with galvanized metal sleeves secured with clamp type saddles.

Electrical Installation Cables

10.4. Excavation, Reinstatement and Laying of Cables

Underground cable shall be laid direct in trenches unless otherwise indicated (i.e. UPVC circular cable ducts).

When cable trenches are opened all cables shall be laid and the trenches shall be backfilled within 24 hours. At all times safety precautions shall be taken and arrangements made to prevent damage to cables.

Trenches shall be excavated to provide the minimum cover as follows :

Type Of	In open Ground and Under Pavements	Under Road Subject to Vehicular Traffic	In Other Situation
Control	500	800	As Indicated
Power L.V. 0.6/1kV	500	800	As Indicated
Power H.V. 1kV and above	1000	1000	As Indicated

Turf and top soil shall be removed carefully and preserved for re instatement in their original positions.

Broken land drains and damage to other services shall be reported and indicated. All subsequent costs due to damages shall be borne by the Sub Contractor.

The excavation shall be kept free of water and properly shored up. Other services uncovered shall be adequately supported by slings or other means and protected.

Before cables are laid, the bottom of the trench shall be evenly graded, cleared of loose stones and then covered with a 75mm layer of earth which has passed through a sieve with a maximum mesh of 12mm or, where local ground is unsuitable, with sand.

Power cables shall be pulled in over adequately spaced cable rollers and the resulting surplus cable shall be snaked across the width of the trench. In straight run trenches cable crossing is not permitted except where cables branch from the main run. At each draw in point, joint or junction box the cable shall be left slack. Cables shall not be pulled taut to straighten them after laying. Cable stockings shall be used for cable hauling. In order to ensure that the strain is taken on the cores as well as the sheath when cables are laid with a cable stocking, a stock plumbed hauling end shall be made. The only permissible exceptions to this requirement are lengths of up to 10 metres not pulled into a thrust boring.

Where more than one cable is laid in a trench the cables shall be spaced apart in accordance with their current rating but subject to the minimum spacing specified as follows:

Cable	HV (mm)	LV (mm)	Telephone (mm)	Co-axial (mm)	Gas, Water and Other
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Electrical Installation

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					Piped Service (mm)
HV	50	300	300	300	300
LV	300	25	150	150	300
Telephone	300	150	50	50	250
Co-axial	300	150	50	50	250
Control	300	150	50	50	250

(Where this is not possible, 50mm thick concrete or stone tiles shall be used as separators)

After laying, the cables shall be covered with enough fine sieved earth (or sand where the local ground is unsuitable) to ensure 50mm cover after tamping and cable tile. Warning covers shall be laid over the cables and the trench filled in and compacted.

Reinstatement shall be effected by back filling in 100mm layers and hand ramming the first two layers. Power rammers may be used for the remaining layers. The turf shall be replaced and the level of the finished reinstatement shall not protrude more than 25mm above the normal ground level.

Co axial and control cables shall be laid to the instructions of the manufacturer and precautions shall be taken to prevent denting, kinking or displacement of the armouring when laying the cable in the trench. In particular the cable shall not be set or bent in a radius of less than 550mm or 12 times the overall diameter of the cable whichever is the greater.

Co axial cables shall not be laid one over the other.

Where it is necessary to change the level of the cable the bottom of the trench shall rise or fall with a slope not greater than 1 in 12.

All cable ends shall be sealed in a manner recommended by the cable manufacturer.

Interlocking cable warning covers complying with B.S. 2484 shall be provided for power cables laid direct in the ground.

The location of all directly buried cables shall be marked by concrete slab markers 600 x 600 x 100mm as directed by the Architect.

Each cable run shall be marked at the point where it leaves the plinth, sub station, feeder pillar, lamp pole or other current controlling device and shall be marked at approximately every 75m along the cable run with an additional marker at each change of direction of the cable run. Cable markers shall be installed flat in the ground immediately above the cable with approximately 25mm projecting above the surface. The Sub-Contractor shall impress the words "LV CABLES" as required on each cable marking slab and shall, also impress additional circuit symbols as directed by the Architect. The letters shall be approximately 100mm high and 75mm wide overall with strokes 12mm wide and 6mm deep.

The location of each underground cable joint shall be marked by a concrete slab placed over the joint with approximately 25mm of slab projecting above the ground. The word "JOINT" shall be impressed on each slab in letters of the size specified.

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The concrete used for all cable markers shall be mixed in the following proportions:

Cement	50 kg
Fine aggregate	0.07m ³
Coarse aggregate (nominal max. size 10mm)	0.14m ³

Electrical Installation

Trunking, Tray, Conduits and Accessories

1. DESCRIPTION

The Sub-Contractor shall install conduits, cable trunking, cable trays, cable ladders and all necessary accessories as specified on the Sub-Contract Drawings and this Section.

2. STANDARDS

All equipment, materials and workmanship shall comply with the appropriate Singapore or British Standards and local authorities requirement/regulations.

3. GALVANISED CONDUIT BOXES AND ACCESSORIES

All conduits shall be galvanized welded steel complying with B.S. 31 Class 3. No conduit shall be of less than 20mm diameter. Conduits installed in the mechanical pump rooms, above the roof and outdoor shall be hot-dipped galvanised complying with IEC 61386.

All conduit outlet boxes and junction boxes shall be malleable iron and of standard circular pattern with spout.

Standard circular pattern boxes shall be used with conduits up to and including 25mm diameter. Rectangular pattern adaptable boxes shall be used for conduits of 32mm diameter and larger.

All conduit boxes shall be provided with lids. Adaptable boxes shall be of mild steel of not less than 2.5mm with hot-dipped galvanized finishes. Boxes shall be not less than 47mm deep and of such dimensions as will enable the largest size cable, for which the conduit run is suitable, to be drawn in without excessive bending of the cables. Lids of the same gauge with brass fixing screws shall be provided. All such boxes shall be drilled for holes according to the conduit entries required.

Spacer bar saddles shall be malleable cast iron with bases and shall be hot-dipped galvanised and comply with IEC 61386.

Socket outlet boxes shall be constructed of sheet steel, galvanized finish and shall comply with B.S. 4662. Flush or surface mounting type outlet boxes shall be used where applicable.

AN EARTHING TERMINAL WITH BRASS SCREW SHALL BE PROVIDED IN EACH LIGHTING AND POWER OUTLET BOX.

All conduit entries to adaptable boxes, outlet boxes and switchgear shall be made with coupling and hexagon male brass bush with serrated steel washer.

4. FLEXIBLE STEEL CONDUIT

Flexible steel conduit and solid type adaptors shall comply with IEC 61386. In addition, the conduit shall be of the metallic watertight pattern, PVC oversheathed and with a separate solidly connected external earth continuity conductor.

5. CABLE TRUNKING

Cable trunking shall be manufactured complying with Singapore Standard SS 249 and shall carry batch-approved certificate on each trunking from PSB. The cable trunking system shall be of the electro-galvanised sheet steel both internal and external throughout and

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Trunking, Tray, Conduits and Accessories

coated with electrostatic epoxy powder with a minimum film thickness of 45 micron. The colour of the trunking shall be electric orange or grey as specified by the Architect.

The trunking systems shall comprises of purpose factory made bends, tees, reducers etc., and shall be electrically continuous grounding by linking each sections and joints with purpose factory made copper link. All screws bolts and nuts shall be of zone plated or cadmium plated.

Covers shall be of the quick-fix pattern with centre captive screw or spring-on type. Fixing arrangement employing self-tapping screws shall not be accepted.

Cable trunking shall have the dimensions and thickness as specified in the following table:-

METAL CABLE TRUNKING SIZE AND THICKNESS

SIZE (MM)		MATERIAL THICKNESS (MM)	
WIDTH	HEIGHT	BODY	COVER
50	25	1.0	1.0
50	50	1.0	1.0
75	50	1.2	1.2
100	50	1.2	1.2
125	50	1.5	1.2
150	50	1.5	1.2
175	50	1.5	1.2
200	50	1.6	1.5
225	50	1.6	1.5
250	50	1.6	1.5
275	50	1.6	1.5
300	50	1.6	1.5
350	50	1.6	1.5
100	75	1.2	1.2
150	75	1.5	1.2
200	75	1.6	1.5
300	75	1.6	1.5
100	100	1.5	1.2
150	100	1.5	1.2
200	100	1.6	1.5
300	100	1.6	1.5
150	150	1.5	1.2
200	150	1.6	1.5

6. CABLE TRAYS

Metal cable tray shall comply with IEC 61537 and be perforated with return edges of minimum 20mm high. The cable tray shall be fabricated from hot-dipped galvanised or electro-galvanised steel sheet with electrostatic epoxy powder coating to minimum thickness of 45 micron.

The tray system shall comprises of purpose factory made bends, tees, reducers etc and shall be electrically continuous grounding by linking each sections and joints with purpose factory made copper link.

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Trunking, Tray, Conduits and Accessories

7. CABLE LADDER

All Cable Ladder systems and accessories materials shall comply with IEC 61537 and be fabricated from hot-dipped galvanised finishing with electrostatic epoxy powder coating to 100 micron minimum.

The Cable Ladder shall consist of side rail and horizontal rungs. These should have rigid welded type construction and fabricated with a minimum of 2.0mm (14SWG) sheet steel. Dimension of side rail should be 132mm x 32mm channel type with flange facing outside. Rungs should be 50mm x 30mm slotted channel type and spaced 300mm apart or to manufacturer standard.

The side rail and all fittings shall have 4 nos. of the square holes on each end for fixing splice plates. All the bolting hardware shall be "carriage" type and finishing with hot dipped galvanized except that electrically continuous grounding jumpers shall be flexible copper, size shall be of 150mm length x 20mm width. All accessories shall be factory made.

Cable Ladder will be supplied in standard length of 2440mm or 3000mm, and clear width or Ladder is 150mm, 300mm, 450mm, 600mm, 750mm or 900mm, or otherwise specified.

8. INSTALLATION

8.1. GENERAL

The Sub-Contractor shall run all sub-circuit and control wiring in PVC cables in galvanized conduit and trunking unless otherwise specified herein or shown on the Sub-Contract Drawings.

All conduit systems in plant rooms, lift motor rooms, false ceiling voids, bulkheads and switchrooms shall be surface mounted on wall and ceilings. Unless special permission has been obtained from the Architect, no conduit shall be installed underneath cable trays or along steel structures. Conduit systems in other areas shall be carried out in concealed conduit.

The complete installation shall comply in every respect with the latest edition of CP5.

8.2. CONDUIT SYSTEM

Conduit systems shall be electrically and mechanically continuous and watertight after installation. They shall be arranged, as far as possible, to be self-draining to conduit outlet points for equipment. The system when installed, and before wiring, shall be kept plugged with wooden plugs. Immediately before wiring, all conduit systems shall be thoroughly swabbed out until dry and clean.

All sets of bends in conduit runs shall be formed on site in bending machines. Inspection bends may be permitted at column, where large bends shall be avoided. Junction box shall be installed wherever the connections exist.

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

The Sub-Contractor shall make good any damage to the finish of all conduits (including

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threads cut at site) by painting two coats of good quality lead paint.

Different conduit and trunking systems shall be provided for each of the following systems as called for in this Specification.

- a) Normal lighting and general purpose outlets (e.g. 13A or 15A switch socket-outlets).
- b) Three phase power supply.
- c) Single and 3 phase motors.
- d) E.L.V. circuits.
- e) Telephone services.
- g) Protective relay circuits.
- h) D.C. circuits.
- i) Security System
- j) Fire Alarm and Detection System
- k) Emergency lighting and power outlets circuits
- l) MATV/SCV /BCS System

The Sub-Contractor's attention is especially drawn to the necessity for keeping all conduit entirely separate from other piping services and no circuit connections will be permitted between the conduits and such pipes.

The Sub-Contractor shall arrange for a telescopic conduit system to be employed where expansion joints are crossed. However, where conduit is surface mounted on walls or ceilings, a normal flexible metal conduit with external earth continuity conductor shall be used. The size of the earth continuity conductor shall be in accordance with CP 5.

All conduit systems shall be installed so as to enable wiring to be carried out on the "loop-in" system.

All conduits shall be swabbed through before installation so as to clean out all dirt, burrs and moisture.

Conduits shall be fixed with spacer bar saddles at intervals not exceeding 1.2m.

All sub-circuit and control wiring shall be installed in galvanised conduit and trunking unless otherwise specified herein or shown on the Sub-Contract Drawings.

8.3. CABLE TRUNKING

Trunking shall be terminated with end flanges which shall be bolted direct to distribution boards or apparatus.

Connecting pieces shall be used and bolted with cadmium plated mushroom head steel screws, nuts and vibration resistant locking washers. Each joint shall have a tinned copper link bolted to each adjacent trunking to ensure electrical continuity. All frayed and sharp edges shall be removed from trunking before installation.

Conduit entry to trunking shall be by galvanized coupling and brass male bush with serrated steel washer.

Where trunking crosses expansion joints, a trunking system shall be used which will allow for expansion and maintain earth continuity. The system used shall be checked by the Contractor prior to it being used.

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Trunking, Tray, Conduits and Accessories

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.

All hangers and support for cables trunking shall be galvanized.

8.4. FLEXIBLE STEEL CONDUITS CONNECTIONS TO FIXED EQUIPMENT

Connections to electric fixed equipment shall be by means of PVC cables in conduits, with the final connection being made by flexible metal conduit, and suitable adaptors. A separate earth continuity copper cable in accordance with CP 5 and B.S. 6004 of not less than 2.5mm² run outside the flexible tube and solidly connected at each tube termination shall be provided.

Flexible conduits installed in the water pump rooms and the like shall be of the metallic watertight pattern, PVC oversheathed and with a separate solidly connected external earth continuity conductor.

8.5. CABLE TRAYS

Cable trays shall be supported from the soffit of structural slab, beams, etc., by heavy duty galvanized steel brackets.

Tray supports shall be spaced according to the number and size of cables being carried on the tray, but nowhere shall they exceed 1.5m intervals to ensure that tray sag does not exceed 1:500 with all cables.

Cables installed on cable trays shall be neatly arranged and secured to the cable trays by PVC covered metal strips at intervals of not exceeding 1m.

8.6. PAINTING

All conduits, trunkings and cable trays shall also be painted with two coats of primer and minimum one coat of final finish be as follows :-

General Electrical	-	ORANGE
Public Address	-	GRAY
Telephone	-	WHITE
Emergency Voice Communication	-	BLUE
Security	-	As background colour

or any other colour as specified by the Architect.

Electrical Installation Wiring Accessories

1. DESCRIPTION

The Sub-Contractor shall supply and install the wiring accessories, including lighting switches, switches for electrical appliances, socket outlets, fused spur units, telephone outlets, etc., which form part of the Works as shown on the Sub-Contract Drawings.

2. STANDARDS

All wiring accessories shall comply with the appropriate Singapore or British Standards.

All wiring accessories shall also comply with the local Authorities' requirements and local Fire Safety & Shelter Department's requirements.

3. LIGHTING SWITCHES

Switches for the control of lighting circuits shall comply with SS 227 and shall be designed specifically for use on 10A a.c. inductive circuits.

Unless otherwise indicated, switches shall be single-pole, one-way, rocker operated and of white square plate pattern.

Switches in plant rooms and switch rooms, etc., shall be mounted in surface mounting boxes. The rocker and the plate shall be of the white insulated type, and secured by means of two nickel plated counter-sunk screws to the galvanized deep drawn steel mounting box.

Switches for emergency supplies shall have red coloured rockers.

Switches in all other areas shall be flush mounted, all insulated, single pole and white in colour.

All lighting switches shall be batch-tested by PSB and bear the approved Safety Mark label.

Multi-gang switch units shall not switch more than one phase and shall be built up on the grid switch system.

Lighting switches in general shall be mounted at 1200mm above finished floor level, unless otherwise specified. The exact positions shall be subjected to Architect's and/or Interior Designer's approval.

IP 66 weatherproof lighting switches complying with IEC 60529 shall be installed at lift pits and areas exposed to weather.

4. SWITCHED SOCKET OUTLETS

Socket outlets shall be 3-pin, 13A or 15A as shown on the Sub-Contract Drawings. All socket outlets shall be switched and shuttered type complying with SS 145 and SS 472 where applicable.

Switched socket outlets in general shall be mounted at 450mm above finished floor level, unless otherwise specified. The exact positions shall be subjected to Architect's and/or Interior Designer's approval.

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Wiring Accessories

In plant rooms and switchrooms, switch socket outlets shall be metal-clad type and surface mounted at a height of 1350mm.

Socket outlets for emergency supplies shall have red coloured rocker switches.

In lift pit and areas exposed to weather and water splashing, socket outlets shall be of the weatherproof type. The live metal parts shall be recessed below the surface to eliminate the danger of touch contact. A brass screw cap with chain attachment shall be provided for the socket when it is not in use.

15A switched socket outlets shall be supplied from the distribution boards and not more than one such outlet will be permitted per circuit.

All switched socket outlets shall be batch-tested by PSB and bear the approved Safety Mark label.

5. FUSED SPUR UNIT

Fused spur units for the control of single phase supplies to fixed equipment shall be provided with separate outlet box allowing final connection of flexible conduits as specified on the Sub-Contract Drawings.

Fused spur units shall have earthing facilities for connection to the metalwork of appliances being fed.

6. INDICATING CONTROL SWITCHES

Indicating switches shall be 20A, double pole, flush mounted, all insulated, white colour, with neon pilot lamps, complying with SS 227.

Proper words shall be engraved on the cover plate to designate the equipment served. Mounting height shall be 1200mm above finish floor level, unless otherwise specified. The exact positions shall be subjected to Architect's and/or Interior Designer's approval. The switches shall be batch-tested by PSB and bear the approved Safety Mark label.

7. TESTING

7.1. Verification of Polarity:

To ensure that all fuses and single pole control devices are connected in the "live" conductor only, and that wiring has been correctly connected to the socket outlet terminals.

7.2. Test on Continuity of Protective Conductor and Equipotential Bonding Conductor:

The test methods and values shall be in accordance with SS CP5.

7.3. Test on Earth Fault Loop Impedance:

The test methods and values shall be in accordance with SS CP5.

7.4. Test on Insulation Resistance:

The test methods and values shall be in accordance with SS CP5.

Electrical Installation Lighting Luminaires

1. GENERAL

The Sub-Contractor shall provide, install, commission, test and set to work a complete lighting scheme in accordance with the light fittings scheduled on the Sub-Contract Drawings and this Specification.

The Sub-Contractor shall include for the purchase and delivery to site of all the light fittings, their storage, safe keeping pending unpacking, their complete assembly erection, connection, testing, and handing over in a clean working condition at the end of the Sub-Contract Period.

Luminaires shall be pre-wired and complete with lamps, controlgear, diffusers, lampholders, mounting brackets etc. all necessary for the complete installation and commissioning.

All luminaires shall be complete with approved type earth terminals for connection to the earth continuity conductor of the final sub-circuit. Luminaires shall be designed for operating on 230V +/- 6%, single-phase, 50Hz supply.

The types and ratings of the luminaires shall be as indicated on the Sub-Contract Drawings.

2. STANDARDS

All luminaires and components shall comply with the appropriate Singapore or British Standards or an acceptable equivalent international standard.

The construction and internal wiring of the luminaires shall comply with the latest edition of the SS CP 5 requirements.

3. LUMINAIRES

Luminaires shall comply with the following IEC Standards:

IEC 60081	- Double-capped fluorescent lamps - Performance specifications
IEC 60155	- Glow-starters for fluorescent lamps
IEC 60400	- Lampholders for tubular fluorescent lamps and starterholders
IEC 60529	- Degrees of protection provided by enclosures (IP Code)
IEC 60598-1	- Luminaires Part 1: General requirements and tests
IEC 60598-2-1	- Luminaires Part 2: Particular requirements. Section 1: Fixed general purpose luminaires
IEC 60598-2-2	- Luminaires Part 2: Particular requirements - Section 2: Recessed luminaires
IEC 60838-2-2	- Miscellaneous lampholders - Part 2-2: Particular requirements - Connectors for LED-modules
IEC 60901	- Single-capped fluorescent lamps - Performance specifications
IEC 60921	- Ballasts for tubular fluorescent lamps - Performance requirements

Electrical Installation Lighting Luminaires

IEC 60923	- Auxiliaries for lamps - Ballasts for discharge lamps (excluding tubular fluorescent lamps) - Performance requirements
IEC 60929	- AC-supplied electronic ballasts for tubular fluorescent lamps - Performance requirements
IEC 61048	- Auxiliaries for lamps – Capacitors for use in tubular fluorescent and other discharge lamp circuits - General and safety requirements
IEC 61049	- Capacitors for use in tubular fluorescent and other discharge lamp circuit - Performance requirements
IEC 61199	- Single-capped fluorescent lamps - Safety specifications
IEC 61195	- Double-capped fluorescent lamps - Safety requirements
IEC 61347-1	- Lamp controlgear - General and safety requirements
IEC 61347-2-3	- Lamp controlgear - Part 2-3: Particular requirements for a.c. supplied electronic ballasts for fluorescent lamps
IEC 61347-2-8	- Lamp controlgear - Part 2-8: Particular requirements for ballasts for fluorescent lamps
IEC 61347-2-9	- Lamp controlgear - Part 2-9: Particular requirements for ballasts for discharge lamps (excluding fluorescent lamps)
IEC 61347-2-13	- Lamp controlgear - Part 2-13: Particular requirements for d.c. or a.c. supplied electronic controlgear for LED modules
IEC 62031	– LED modules for general lighting – Safety specifications
IEC 62471	- Photobiological safety of lamps and lamp systems
IEC 62560	– Self-ballasted LED lamps for general lighting services by voltage > 50v – Safety specifications
IEC 62612	– Self-ballasted LED lamps for general lighting services with supply voltage > 50v – Performance requirements
IEC 62384	– DC or AC supplied electronic controlgear for LED modules – Performance requirements
IEC 62717	– LED modules for general lighting – Performance requirements
IEC 62722-2-1	– Luminaire performance – Part 2 -1: Particular requirements for LED luminaires

4. CONTROLGEARS FOR LUMINAIRES

All controlgears shall be totally built into the fitting assembly, and shall provide for switch start operation. The controlgears shall be high-quality and low-inrush (less than 10 times) type similar to Philips / Lutron or approved equivalent, and designed and tested to comply

Electrical Installation

Lighting Luminaires

fully with NEMA 410.

Ballasts shall be designed to operate on a 230 volts \pm 6%, single phase at 50 Hz \pm 2%. The loss under normal operation conditions shall not exceed 6.5 watts for each of the 36 watt or 18 watt ballast. All ballasts shall comply with IEC 61347 and be BATCH-TESTED by PSB and bear PSB labels of approval. Ballasts which have not obtained certification from local authorities will not be accepted.

Power factor correction capacitors shall be provided to correct the power factor for each fitting to not less than 0.95 lagging two hours after the fitting has operated continuously on site. The capacitors shall be of the metallized polypropylene strips wound onto cylindrical formers. Oil type capacitors shall not be accepted.

Radio interference filter shall be fitted to each fitting. The filter shall be suitable for suppressing mains-borne interference generated from the light fitting to meet the limit specified in B.S. 800 "Limits of Radio Interference".

Controlgear and wiring assemblies shall be sprayed with an acceptable non-hardening lacquer coating to prevent the ingress of water moisture.

Where specified, all starters complete with starter bases shall comply with IEC 60155 and suitable for fluorescent lamps.

Lamp holders shall comply with IEC 60400, and shall be non-inflammable and non-conductive. When installed, the lamp holders shall be adjustable to allow manufacturing tolerance (within the manufacturer's specification) in the length of lamps.

Fluorescent fittings shall accept either 38mm or 26mm diameter fluorescent tubes.

5. WIRING

Inter-component wiring shall be rated at 105°C 450V flame-retardant PVC and shall be neatly secured within the fitting to prevent contacts being broken.

External cable connections shall be at fused terminals blocks provided on the fitting and, in the case of pole mounted luminaires, the terminals shall be located within the service compartment at the base of the pole. Cartridge fuses shall be provided.

Where wiring passes through or past the edge of any metal section of the fitting, it shall be protected by an approved grommet and be doubly insulated.

Earthing of each fitting shall be made on the earth terminal provided within the fitting.

6. FLUORESCENT TUBE

Fluorescent tubes shall conform to with IEC 60081 / IEC 60901

Colour of the tubes shall be "White" with nominal colour temperature of 4000K and Colour Rendering Index of 84 unless otherwise specified elsewhere on the Sub-Contract Drawings. All tubes shall be either T8 to T5 type and shall have the following characteristic:

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Lighting Luminaires

<u>TUBE LENGTH</u>	<u>WATTAGE</u>	<u>MIN. OUTPUT LUMEN</u>
600mm	18W/T8	1300
1200mm	36W/T8	3300
550mm	14W/T5	1200
1150mm	28W/T5	2600

In M&E plantroom areas, the Colour Rendering Index of 80 for the tubes may be acceptable.

7. INCANDESCENT LAMPS

Incandescent lamps shall comply with the following IEC Standards where applicable:

- IEC 60432-1 - Incandescent lamps - Safety specifications - Part 1: Tungsten filament lamps for domestic and similar general lighting purposes
- IEC 60432-2 - Incandescent lamps - Safety specifications - Part 2: Tungsten-halogen lamps for domestic and similar general lighting purposes
- IEC 60432-3 - Incandescent lamps - Safety specifications - Part 3: Tungsten-halogen lamps (non vehicle)
- IEC 60064 - Tungsten filament lamps for domestic and similar general lighting purposes - Performance requirements
- IEC 60238 - Edison screw lampholders
- IEC 61184 - Bayonet lampholders

Lamps up to and below 150W shall have bayonet cap and larger ratings shall have ES or GES holders as appropriate.

Average rated life for incandescent lamps shall not be less than 1000 hours.

8. FLAMEPROOF FLUORESCENT FITTING

Flameproof fluorescent fittings shall comply with the following IEC Standards:

- a) IEC 60079-1 - Explosive Atmospheres - Part 1: Equipment Protection by Flameproof Enclosures "d"
- b) IEC 60529 - Dust tight and jetproof to IP65

The fitting shall be completed with a cast aluminium end box which shall be rigidly supported by a steel connecting tube.

The fitting shall also be completed with switches, controlgear and underslung mains cable entry.

All visible joints shall be gasketed and external screws shall be stainless steel socket headed type.

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Lighting Luminaires

9. METAL HALIDE DISCHARGE LUMINAIRES

Metal halide discharge lighting shall be as specified on the Sub-Contract Drawings and shall be suitable for the luminaires selected.

The luminaires shall be completed with the appropriate controlgear and lamps.

Where the luminaires are specified to be installed outdoor, controlgear shall be mounted within a weatherproof box duly ventilated.

10. HIGH PRESSURE SODIUM LAMP

High pressure sodium lamp shall be installed as shown on the Sub-Contract Drawings.

All lighting fittings shall be against electric shock and splash-proof.

All lamp poles shall be galvanized, supplied and installed by the Sub-Contractor.

The height of the lamp poles shall be as shown on the Sub-Contract Drawings.

The light fittings shall be completed with controlgear and lamps.

11. EXIT SIGNS

'EXIT' signs shall be of the maintained self-contained type complying with the requirements of Fire Safety and Shelter Department and SS 563. The 'EXIT' signs shall be BATCH-TESTED by PSB and bear PSB labels of approval.

Each sign shall consist of fire retardant acrylic plates with white legend 'EXIT' (with or without directional arrows) on green background or vice versa. The sign shall be illuminated by a single 8 watts T5 fluorescent tube and shall be either single- or double-sided as specified.

The housing for the batteries, battery charger, converter, controlgear shall be constructed from minimum 20 gauge mild steel and epoxy painted to standard black or any other colour as approved by the Architect. Ventilation slots shall be provided at top and sides.

The batteries shall be high temperature rated rechargeable sealed nickel- metal hydride (Ni-MH) or nickel-cadmium (Ni-Cd) type with sufficient capacity to operate the fluorescent tube for not less than 2 hours.

The charging unit shall be a solid state two rate fully automatic, voltage regulated, temperature compensated with trickles charge facility. The unit shall be provided with low-volt cut-off facility to protect the battery from over-discharging.

The housing for the batteries, battery charger and inverter shall be of the recessed type for installation in false ceiling. Surface mounted types shall be provided for areas without false ceilings.

The charging of the battery shall be monitored by a neon lamp or light emitting diode which shall be easily visible. A test button shall be provided for periodic inspection of the signs.

Electrical Installation

Lighting Luminaires

12. MAINTAINED EMERGENCY LIGHTING

Unless otherwise specified, all luminaires marked 'B' on the Sub-Contract Drawings shall be equipped with battery-operated power supply units with sufficient capacity to operate the lamps for not less than 2 hours in the event of a mains power failure.

The batteries shall be rechargeable sealed Nickel-Metal Hydride or Nickel-Cadmium type and housed together with the charger, inverter, etc. in a separate stove-baked enamel white steel enclosure mounted adjacent to the respective luminaires and above the false ceiling, or alternatively within the housing of the fluorescent fittings.

In the case of the fluorescent fittings, the capacity of the batteries shall be capable to operate at least one tube at 90% efficiency for 2 hours.

All maintained emergency lights shall be provided with non-switch charging/sensing cables for charging and operating of the emergency power tube.

All emergency lighting shall be provided with charger indicating lights (Neon or LED), test-buttons and approved emergency labels.

13. INSTALLATION

All luminaires shall be adequately supported in accordance with manufacturer's recommendations and to the satisfaction of the Architect. In all practical cases, all fittings shall be suspended independently. Mounting heights for luminaires shall be directed and agreed on site with the Architect.

All wiring connection to luminaires shall be installed in conduits and terminated in ceiling roses. Connections for ceiling roses to the luminaires shall be in flexible conduits.

Final connections to luminaires in areas of suspended ceilings shall be in flexible conduit bonded by male brass bush and serrated washer direct to luminaires.

The Sub-Contractor shall include for adapting conduit terminations to suit the specified luminaires and method of installation.

Prior to commencement of site works installation drawings incorporating the manufacturer's recommendations shall be submitted for checking complete with all fixing details, suspensions and supports.

Fluorescent luminaires shall be independently suspended from the soffit or ceiling by adjustable brackets to the satisfaction of the Architect. In areas without suspended ceilings, luminaires shall be supported on conduit suspensions painted to match the ceiling finish.

All external lights shall be mounted on the lamp post with the height as shown on the Sub-Contract Drawings. Unless otherwise specified all lamp posts shall be constructed by hot-dipped galvanized steel and painted with two layers of under coat. The colour of the lamp post shall be determined by the Architect.

Electrical Installation Busduct System

1. DESCRIPTION

The proposed busduct shall be copper make unless otherwise specified.

All system components including busducts, busduct tap-off units, elbow, etc., shall fully comply with this Section.

The low impedance copper busduct distribution systems shall comprise metal-clad three phase with full neutral and separate 50% earth busbar in straight, elbow and custom bend sections, flanged ends, enclosures, expansion joints, wall flanges, fire stops, spring supports, adaptor channels, hangers, supports, cable/busbar transition enclosures, etc.. Accessories and busduct systems shall be of the same rating and fault current withstand level throughout unless otherwise specified.

2. MANUFACTURE

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

All equipment and accessories delivered to site shall be new and shall be clearly marked to identify different types, materials and sections of the busducts.

3. STANDARDS

All equipment, materials and workmanship shall comply and type-tested to IEC 61439-6 and installed in accordance with SS CP 5 and Fire Safety and Shelter Department's requirements. The type test certificate shall be issued by an independent and recognised test authority (eg. ASTA, KEMA, etc.).

4. BUSDUCT

The busduct shall be of copper conductors consisting of three phase, full neutral and half-size earth busbar.

The copper busbars shall be electrolytically tin-plated. Each busbar shall be insulated over its entire length with epoxy Class B insulation or its equivalent.

The busbar shall be designed and tested such that the temperature rise at any point in the busbars shall not exceed 55°C rise based on a 40°C ambient temperature operating at full rated current condition.

The busduct housing shall be rust proofed metal clad or extruded aluminium housing, totally enclosed and non-ventilated to protect against mechanical damage and dust accumulation. Suitable water sheds shall be installed, where the busduct crosses expansion joints, to guard against possible building leakage. The construction of the busduct housing shall be such as to reduce hysteresis and eddy current losses.

Weatherproof type feeder busduct housing shall be designed to exclude entrance of water and prevent possible moisture condensation. A gasketed joint cover shall be provided to ensure a completely weatherproof joint. The design shall allow the busduct to be mounted in any position and remain weatherproof.

Where the busduct passes through wall and floors, space so enclosed by the wall flanges shall be sealed with a fire stop material acceptable to the busduct manufacturer and to

Electrical Installation Busduct System

FSSD's requirements.

The busduct joint design shall permit safe, practical testing of joints for tightness without de-energizing. This operation must be possible without exposing maintenance staff to any electrical hazard and without downtime of the busduct and equipment it feeds.

Access shall be required to only one side of the busduct for tightening joint bolts for runs close to a ceiling or wall. It shall be possible to remove any one length in a run without disturbing the two lengths which it connects. All bolted connections shall include Belleville washers.

Expansion joints in feeder busduct shall be provided where the structural expansion joints occur. The busduct expansion joints shall be capable of taking up all thermal expansion due to the temperature differential of the busbars, the building expansion joint differentials of 15mm.

The short circuit rating of feeder busduct and of plug-in busduct shall not be less than 65kA R.M.S. symmetrical at 433V, unless otherwise specified.

Busduct systems that cannot provide a type test certificate for the above mentioned short circuit rating, and therefore cannot guarantee its performance under these conditions will not be accepted.

The busduct system shall be designed to operate on a 400V/230V 3-phase 50 Hz supply and shall be of the low impedance type in order to regulate the volt drop to the minimum value.

Spring vertical hanger shall be provided at every floor level to support the busduct. Expansion joints shall be provided at intervals of every 40 metres.

The vertical busduct shall be designed and provided in such a way that every one section or unit shall be removable without disturbing adjacent units.

All bolts, nuts and screw washer hardware, etc shall be zinc-coated.

5. PLUG-IN BUSDUCT TAP-OFF UNITS

Plug-in busduct shall have a minimum of three plug-in openings on each floor and all openings shall be usable simultaneously. Each phase position of plug-in openings shall be individually insulated. It shall be possible to inspect the plug-in openings and busduct prior to the installation of the plug.

The plug-in busduct system shall be complete with purpose made plug-in tap-off units of similar manufacture, size and rating as shown on the Sub-Contract Drawings.

Each plug-in tap-off unit shall be mechanically interlocked with the busduct housing to prevent installation or removal of units while in the "ON" position, and be equipped with an openings handle which always remains in control of the switching mechanism.

Plug-in unit enclosures shall make positive earth connection to the busduct housing before the jaws make contact with the busbars. This earthing method shall be such that it cannot be defeated by future painting of the housing.

The plug-in tap-off units shall be equipped with internal barriers to prevent accidental contact

Electrical Installation Busduct System

with pull wires and conductors with live parts on the line side of the protective device during time of wire pulling.

Covers of all plug-in units must have "releasable" type interlocks to prevent the cover from being opened while the breaker is in the "ON" position. The units must be provided with means for padlocking the breaker in the "OFF" position.

Plug-in tap-off units must be equipped with means for direct positioning or hanging so that all weight is borne by the duct before the plug-in jaws make contact. For safety reasons, no projections shall extend into the housing other than the plug-in jaws.

The plug-in tap-off units enclosures shall contain a moulded case circuit breaker complying with IEC 60947-2 of the rating and type specified on the Sub-Contract Drawings and arranged to give close excess-current protection to the outgoing circuits, automatically tripping on overload and short circuit.

The overload tripping shall be operated by a thermal device with inverse time characteristics and short circuits shall be cleared by magnetic tripping.

Each outgoing circuit M.C.C.B. shall be capable as a whole of withstanding the electrical and mechanical stress produced by interrupting prospective fault currents of up to and including 35,000 amperes R.M.S. at 415V, unless otherwise specified.

The case of the M.C.C.B. shall be manufactured from a moulded phenolic material or similar with a high mechanical strength and non-tracking properties. The operating handle shall be trip free and have the three positions "ON", "OFF" and "TRIP" clearly indicated in the toggle slot, visible from the tap-off unit operating position.

Means of preventing unauthorized personnel from operating all circuit breakers shall be provided by means of padlocked handles or the other approved method.

M.C.C.B's shall have suitable terminals ready for accepting cables running to area sub-distribution boards.

6. INSTALLATION

The Sub-Contractor shall provide all labour and material to form the complete busduct distribution system as specified in this Sub-Contract.

The installation shall generally be in accordance with the Sub-Contract Drawings but full allowance shall be made by the Sub-Contractor for the detailed development and on-site co-ordination of the scheme and for future removal and dismantling of faulty sections.

The busduct system shall be supported by hangers spaced and side braced (designed and provided by the Busduct Manufacturer), in accordance with the manufacturer's recommendations. The side bracing shall be designed to give sufficient support to the busduct in order that no visible stress is apparent from either unbalanced plug-in tap-off units or from supporting a man and ladder.

The feeder busduct vertical risers shall be supported at each floor by a spring support system (designed and provided by the Busduct Manufacturer) which shall be capable of supporting the full weight of the busduct and shall make allowance for thermal expansion. Where floor to floor height exceeds 5m, intermediate spring supports shall be provided.

Electrical Installation Busduct System

All hangers spaced, side braced, spring support system and spring supports shall be designed and provided by the Busduct System manufacturer.

The plug-in tapping off units where installed on the vertical busduct shall be in the up-right position. Under no circumstances, shall the tap-off units in the upside-down position be acceptable.

Busduct housing shall be either galvanised steel or aluminium. Hangers, and side braces shall be galvanised steel.

Horizontal busduct system installations shall include all supporting steelwork fixed to suit the building structure and arranged to facilitate future removal of damaged or defective busduct sections.

Supports shall be by demountable proprietary steel channel system of "Unistrut" manufacture, type P1000, 40mm width or equal, constructed in accordance with the manufacturer's data and recommendations to carry the busduct system loads with a minimum factor of safety of 5.

All components of the supporting steel channel shall be by one manufacturer to ensure compatibility and uniformity with hot dipped galvanized finish.

All fittings, joints, intersections and supports shall be made using proprietary components utilizing two 12.50mm diameter bolts for each connecting leg.

Provision shall be made to install flush steel channel concrete inserts type, as type P3200 or equal by casting in line mass concrete in the positions indicated on the Drawings.

The regularity of 1.5m centres of these channel inserts shall form the construction matrix for the busduct supporting steel channel framework.

Electrical Installation Uninterruptible Power Supply

1. GENERAL DESCRIPTION

The present specification indicates the characteristics required for the supply of Uninterruptible Power Supply (UPS) Systems. The product supplied must be compatible with the specification requirements. Any departure from the specification must be indicated in the bid phase.

2. MATERIALS/COMPONENTS INCLUDED

- a. IGBT Rectifier/Charger
- b. Inverter
- c. Static transfer switch
- d. Rechargeable sealed lead acid battery
- e. Control, indication and alarm
- f. Remote indication, alarm and control panel via PC
- g. Main By-pass Switch
- h. Battery Cabinets and DC Breakers

3. SUBMITTALS

- a. Tender Stage
 - i. Technical data and product catalogues (inclusive of battery)
- b. Site Installation and Commissioning
 - i. Installation manual
 - ii. Testing and commissioning test procedures
 - iii. Testing and commissioning test records
 - iv. O&M manuals

4. DESCRIPTION

- a. The system required of rating (refer to drawing) kVA uninterruptible power supply (UPS) system with (refer to drawing) back-up time. On Line double conversion (VFI) technology. The load is constantly powered by the inverter, which provides a sinusoidal voltage that is filtered and stabilized in voltage, form and frequency. Moreover, the input and output filters significantly increase the immunity of the load against mains interference and lightning.
- b. The UPS system has to provide a power supply that is filtered, stabilized and reliable (On Line double conversion VFI technology in accordance with standard IEC62040-3) with filters for the suppression of atmospheric noise. The on line technology guarantees maximum protection for the connected loads. A double conversion stage

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is also required to filter and stabilize the input voltage, by regenerating it and removing mains interference (over voltages, frequency and voltage fluctuations)

- c. The UPS shall be capable of providing precise, continuous and regulated output voltages regardless of voltage variations, transient peak and peak outages as specified here within. The equipment shall be fully tropicalised and designed to operate 24 hours a day, 365 days a year.
- d. The Battery Bank shall be AGM technology with high performance and high capacity rate that provide (refer to drawing) autonomy back-up time for full load of (refer to drawing) kVA in the event of absence of the mains supply

5. QUALITY ASSURANCE

- a. The UPS manufacturer should qualify as confirming to ISO 9001.
- b. The UPS system shall be designed, manufactured, and tested in according with the application portion of the latest edition of the following standards,
 - i. Standard IEC/EN 62040-1-1 - Uninterruptible power systems (UPS) Part 1-1 General and safety requirements for UPS used in operator access areas;
 - ii. Standard IEC/EN 62040-1-2 - Uninterruptible power systems (UPS) Part 1-2 General and safety requirements for UPS used in restricted access locations;
 - iii. Standard IEC/EN 62040-2 - Static uninterruptible power systems (UPS) Part 2 Electromagnetic compatibility (EMC) requirements;
 - iv. Standard IEC/EN 62040-3 - Static uninterruptible power systems (UPS) - Methods of specifying the performance and test requirements
 - v. Standard IEC/EN 50272-2 - Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries;
 - vi. Standard IEC/EN 60896-11 Lead acid stationary accumulator batteries. General requirements and methods of test. Part 1: Vented types.
 - vii. Standard IEC/EN 60896-21 - Lead acid stationary batteries, part 21: valve-regulated types - Test methods;
 - viii. Standard IEC/EN 60896-22 - Lead acid stationary batteries, part 22: valve-regulated types - Requirements;
 - ix. Standard IEC/EN 60146-1-1 - Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specifications of basic requirements
 - x. IEC/EN 60950-1 - Information technology equipment - Safety Part 1: General requirements.
 - xi. ISO 3746 - Acoustics - Determination of sound power levels of noise sources using sound pressure - Survey method using an enveloping measurement surface over a reflecting plane.

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- xii. Standard EN 60529-2 (Europe). Protection levels of enclosures (IP rating).
- xiii. Standards ASTM D999 and D800 and AFNOR NF H 00-042. Transportability and resistance to vibration, inclined planes and tipping over.

The static UPS to which this specification relates must carry the CE mark, in accordance with European directives on safety and radio interference (2006/95/CE Low Voltage Directive and 2004/108/CE EMC).

- c. The manufacturer shall have more than 20 years' experience in the manufacture of similar equipment.
- d. The manufacturer shall have full parts back-up and service availability for the equipment provided.

6. SYSTEM REQUIREMENT

The UPS shall be designed to operate with the following input power characteristics without any deviation from the output performance required:-

- a. Efficiency (AC to AC) $\geq 95\%$ at 100% load

Operating temperature: 0 to 40°C

Relative Humidity: 95% at non-condensing

Noise should be less than $\leq 55\text{dBA}$ at 1 meter [from 10 to 40kVA UPS], $\leq 65\text{dBA}$ at 1 meter [from 60 to 160kVA UPS], $\leq 74\text{dBA}$ at 1 meter [from 160 to 1000kVA UPS],

b. INPUT POWER CHARACTERISTICS

- i. UPS Input Voltage/Phase: 400VAC / 3-phase.
- ii. UPS Input Voltage Range: $\pm 20\%$ and up to -40% at partial load.
- iii. UPS Input Frequency: 50Hz
- iv. Power Factor ≥ 0.99
- v. Current distortion (THDi): $\leq 2.5\%$

c. OUTPUT POWER REQUIREMENT

- i. The UPS shall carry its rated load continuously with the following performance and UPS components under the above-mentioned input characteristics and environmental conditions.
- ii. UPS Output Voltage/Phase: 400VAC /3-phase + N
- iii. Frequency: 50 Hz
- iv. Output power factor: 1.0
- v. Output Voltage distortion: $< 1.5\%$ @ linear load
 $< 5\%$ @ non-linear load

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- vi. Frequency accuracy: $\pm 0.1\%$

Overload capacity:

125% for 10 minutes,

150% for 1 minutes,

7. FUNCTION & OPERATION

The UPS shall be capable of but not limited to the following functions:-

- a. The A/C Main supplies to an IGBT (Isolated Gate Bipolar Transistor) rectifier that is rigidly connected to the battery and inverter input. During normal operation use rectifier supplies the full inverter input current as well as it provides the battery with floating charge. After a discharge of the battery system the rectifier charge and shall be capable to supply nominal inverter input current as well as the charging current at the same time. After the main voltage is restored as a result of a failure, charging shall automatically proceed according to a V-I characteristic. The control device shall provide not only absolute current charge limitation, but also limit the charging current for the battery to a constant value. Charging shall be possible with float voltage for normal operation the full battery capacity shall be maintained under all circumstances at the float voltage.
- b. A fully automatic static main bypass shall be provided. In normal operation the load is supplied with power through charger and inverter (converter). If a failure occurs inside the converter, uninterrupted changeover to the mains shall take place. The static main by pass shall be designed for further advantages. Should a very large load variation or over load occur the bypass shall be automatically switched on to supply the excessive current from the main during few cycles, provided the inverter runs in synchronism with the main supply. The static main bypass switch as well as the static output switch of the inverter must be designed to operate within mili seconds. The load transfer from the static bypass to the inverter shall be affected by means of a walk in procedure so that no large load steps will be applied to the inverter.
- c. The inverter shall transformer the d.c energy into an alternative voltage of constant frequency and amplitude. The inverter shall be capable to maintain the output a.c. voltage and frequency during all permissible conditions on the d.c. circuits. Any interruption of fluctuation of the mains shall not be transferred to the output of the UPS – mode. The inverter should be on IGBT (Isolated Gate Bipolar Transistor) technology.
- d. The UPS System shall include a build-in mechanical bypass switch. This switch shall bypass the whole equipment during maintenance. If his servicing bypass is switched in the whole equipment must be dead i.e. Few parts remaining alive shall be fully enclosed. The electrical arrangement of the servicing bypass shall guarantee an uninterruptible changeover from inverter and vice versa. No separate which will be allowed from this components

8. RECTIFIER/CHARGER

- a. The incoming AC power shall be converted to a regulated DC output by the rectifier/charger. The rectifier shall IGBT (Isolated Gate Bipolar Transistor) type

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throughout with DSP (Digital Signal Processor) control.

- b. The rectifier shall be designed to limit the input Total Harmonic Current Distortion (THDi) feedback into the source to a maximum of $\leq 2.5\%$ at 100% load.
- c. The rectifier protection shall be internally fused and electronically current limited to prevent battery damage and also protect the inverter input.
- d. The UPS must be able to carry out an automatic battery test that allows the system to periodically check the efficiency of the batteries to prevent faults occurring to them. The test does not in any way compromise the power supply to the connected users and given the short duration, does not affect the life or the back up of the batteries.

9. INVERTER

- a. The inverter will be equipped with an IGBT switching circuit (PWM type) to convert the rectifier or battery DC voltage into AC, and an output filter rated to create the output voltage envelope. The inverter will be digitally controlled via DSP.
- b. The inverter must be able to deliver the rated power at the rated voltage and frequency and the following output specifications:

Inverter technology and topology	IGBT
Rated active power specified on UPS ratings plate, in accordance with EN 62040-3	(refer to drawing) kVA
Permanent maximized active power at 35°C in accordance with EN 62040-3	(refer to drawing) kVA
Stable voltage in static operation with input in the admitted range and load variation from 0 to 100%	$\pm 1\% V_n$
Stable voltage in dynamic operation with input in the admitted range and load variation from 0 to 100% and vice versa	Compliant with IEC/EN 62040-3, Class 1 (VFI-SS-111)
Distortion of voltage waveform at linear rated load	$\leq 1.5\%$
Distortion of voltage waveform with non-linear rated voltage as per IEC/EN 62040-3	$\leq 5\%$
Overload capacity for 10 minutes	125%
Overload capacity for 60 seconds	150%

- c. The inverter is equipped with its own output current-limiting logic, so that components are not damaged in the event of a short-circuit.
- d. In the case of UPS units configured in parallel, the inverter is protected by a combination of electronic circuitry and fuses.
- e. The system will indicate the following situations affecting the inverter:
 - i. general maximum temperature warning, with subsequent shutdown of the machine;
 - ii. uncoupling of frequency generator from auxiliary power source;
 - iii. tripping of power circuit fuses.

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- f. The inverter must be connected to the load (in both single and parallel configurations) via a contactor to permit galvanic separation of the circuits.
- g. In battery mode, a stability of $\pm 1\%$ of the output voltage value must be maintained to the minimum battery voltage.
- h. The inverter must be able to automatically open the battery circuit to prevent damage in case of slow discharge

10. BATTERY BANK

- a. Each Battery Bank shall be of high performance and high capacity rate and unless otherwise specified shall be capable of supplying maximum demand of the UPS output for (refer to drawing) minutes.
- b. The batteries product range offered should be designed, constructed and tested to the requirement of BS 6290 Part 1 and 4 (1997) where intended. Contractor shall state the results of all test requirements in BS Standard in their tender.
- c. The batteries shall be manufactured following quality procedures ISO 9001 and ISO 14001. International or recognised standard bodies shall validate certification of this quality procedure.
- d. The battery should be in AGM type technology.
- e. Capacity of battery offered by contractor shall be based on 25 degrees C at nominal to end voltage of 1.70 volt per cell. Minimum 2 string of batteries.
- f. The battery rack / cabinet shall be designed to provide a compact battery arrangement, easy and safe access during installation and operation. The battery cabinet shall be of steel and finished in epoxy paint and shall be acid and saline proof.
- g. The batteries shall be complete with cell inter connectors and output terminals.
- h. Calculation and manufacturer's catalogue, technical data, inclusive of battery performance curve etc. must be submitted to prove the adequacy of the ampere hour capacity etc. of the battery bank. The batteries shall also be able to withstand rapid recharging.

11. AUTOMATIC BY-PASS

- a. A static bypass must be installed in parallel with each inverter (for both single and parallel installations) to provide:
 - i. automatic load transfer without interruption to the standby power supply in case of :
 - 1. overload;
 - 2. out of tolerance inverter input DC voltage;
 - 3. over-temperature;

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4. inverter fault;
- ii. automatic transfer from standby circuit to inverter when normal conditions are restored, and verification of the inverter parameters.

Transfer time with inverter synchronous with bypass	No interruption
Maximum overload:	
• permanent	110%
• for 10 minutes	125%
• for 1 minutes	150%

- b. The UPS must continuously monitor the standby power supply parameters (voltage, current and frequency).

12. INTERNAL MAINTENANCE BY-PASS

- a. Non-automatic switch. By closing the maintenance by-pass switched and opening all the other switched the UPS is excluded, while the power supply to the load is maintained.
- b. This operation must be performed whenever any maintenance or repair works needs to be carried out on the internal components of the UPS. When the maintenance by-pass switch is closed and all the other switches are open there is no voltage present inside the machine. These devices are essential for UPS systems of a certain size, where maintenance work is carried out on site.
- c. The maintenance by-pass shall allow continuing powering the load, without affecting the system.

13. USER INTERFACE, CONTROLS AND ALERTS

- a. User interface

The user interface on the UPS must be composed of a colour graphic display as follows:

- i. High visibility screen;
- ii. Reinforced protection against accidental impact.
- b. The interface must provide the following controls/alerts:
 - i. synoptic electrical diagram of the UPS;
 - ii. selectable languages: at least 30, including English, French, Italian, Spanish, German, Swedish, Polish, Russian and Chinese, with localised installation and user manual.
 - iii. There must be a USB port for updating the languages and downloading the event/alerts log.
 - iv. Display of the following parameters:

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1. input and output voltages;
2. input and output currents;
3. input, output and auxiliary frequency;
4. battery voltage;
5. total and remaining battery capacity;
6. battery charge / discharge current;
7. apparent and active power;
8. output load

v. Statistical and graphical measurement of:

1. capacities less than 2 minutes, from 2 to 5 minutes, and greater than 5 minutes;
2. output load;
3. overload less than / greater than 5 seconds;
4. loss of redundancy;
5. internal and battery temperature;
6. time of operation as genset.

c. Communications

The UPS will be able to communicate with the central control system via:

- i. Status, measurements, alarms and controls are transmitted via serial link RS485 using MODBUS protocols and SNMP card.
- d. The system must be able to send SMS's over a GSM modem, to report particularly important alerts and events.

The configuration must be settable via the HTML interface.

Remote serial alerts and commands

The interface must be able to display at least the following status or event information:

- i. general alert;
- ii. battery mode with mains supply / no mains supply;
- iii. normal operation (inverter in-line);

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- iv. static bypass operation;
- v. residual capacity in battery mode;
- vi. battery low charge warning;
- vii. battery on fast charge;
- viii. abnormal battery recharge voltage;
- ix. minimum battery voltage;
- x. battery fault;
- xi. battery charge circuit broken;
- xii. battery charger system fault;
- xiii. overload alert;
- xiv. ventilation fault alert;
- xv. out of range temperature/humidity alert;
- xvi. standby power supply out of tolerance;

e. Communication Software

The UPS shall be supervised by software dedicated to the manufacturer's equipment on a PC workstation.

This software shall include the following functions:

- i. Animated mimic panel (up to 128 equipment)
- ii. List of status, alarms and measurements
- iii. Log file, output power curves
- iv. Web server for remote access via Ethernet

The software centralizes all the information about the manufacturer's units installed on the site.

14. FABRICATION

- a. **CONSTRUCTION.** The UPS components shall be housed in a freestanding modular enclosure having removable panels. The enclosure shall be fabricated from zinc-coated sheet steel and give protection as standard to IP20.
- b. **MOUNTING.** The UPS shall be structurally adequate and have provision for hoisting, jacking and fork lift handling from the front.
- c. **ACCESS.** All internal subassemblies shall be accessible for servicing, adjustment

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and installation from the front of the unit via hinged doors. Rear access shall not be required for installation or servicing.

- d. WIRING. Cable entry shall be from the bottom on all cabinets, and shall also be possible from the top as an option.
- e. The cooling system shall be of the forced ventilation type such that cool air shall be drawn into cubicles and exhaust out through the back / top. Motor-driven fans protected against overload by means of circuit breaker or fuse shall affect the cooling system.

15. ACCEPTANCE TESTS [FACTORY ACCEPTANCE TEST & SIDE ACCEPTANCE TEST]

This section provides a brief description of the intent of the design, and shall in no way be exhaustive

The tests, with a representative of the client in attendance, includes the following steps:

- a. documentation check
- b. design, fabrication and installation check
- c. interconnections
- d. instrumentation check
- e. options description
- f. description of synoptic panel
- g. rectifier static performance
- h. battery and charger performance
- i. inverter static regulation
- j. inverter overload (with resistive load)
- k. inverter dynamic regulation
- l. bypass transfer test

All tests must be conducted with appropriate instrumentation with valid calibration certificates.

Following a positive outcome of the testing procedure, the manufacturer will issue the relative certificate listing the tests conducted and the results obtained.

16. SPARE PARTS

The supplier shall undertake to supply spare parts for a minimum period of 10 years after delivery and installation.

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17. WARRANTY

Warranty is 12 months after site full handover for parts and on-site labour for the UPS and Battery.

Quarterly preventive maintenance visit shall be included after commissioning and during warranty period.

Electrical Installation Earthing

1. DESCRIPTION

The earthing system shall consist of earth electrodes and earth continuity conductors, etc., for providing safety earth to the electrical system.

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

All equipment and accessories delivered to site shall be new and shall be clearly marked to identify different type and materials.

All equipments shall be suitable for use in tropical climate.

2. STANDARD

All equipment, materials and workmanship shall comply with Singapore Standards.

The earthing system shall comply with the requirements of SS CP 5 and SS 551.

All aspects of the installations shall comply with the statutory obligations and Electricity regulations.

3. POWER SYSTEM EARTH

The Sub-Contractor shall provide, install, test, commission and set to work a complete earthing network as shown on the Sub-Contract Drawings and specified herein in respect of the HV and LV electrical installation. The Sub-Contractor shall include for payment of all necessary fees to SPPG.

Power system earth tapes shall be tinned copper tapes with 25 x 3mm cross-section.

All metal work associated with the installations not forming part of a phase or neutral circuit shall be bonded together and shall be solidly and effectively earthed.

4. EARTH ELECTRODES

Each earth electrode shall comprise of one or more hard drawn copper rods of 16mm diameter and provided with bronze couplings (in lengths of 2500mm). Each electrode shall be spaced at a minimum distance of 3m apart.

5. EQUIPOTENTIAL BONDING

Equal potential bonding shall be provided for all exposed metallic parts by the Sub-Contractor, in accordance to CP 5 and SS 551.

This bonding shall include but not be limited to any metallic window frames, doors and door frames, handrails, curtain rails, sinks, bath tubs, towel rails, brackets and pipes, etc.

6. BONDING OF PIPES, WATER HEATERS, ETC.

In addition to above Clause 13.5, the Sub-Contractor shall pay special attention to bond all water and gas pipes (after water and gas meters) either for each apartment units in compliance with authorities' requirements.

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Hot water pipes of water heaters (in all apartment units) and steel bath tubs in apartment units shall also be bonded to earth.

All Breeching inlets are to be bonded and provided with earth pits.

7. INSTALLATION

a. POWER SYSTEM EARTH

Networks shall be formed from plain annealed copper strip complying with B.S. 6360:1969 of cross sectional area of not less than 180mm² and shall be provided complete with a green PVC over-sheath complying with B.S. 6746. In areas where the PVC sheath is not provided, the copper strip shall be tinned over its entire length.

Joints in the earth bars shall have a resistance not exceeding that of an equivalent length of conductor, and the Contractor may require any joints to be tested to prove compliance with this requirement. No drilling of the earth conductor shall be allowed except for jointing or terminating unless approved by the Architect.

Joints in, and connections to, the earthing system shall be so effected as to avoid reduction of the current-carrying capacity of the earth bar. Special precautions shall be taken to ensure that the available contact area is fully utilised in all connections to plant and apparatus.

The contact faces of earth terminals shall be cleaned before connections are made to the earthing system.

Along each sectional joints of cable trays or cable trunking, a copper strip shall be provided to electrically bond the two joining sections.

b. L.V. EARTHING

This electrical earthing system shall be installed both vertically and horizontally along the routes shown on the Sub-Contract Drawings and shall form network bonding all HV and LV switchboards, motor control panels, distribution boards and associated metal work to a common building earth bar.

A tinned copper terminal bar not smaller than 50mm x 6.4mm cross section shall be provided by the Sub-Contractor in each of the plant room. The Sub-Contractor shall be responsible for connecting the earth tapes to the terminal bar.

All switchboards, motor control centres and distribution boards shall be fitted with a 180mm² tinned copper earth bar over their entire length to which the building main earth network shall be connected.

Transformer frame earths shall be connected to the L.V. and H.V. system earth bar but transformer neutrals shall be earthed separately via the neutral earthing strips.

Standby Generator frames and neutrals shall be earthed as part of the L.V./H.V. earth network.

The Sub-Contractor shall provide and install the PVC-insulated earth to the generator room and terminate on to the generator main frame earth.

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c. NEUTRAL SYSTEM

A neutral earth system shall be provided which interconnects the transformer neutrals and any standby generator neutral bar by means of a 180mm PVC copper tape. The Sub-Contractor shall provide and install PVC-insulated earth to the location of the generator room neutral earth bar leaving sufficient spare tape to allow for the connection of the tape to the bar.

d. EARTH ELECTRODES AND PIT

All the common bars specified for the above systems shall finally be run to ground level where they shall be solidly and individually earthed by means of multiple earthing electrodes which shall be spaced a minimum of 3.0m apart.

The lightning protection earthing system shall NOT be connected to the electrical earthing system. Separate earth electrodes/pits shall be provided.

The earthing electrodes shall comprise hard drawn copper rods 16mm dia. and 2500mm long driven into the ground, and the Sub-Contractor shall include for at least two electrodes per earth pit. More rods shall be provided where necessary to obtain an earth resistance of not more than 1 ohm for electrical earthing system and shall not exceed 10 ohm for lightning protection system.

Each individual earthing system shall be connected to their separate earthing electrode systems by means of PVC-insulated tinned copper tape or strip of the size specified above.

Any copper tape exposed externally shall be protected against mechanical damage and theft.

On completion of the electrical installation the earthing resistance shall be TESTED and WITNESSED IN THE PRESENCE OF THE ARCHITECT OR HIS REPRESENTATIVES. The testing results shall be presented to the Contractor for approval.

Earthing leads shall be clamped to the earth electrode by bolted clamps as approved and supplied by the earthing electrode manufacturer. The method shall allow the disconnection and testing and remaking as many times as necessary.

For each earth electrode, the clamping arrangements shall be contained within a small concrete lined pit with an easily removable galvanised iron lid to enable inspection at will.

All earthing electrodes forming a system shall be linked together by means of a PVC-insulated tinned copper earthing tape of the dimensions indicated above.

The earthing / bonding clamps installed shall comply with SS 322 and completed with a permanent label marked with the words "SAFETY ELECTRICAL EARTH - DO NOT REMOVE" in English permanently attached to the final earthing leads connection.

Electrical Installation Testing And Commissioning For Low Voltage

1. DESCRIPTION

This section sets out the basic requirements for the testing and commissioning of the entire electrical installation.

The Sub-Contractor shall be responsible for the complete and thorough testing and commissioning of the system/equipment installed and to bring into safe and reliable operation the entire Electrical System. All instruments, materials and labour necessary for the tests shall be provided by the Sub-Contractor at no extra cost to the Employer.

2. MATERIALS AND EQUIPMENT SUPPLY

All materials and equipment supplied and installed under this Sub-Contract which fail the test shall be replaced or rectified by the Sub-Contractor without extra cost to the Employer and further tests shall be carried out.

3. TESTS BY LICENSED ELECTRICAL TESTING ENGINEER

All tests on installation, equipment and materials as described under this Section shall be conducted by the Licensed Electrical Engineer holding a valid High Voltage Switching Licence for HV installation (or appropriate grade of Licensed Electrical Worker for LV installation). The Sub-Contractor shall be responsible for arranging its qualified Testing Engineer for such tests at no extra cost to the Employer.

4. NOTICE

The Sub-Contractor shall notify the Architect / Consultants in writing of his programme to test and commission the equipment and systems at least seven (7) days before actual execution.

5. RECORDS

The Sub-Contractor shall make records of all tests which shall be conducted in the presence of and to the satisfaction of the Architect / Consultants. Written reports of the results of all tests etc. shall be submitted in duplicate by the Sub-Contractor to the Architect / Consultants within seven (7) days of completion of such tests.

6. TESTING

The Sub-Contractor shall be responsible for the testing of all switchboards, sub-main cabling, final sub-circuits, earthing, etc. Generally, tests shall include but not be limited to the following:

- a. Insulation resistance and continuity tests.
- b. Operation of protective relay circuits and system faults circuits for checking sensitivity and stability.
- c. Earth fault loop impedance and earthing system tests.
- d. Phasing out, polarity and phase rotation tests.
- e. Functional tests on correct operation of interlocks, tripping, closing circuits and indications.

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- f. Effective bonding of earth terminals in metal enclosures of all light fittings, switches and socket outlets.
- g. Measuring instruments and sensing equipment accuracy.
- h. Tightening torques for the verification of mechanical strength at all cables terminations based on the manufacturer's instructions, or in the absence of such instructions, in accordance with the respective IEC standards.
- i. Any other tests as reasonably required by the Architect / Consultants.

7. PROTECTION RELAY SETTING TEST

The Sub-Contractor shall be responsible for the calibration and setting of all protection systems in the presence of the Architect / Consultants. All settings shall then be permanently marked on the control equipment. All calibration procedures shall be properly recorded.

8. TYPE TESTS AND BATCH TEST

The Sub-Contractor shall submit Type Test and Test Certificates issued by recognised Testing Authorities on specific equipment as stated in this Specification. All Controlled Goods as specified by the Safety Authority shall be batch-tested by PSB and bear the approved Safety Mark label.

9. AUTHORITIES TESTS

The Sub-Contractor shall prepare all necessary documents/drawings and make all necessary arrangements including paying any fees incurred for all tests required by the relevant Authorities before and after the installation turn-on. It is the responsibility of the Sub-Contractor to ensure that the tests are scheduled to avoid delay in the turn-on and overall completion of the project.

It is the responsibility of the Sub-Contractor to arrange and make appointment with relevant testing authorities such as SP Services and SP PowerGrid to jointly carry out the inspection and testing of the electrical installation of each apartment unit (or sample unit test) and obtain clearance from the relevant Authorities prior to the application of TOP of the whole project. All fees for the tests and re-tests incurred shall be borne by the Sub-Contractor.

10. GENERAL TESTS

The following tests shall be made on site during and on completion of erection of the switchgear. All tests shall be carried out by a LICENSED ELECTRICAL TESTING ENGINEER with appropriate class.

a. CURRENT CARRYING AND EARTHING CONNECTION

All primary conductors and conductors used for the earthing system shall be tested to ensure full clamping pressure is applied to all contact surfaces and that all bolted connections are tightly secured with lock washers. Flexible connections shall be tested to ensure that sufficient slack is available for expansion.

b. SECONDARY WIRE AND CIRCUITS

All wiring shall be checked against wiring diagrams provided by the Sub-Contractor.

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Testing And Commissioning For Low Voltage

Tests shall be made to ensure the continuity of each wire.

c. **OPERATION TESTS**

The operation of trip and closing devices, mechanism motors, etc. shall be checked.

d. **BATTERY TESTS**

Battery units shall be checked and tested for correct output voltage and proper functioning of charging equipment.

11. COMMISSIONING TESTS FOR SWITCHGEAR

a. **MECHANICAL OPERATION TESTS**

All circuit breakers shall be tested for satisfactory performance by subjecting it to the mechanical operating tests as follows :-

- i. Electrical closing and opening operating operation test at maximum, minimum and rated DC supply voltage. Motor-charging operation test shall also be tested at minimum AC supply voltage.
- ii. Manual operation cycle (ON and OFF test).

All disconnectors and earthing switches shall be tested for satisfactory performance and subjected to the mechanical operation test as follows :-

- i. Operating cycle (ON and OFF) test.
- ii. Inserting and withdrawing of circuit breaker to various positions as specified in the technical specifications.

b. **INTERLOCK TESTS**

The correct operation of the interlocks shall be checked.

c. **CONTACT RESISTANCE TEST**

The contact resistance of each pole of the main circuit breaker shall be measured with 100 amps DC in accordance to Clause 3.1 of BS 5311 Part 4.

The resistance measured in the closed position shall not exceed $1.2R$ where R is the resistance measured during the corresponding type test.

d. **SI TEST**

Relays shall be tested for accuracy and compliance with BS 202 requirements by the secondary current injection method.

This test shall be conducted by a licensed electrical worker of appropriate grade.

e. **RELAY OPERATION AND TRIPPING TESTS**

All relays shall be operated to assure the correct tripping of circuit breaker.

Electrical Installation Testing And Commissioning For Low Voltage

f. SECONDARY WIRING TESTS

The insulation of the secondary wires and circuits shall be checked with an insulation tester.

g. SUPERVISORY CONTROL SYSTEM

The complete supervisory control system inclusive of accessories and wiring shall be checked by simulation and insulation tests.

h. PI TEST

All protective systems shall be tested for correct current transformer ratio, polarity and relay operation by the primary current injection method.

This test shall be conducted by a licensed electrical worker of appropriate grade.

12. POWER CABLES

a. INSULATION TEST

Megger test shall be carried out immediately before and after pressure test to measure the insulation resistance between conductors and between conductors and the sheath.

b. PRESSURE TEST

Test voltage shall be applied between conductors and between conductors and the sheath for a 10-minute duration. The test voltage shall be 48kV between conductors and between conductor and sheath.

13. CONTROL CABLES

Megger tests shall be carried out to measure the insulation resistance between conductors and between conductors to earth.

14. CURRENT AND VOLTAGE TRANSFORMERS

a. CURRENT TRANSFORMER

The polarity and spill current shall be tested at 100% rated current.

b. VOLTAGE TRANSFORMER

The following tests shall be carried out on site:-

- i. Polarity Check
- ii. Phase sequence test

15. IDMTL RELAYS

The following secondary injection tests shall be carried out during commissioning :-

Electrical Installation Testing And Commissioning For Low Voltage

a. OPERATING CHARACTERISTIC TEST

With the plug setting at the designed value, the operating characteristic test shall be carried out on the relays at unity time multiplier for a current up to 10 times of plug setting.

b. TIME MULTIPLIER TEST

With the plug setting at the designed value and with an injection current at 200% of plug setting, the operating time at time multiplier setting at 0.2, 0.5 and 0.8 shall be tested.

c. PICK UP CURRENT

With the plug setting at the designed value, the minimum current at which the relay disc starts to rotate shall be measured.

Primary injection shall be carried out to verify the operation of each relay at all likely type of faults as prescribed by the Engineer.

16. PHASING TEST

The Sub-Contractor shall be responsible for phasing tests on the LV switchboards after turn on. Such tests shall be carried out by the Licensed Electrical Tester.

17. OTHERS

a. REPEAT TESTING AND SITE TEST REPORT

If to the discretion of the Engineer, certain tests need to be repeated (eg mechanical operation test) numerous times, the Sub-Contractor shall be required to carry out these tests until such time as the Engineer is satisfied with the results.

All tests as listed above shall be conducted by the Licensed Electrical Engineer of appropriate grades. Satisfactory test reports shall be submitted to EMA for recording/approval with copies (3 sets) to the Engineer prior to the scheduled turn-on of the supply.

b. HANDLING-OVER OF EQUIPMENT

The physical finishing of switchgear, alignment, satisfactory mechanical operation of switchgear and accessories, etc. shall be checked in the presence of the Engineer.

Extra Low Voltage Installation Structural Cabling Installation

1. Purpose

The purpose of this document is to provide a standard specification that will be used for all NTU facilities requiring cabling installation. This document provides the minimum performance criteria for the components and sub-systems comprising a complete cabling system that shall accommodate the NTU's requirements.

2. General Requirement

This document provides the minimum performance criteria for the components and sub-systems comprising the patch panels, frames, patch cords, cables, faceplates and outlets necessary to build a standard compliant generic premises cabling system.

Product specifications, general design considerations, and installation guidelines are provided in this written document. Quantities of telecommunications outlets, typical installation details, cable routing and outlet types for a specific facility will be provided as an attachment to this document. If the bid documents are in conflict, the written specification shall take precedence. The successful vendor shall meet or exceed all requirements for the cabling system described in this document.

The proposed cabling solution shall function for a multi-media communications solution and guarantee to support up to 1000Mbps (1GBE) transmission rate for copper and 10GBE transmission rate for fiber to the work areas and Backbone cabling. The cabling system shall be backed by a 25-Year System Warranty program. The system warranty shall be facilitated by the Contractor and be established between NTU and the cabling system Manufacturer.

a. Conformity to Standards

The cabling system described in this specification is derived in part from the recommendations made in industry standard documents. The list of documents below is incorporated by reference. The latest versions of the following standards are to be complied with unless otherwise specified:

i. ISO/IEC 11801:2002 Ed 2

Information Technology – Generic cabling for customer premises – Class A to F

ii. ISO/IEC 11801 Ed 2 Amendment 1:2008

Information Technology – Generic cabling for customer premises – Class EA and FA Channels

iii. ISO/IEC 11801 Ed 2 Amendment 2:2010

Information Technology – Generic cabling for customer premises – Class EA and FA Permanent Links and Components

iv. ISO/IEC 14763-2

Information technology – Implementation and operation of customer premises cabling

Extra Low Voltage Installation Structural Cabling Installation

Part 2: Planning and installation

v. ISO/IEC 14763-3:2006

Information technology – Implementation and operation of customer premises cabling

Part 3: Testing of optical fibre cabling

vi. ISO/IEC 14763-3 Amendment 1:2009

Information technology – Implementation and operation of customer premises cabling

Part 3: Testing of optical fibre cabling – Amendment 1

vii. IEC 61935-1

Generic specification for the testing of generic cabling in accordance with ISO/IEC 11801 – Part 1: Installed cabling

- b. This specification uses the International Standard (e.g. ISO/IEC 11801) wherever possible to reflect the global nature of this specification and the expected global performance requirements.

3. STRUCTURED CABLING SYSTEM (SCS)

All products supplied under this tender shall be genuine and RoHS compliant products. Online resource must be available for the verification of the products proposed.

The communications channel shall be fully standard compliant and is capable of supporting 1GBE (1000BASE-T) Ethernet to the desktop. This shall be supported by a copy of the certificate from an independent 3rd party test laboratory during document submission for the tender.

All copper products in the communications channel shall be from a single-manufacturer solution capable of supporting the provision of power to the Data Terminal Equipment via the electrically conductive Media Dependant Interfaces as specified in the latest IEEE 802.3at and IEEE 802.3af “Power over Ethernet” standard.

a. Cross-Connection Distributors

The size, location and provisioning of services and facilities in the Entrance room (ER), Campus Distributor (CD), Building Distributor (BD) and Floor Distributor (FD) should be in accordance with ISO/IEC 11801.

All internal horizontal and/or backbone copper cables shall be terminated on rack mounted patch panels. The CD, BD and FD also house the rack mounted or wall mounted fibre termination units for termination of optical fibre cable as defined in the drawings.

Patch cords shall be provided when patching of voice and/or data circuits is required at the cross-connections to facilitate Moves, Adds and Changes (MAC's). The patch cords supplied shall be able to support the designed application, like 1GBE

Extra Low Voltage Installation

Structural Cabling Installation

applications.

All cabinets and racks shall be mechanically fixed/bolted to the floor and/or wall to prevent movement to themselves and the cables.

All cabinets and racks shall be augmented with horizontal and vertical management hardware, allowing excess patch cord lengths to be stored in the sides of the cabinet, both front and rear, to properly dress horizontal cables and patch cords.

b. Work Area Subsystem

Cat 6 interconnections shall be install to connect active terminal devices to the telecommunication outlets. This includes patch cords, connectors, faceplates, as well as the work area patch cords (equipment cord) needed to make connections.

i. Faceplate Specifications

The faceplate for TO installation shall include the following features:

1. Dimension: 86mm X 86mm BS style
2. A choice of 1 or/and 2 outlets
3. A clear label for application of circuit identification
4. Detachable jack holder kit that support angular mounting of the outlet/s
5. Spring loaded, transparent shutter pn the jack holder kit
6. Accepts SL series RJ45 jacks

The faceplate shall be constructed with the following materials:

1. Frame: ABS, UL94V-0, Anti-UV
2. Jack Holder: PC, UL94V-0, Anti-UV
3. Shutter: PC (clear), UL94V-0, Anti-UV
4. Frame Cover: ABS, UL94V-0, Anti-UV
5. Label Cover: Acrylic (clear)
6. Spring: Stainless Steel

ii. Telecommunication Outlets (TO) Specifications

All copper telecommunication outlets shall be 8-position / 8-contact modular jacks, accepting standard modular RJ45 plugs.

The telecommunication outlet shall include the following features:

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1. Modular jacks shall be unkeyed, unshielded, 4-pair, RJ-45, and shall fit in a .790" X
2. .582" opening.
3. Modular jacks shall terminate using 110-style pc board connectors, color-coded for both T568A and T568B wiring.
4. Each modular jack shall be wired to T568B wiring pattern
5. The 110-style insulation displacement connectors shall be capable of terminating 22-24 AWG solid or 24 AWG stranded conductors.
6. The insulation displacement contacts shall be paired with additional space between pairs to improve crosstalk performance.
7. Modular jacks shall utilize a secondary PC board separate from the signal path for crosstalk compensation.
8. Each modular jack shall meet the ISO/IEC 11801 Category 6 standards.
9. Each modular jack shall be provided with a bend-limiting strain relief. The strain relief shall provide cylindrical support to limit the bend radius at the point of termination.
10. Modular jacks shall be UL Listed under file number E81956.
11. Termination of UTP modular jacks at every TO shall be completed using a hand tool which employs a fully repeatable, self centering, non-impact mechanical termination process. This process shall simultaneously cut and terminate all 8 conductors to the modular jack.

The telecommunication outlet shall meet the following mechanical performance:

1. Modular Jack – 750 mating cycles
2. 110 Contacts – 200 terminations
3. Pull Force – 20lbs (89N)
4. Voltage – 150VAC max.
5. Operating Temperature – -40° – 70°C (-40° – 158°F)

The telecommunication outlet shall be constructed with the following materials:

1. Modular Jack Housing – Polyphenylene oxide, 94V-0 rated
2. 110 Connecting Blocks – Polycarbonate, 94V-0 rated
3. Contacts – Beryllium copper, plated with 1.27µm [50µin] thick gold in

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localized area and 3.81µm [150µin] minimum thick matte tin in solder area over 1.27 µm [50 µin] minimum thick nickel underplate

4. Insulation Displacement Contacts – Phosphorous bronze, plated with 3.81µm [150µin] minimum thick matte tin-lead over 1.27µm [50µin] minimum thick nickel underplate.

iii. Work Area Patch Cord Specifications

1. Slimline RJ-45 Cat 6 patch cords shall be install for the user work area.
2. Patch cords shall be factory terminated with 4-pair U/UTP stranded cable.
3. Patch cords shall be available with lengths of 5, 10, 15 and 20 ft.
4. Patch cords shall be available in white, blue, grey, red, green color, and fitted with transparent color strain relief boot at each end of the patch cord

c. Horizontal Distribution Subsystem

Category 6 horizontal 4 pair solid cable shall be install to connect each telecommunication outlet (TO) or consolidation point (CP) to the floor distributor (FD).

i. Horizontal Distribution Cable Specifications

The Category 6 cable shall meet the following characteristics:

1. Horizontal cabling shall be 23 AWG, 4-pair U/UTP, with a white LSZH, lead free cable jacketing material.

Description	Nominal Diameter		Vp (nom%)	Weight	Package
	Dielectric	Outside			
4-Pair LSZH	1.074 mm	6.30 mm	66	43.3 kg/km	305m PB
					305m RB

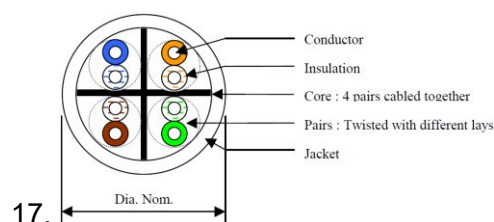
2. Performance Characteristics

Frequency (MHz)	Attenuation (dB/100m)	NEXT (dB)		PSNEXT (dB)		ELFEXT (dB)		PSELFEXT (dB)		RL (dB)	
	Maximum	Minimum	Typical	Minimum	Typical	Minimum	Typical	Minimum	Typical	Minimum	Typical
1	2.0	77	99	75	92	67.8	95	64.8	88	23.0	28
4	3.8	68	91	66	82	66.0	84	64.0	76	23.0	32
8	5.3	64	82	62	76	49.7	76	47.7	68	24.5	35
10	6.0	62	85	60	79	47.8	72	45.8	65	25.0	35
16	7.6	59	81	57	74	43.7	67	41.7	60	25.0	35
20	8.5	58	83	56	75	41.8	65	39.8	59	25.0	35
25	9.5	56	78	54	71	39.8	65	37.8	59	24.3	36
31.25	10.7	55	74	53	68	37.9	65	35.9	54	23.6	35
62.5	15.4	50	73	48	63	31.9	59	29.9	51	23.0	42
100	19.8	47	71	45	66	27.8	57	25.8	45	23.0	39
200	29.0	43	64	41	58	21.8	51	19.8	44	20.0	38
250	32.8	41	67	39	56	19.8	59	17.8	40	19.0	38

3. Impedance: 100 ohms + 15%, 1 MHz to 250 MHz

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4. Propagation delay: 536 ns/100 m max. @ 250 MHz
5. Delay Skew: 45 ns max, 1 MHz to 250 MHz
6. Min. Bend radius: 4 x cable diameter
7. Loop resistance: 30.0 ohms/100m max
8. Mutual capacitance: 5.6 nF max/100 m
9. Voltage: 300 volts AC or DC
10. Fire Rating: IEC 60332-1
11. Calorific Value: 600.00 MJ/km
12. Conductors – 0.554mm (23 AWG) solid bare copper
13. Insulation – Polyethylene.
14. Jacket – LSZH
15. Operating temperature: -20OC to +60OC
16. Storage temperature: -20OC to +80OC



ii. Horizontal Distribution Cable Installation

Horizontal distribution cable routing shall be planned to ensure adequate segregation from electrical and hazardous services, ensuring system integrity and performance, ensuring that it does not present problems of maintenance or access, and ensuring there is no conflict with the operation and maintenance of other systems.

Horizontal distribution cable shall be installed in accordance with manufacturer's recommendations and best industry practices.

Cable tray, trunking and conduits shall not be filled greater than the ISO/IEC 14763-2 maximum fill for the particular pathway type.

Cables shall be installed in continuous lengths from origin to destination (no splices) unless specifically addressed in this document.

The 4-pair U/UTP cable shall be run using a star topology format from the crossconnect at the floor distributor (FD) on each floor to every individual telecommunication outlet on that floor.

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Consolidation points (CP) are permitted provided Class E channel performance is maintained.

All horizontal U/UTP cable must meet requirement specified for current applications such as IEEE 802.3, 10/100/1000 BASE T; IEEE 802.5, 4/16/100Mbps; ATM Forum

52/155/622/1200 Mbps, 1 Gigabit Networking.

The length of each individual run of fixed horizontal cable from the floor distributor (FD) to the telecommunication outlet (TO) shall be based on the distance set out in the tables and formulas in ISO/IEC 11801 plus the appropriate length de-rating for maximum ambient temperatures above 20°C. Installed lengths may differ from the designed lengths as long as they pass testing.

iii. Copper Patch Panels Specifications

The patch panel shall include the following features:

1. Category 6 patch panels shall be 1U high and support 24 modular jack ports or 2U high and support 48 modular jack ports, wired to T568B, and shall accept RJ-45, 8- Position modular plugs.
2. The patch panel shall be integrated with built-in individual sensor contact to enable real-time connectivity management. The sensor shall be IDC type connected with I/O cable to the analyzer.
3. Patch panels shall be configured as 6-port modules with individually replaceable jacks.
4. The front of each module shall be capable of accepting 9mm to 12mm labels.
5. Each port shall be capable of accepting an icon to indicate its function.
6. Patch panels shall terminate the building cabling on 110-style insulation displacement connectors.
7. Patch panels shall be supplied unloaded with jacks bagged separately.
8. Termination of UTP modular jacks on the patch panel shall be completed using a hand tool which employs a fully repeatable, self centering, non-impact mechanical termination process. This process shall simultaneously cut and terminate all 8 conductors to the modular jack.
9. The install system shall comply with the Category 6 performance characteristics listed in the following table

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Frequency MHz	Insertion Loss dB		Return Loss dB		NEXT dB		FEXT dB	
	Category 6 Standard	Max	Category 6 Standard	Min	Category 6 Standard	Min	Category 6 Standard	Min
1	0.10	0.02	30	52.4	75.0	84.8	75.0	83.7
4	0.10	0.02	30	53.7	75.0	80.3	71.1	74.8
8	0.10	0.02	30	55.3	75.0	77.4	65.0	69.4
10	0.10	0.03	30	56.1	74.0	76.4	63.1	67.5
16	0.10	0.03	30	57.6	69.9	72.0	59.0	62.9
20	0.10	0.04	30	59.3	68.0	71.9	57.1	61.7
25	0.10	0.04	30	59.4	66.0	69.1	55.1	59.8
31.25	0.11	0.05	30	56.8	64.1	67.7	53.2	58.2
62.5	0.16	0.06	28	42.3	58.1	61.5	47.2	52.6
100	0.20	0.06	24	33.2	54.0	57.7	43.1	48.7
200	0.28	0.06	18	21.2	48.0	52.5	37.1	42.2
250	0.32	0.10	16	17.4	46.0	47.9	35.1	40.1

10. Patch panels shall be UL Listed under file number E81956

The patch panel shall be constructed with the following materials:

1. Connector Housing Interface (6-Pack Module) – Polyester molding compound, black
2. Panel – Steel, black powder coat.

iv. Patch Cords and System Leads Specifications

1. Slimline RJ-45 Cat 6 patch cords shall be install for cross-connection and/or inter- connection of termination modules, patch panels and network equipment.
2. Patch cords shall be factory terminated with 4-pair U/UTP stranded cable.
3. Patch cords shall be available with lengths of 5, 10, 15 and 20 ft.
4. Patch cords shall be available in white, blue, grey, red, green color, and fitted with transparent color strain relief boot at each end of the patch cord.
5. Cat 6 system leads shall be install to connect the network equipment to the cross- connect or interconnect modules.
6. The system leads shall be factory terminated with 4-pair U/UTP solid conductor cable with length suited to the installation.

d. Backbone Cabling Subsystem

Optical fibre cable shall be install for the data backbone between the Campus Distributor (CD), Building Distributor (BD) and each Floor Distributor (FD). Within the CD, the BDs and the FDs, backbone fibre cores are terminated and housed in rack-mount fibre termination unit (enclosures).

The 19" rack mount fibre termination unit shall consist of a frame mountable housing for terminating and/or splicing fibre optic cables and allow for organisation of the fibre optic interconnects.

Consideration should be given to the use of Pre-Terminated Optical Fibre cable for faster and easier installation.

Extra Low Voltage Installation Structural Cabling Installation

i. Optical Fibre Cable Specifications

1. Multimode optical fibre cable shall be of tight buffered or loose tube construction suitable for indoor and outdoor applications containing 50/125 micron OM3 or OM4 fibres surrounded by E-glass or aramid strength members and ULSZH outer jacket.
2. The multi-core optical fibre cable shall consist of color coded fibres for identification purpose.

The fibre cables shall meet the following transmission specification: -

where, OFL = Overfilled Launch Bandwidth, and EMB = Effective Modal Bandwidth

3. OM3 Specification (50/125 μ m Fibre):

Fibre Attenuation:	≤ 2.7 dB/km at 850 nm ≤ 1.5 dB/km at 1300 nm
Fiber Bandwidth:	$\geq 1,500$ MHz.km at 850 nm (OFL) ≥ 500 MHz.km at 1300 nm (OFL) $\geq 2,000$ MHz.km at 850 nm (EMB)
Supported length for 1GBE	1000 m (1000Base-SX)
Supported length for 10GBE	300 m (10GBase-SR)

4. OM4 Specification (50/125 μ m Fibre):

Fibre Attenuation:	≤ 2.7 dB/km at 850 nm ≤ 1.5 dB/km at 1300 nm
Fiber Bandwidth:	$\geq 3,500$ MHz.km at 850 nm (OFL) ≥ 500 MHz.km at 1300 nm (OFL) $\geq 4,700$ MHz.km at 850 nm (EMB)
Supported length for 1GBE	1040 m (1000Base-SX)
Supported length for 10GBE	550 m (10GBase-SR)

5. OS2 Specification (9/125 μ m Fibre):

Fibre Attenuation:	≤ 0.34 dB/km at 1310 nm ≤ 0.31 dB/km at 1383 nm ≤ 0.22 dB/km at 1550 nm
Cabled cut-off wavelength:	≤ 1260 nm
Supported length for 1GBE	5,000 m minimum, depending on application
Supported length for 10GBE	10,000 m minimum, depending on application

ii. Fiber Cable Installations

All fiber backbone cables shall be install in the following manner:

1. Backbone cable routing shall be planned to ensure adequate segregation from electrical and hazardous services, ensuring system integrity and performance, ensuring that it does not present problems of maintenance or access, and ensuring there is no conflict with the operation and maintenance of other systems.

Extra Low Voltage Installation Structural Cabling Installation

2. Backbone cables shall be installed in accordance with manufacturer's recommendations and best industry practices.
3. Backbone cables shall be install separately from horizontal distribution cables.
4. Where cables are housed in conduits, the backbone and horizontal cables shall be install in separate conduits.
5. Where backbone cables and distribution cables are install in a cable tray or wireway, fiber backbone cables shall be install first and bundle separately from the horizontal distribution cables.
6. All singlemode fibres (SMF) shall be fusion splice on site for optimum performance.

iii. Optical Fibre Connecting Hardware Specifications

1. The optical fibre patch panel(s) shall each be capable of containing 48 LC Duplex connectors in a 1U enclosure.
2. The optical fibre patch panel(s) shall have rear openings for cable entry, with posts to accept strain relief terminations and with fibre storage guide facilities for maintaining bend radius.
3. The LC connectors shall be 50 micron, multimode connectors, capable of terminating either 250 micron coated or 900 micron buffered fibres.
4. The connectors shall be field-installable, requiring no epoxy, or polishing. The connectors shall meet the intermateability requirements of IEC 61754-20.
5. Connector performance requirements are listed in the following table:

LC Connector Performance Characteristics

Test Description	Requirement (dB)	Test method
Interface dimensions	IEC 61754-20	
Random attenuation (insertion loss)	100% \leq 0.75 dB 95% \leq 0.50 dB 50% \leq 0.35 dB	61300-3-34
Return Loss	\geq 20 dB	61300-3-6
Impact (5 drops from 1.5 meters)	\leq 0.75 IL, \geq 20 RL	61300-2-12
Mating durability (500 cycles)	\leq 0.75 IL, \geq 20 RL	61300-2-2
Cable Retention (50N, 120 sec.)	\leq 0.75 IL, \geq 20 RL	61300-2-4
Flex of strain relief (2N , 100 cycles)	\leq 0.75 IL, \geq 20 RL	61300-2-44
Static side load (1N, 60 min.)	\leq 0.75 IL, \geq 20 RL	61300-2-42

iv. Optical Fibre Patch Cords Specifications

6. Optical fibre patch cords shall be install for fibre cross-connection and/or inter- connection of termination modules, patch panels and network equipment.
7. Fibre patch cords shall be constructed from 18mm tight buffered zip-cord fibre cable with with fibre type matching the installed backbone

Extra Low Voltage Installation Structural Cabling Installation

(OM3, OM4, or OS2) fibre optic cabling.

8. Be factory terminated with LC ceramic connectors at each end. Meet the following specifications:-
9. Minimum bend radius: 25 mm
10. Operating temperature: -40 to +75° C
11. Loss: 0.75 dB per mated pair of connectors
12. Return Loss Maximum: -45dB
13. Cable OD: 1.8 mm
14. Tip material: Ceramic

e. LABELLING AND NUMBERING

Each piece of equipment, patch panel and outgoing cable from the patch panels shall be labelled. Corresponding labelling and numbering shall also be provided on the telecommunication outlets.

All cable labels should be of clear wrap around self-adhesive type or slip-on plastic ring type or a long plastic strip type fixed onto each cable. Each cable is to be labelled at each end 100 - 150mm from the termination point. Lettering on the label is to be machine typed.

Telecommunication Outlets (TO) are to be labelled with an approved label secured to the outlet faceplate/cover in a prominent position, firmly affixed.

Cable and TO numbering shall be the same and should be in the format of; "BUILDING FD ROOM Number(where patch panel and active equipment locate)-TO FLOOR-TO ROOM-TO NUMBER". The designations can be letters or numbers. TO Room is optional. TO NUMBERS must be in sequential numbers. Use a dash between each designation with no spaces.

Consolidation Points are to be additionally labelled with the distance back to the FD, in metres.

MUTOs are to be additionally labelled with the maximum allowable patch cord length in metres, as per the MUTO cabling design.

f. Grounding and Bonding

The facility shall be equipped with a Telecommunications Bonding Backbone (TBB). This backbone shall be used to ground all telecommunications cable shields, equipment, racks, cabinets, raceways, and other associated hardware that has the potential for acting as a current carrying conductor. The TBB shall be installed independently of the building's electrical and building ground and shall be designed in accordance with the recommendations contained in the IEC 60364 and ISO/IEC 14763-2 standards.

The main entrance facility/equipment room in each building shall be equipped with a

Extra Low Voltage Installation Structural Cabling Installation

telecommunications main grounding bus bar (TMGB). Each telecommunications closet shall be provided with a telecommunications ground bus bar (TGB). The TMGB shall be connected to the building electrical entrance grounding facility. The intent of this system is to provide a grounding system that is equal in potential to the building electrical ground system. Therefore, ground loop current potential is minimized between telecommunications equipment and the electrical system to which it is attached.

4. Certified Installer

The successful tenderer shall provide documents of proof as a certified installer accredited by the manufacturer of the cabling solution to be installed for the bid cabling project.

5. Compliance Tests

The installer must individually test 100% of the U/UTP cables and fibre optic cables after installation of the cables to determine compliance to ISO/IEC 11801 performance requirements. Where ever possible, progressive testing of both fibre and copper Permanent Links or Channels is recommended to ensure errors or unacceptable installation practices are minimised on the site.

a. Class E Balance Cabling Testing

The Horizontal Distribution Cabling System shall be tested by the installer for compliance to the requirements specified in the latest ISO/IEC 11801 standard for Class E performance using Level 3 testers or better in accordance with IEC 61935.1 – Generic specification for the testing of generic cabling in accordance with ISO/IEC 11801 – Part 1: Installed cabling

Channel performance is the preferred acceptance criteria for all installations if possible. All Permanent Links are to be installed and all end-user patch cords, equipment cords and work area cords should be in place, and left in the position where they were tested. Where this is not practical, the Permanent Link performance will be the acceptance criteria for the installation.

Alien Crosstalk (AXT) testing is not required; therefore no AXT sampling plan is necessary for this project.

b. Optical Fibre Link Testing

All multimode and singlemode optical fibre links must be tested for;

- i. Continuity and Maintenance of Polarity
- ii. Length
- iii. Propagation Delay
- iv. Optical Attenuation of Link, 2 x wavelengths, 2 x direction

Conduct the tests in accordance with ISO/IEC 14763-3 – Information technology – Implementation and operation of customer premises cabling – Part 3: Testing of optical fibre cabling – Amendment 1

Extra Low Voltage Installation Structural Cabling Installation

6. Customer Acceptance

At the conclusion of the installation a preliminary walkthrough with the installation contractor will be performed to check for installation quality, accurate performance of the work, and to verify engineering diagrams. Any modifications to the documentation or the installation that may be required shall be accomplished within a 2 week period.

"Customer Acceptance" shall consist of a final walkthrough with the installation contractor. The walk through shall be scheduled within 3 weeks of the completion of the installation in order to turn the project and documentation over to the end-user. "Customer Acceptance" does not release the installation contractor from repairing any cabling errors or improperly labelled circuits, caused by the installation contractors that may be discovered at a later date.

7. Documentation

The contractor shall provide complete documentation covering the installation and maintenance of the Structured Cabling System. This includes "as built" drawings showing the location of all installed equipment and racks in all Telecommunications Rooms, all main cable runs, cable trays and catenaries, CPs, MUTOs and TOs, complete with outlet numbering.

a. Test Result Documentation

A copy of the full "Plot Data Enabled" test results in tester format for each copper cable run and each core of each optical fibre cable run shall be supplied to the end user on CD in a recognised test vendor's application format like Fluke LinkWare or Agilent DataScope Pro or LANTEK Reporter. PDF files are not acceptable.

Extra Low Voltage Installation Public Address System

1. GENERAL

This Section specifies the various equipment for the sound and public address systems which shall form part of the Sub-Contract Works. All equipment and materials used for installation shall be of the same make and type to ensure uniformity of standards and composition.

The system shall comprise the supply of all sound equipment, installation and commissioning of the Public Address and Sound Systems serving the entire project as shown on the Sub-Contract Drawings.

The Sub-Contractor shall supply and install the system for broadcasting the following channels :-

- a. Background music channel. (where shown on the sub-contract drawings)
- b. Emergency or paging override channels for the zones as shown on the Sub-Contract Drawings.
- c. "All Zone" calls

2. STANDARDS

The entire sound and public address system shall comply with Singapore Standard SS 546 - Code of Practice for Emergency Voice Communication Systems in Buildings

3. POWER SUPPLY

The Sub-Contractor shall note that the main power supply provided to the Sound Equipment Rack at Reception Counter for use of the Public Address and Sound System shall be as follows :-

Voltage	:	230V +/- 6% single phase 2 wire
Power Supply	:	13A switched socket outlets
Frequency	:	50 Hz +/- 4%

The Sub-Contractor shall make due allowance by providing all necessary power supply units, voltage regulators, spike eliminators, step down transformers, rectifiers, relays, radio suppressor, converters, etc., to ensure that all his equipment will perform completely satisfactorily. All necessary power supply required for the operation of amplifiers, speakers, sound equipment, devices, controls, etc., after the main power supply point, shall be supplied and installed by the Sub-Contractor.

4. SYSTEM DESCRIPTION

A sound and public address system complying with the requirements of CP 25 - Code of Practice for Emergency Voice Communication System in Buildings and having the following equipment shall be supplied and installed throughout the building as shown on the Sub-Contract Drawings :

- a. Power amplifiers and mixing pre-amplifier
- b. Amplifier and Speaker line supervisory units

Extra Low Voltage Installation Public Address System

- c. Cassette record player suitable for above message cassette.
- d. Microphone to be located at Reception Counter
- e. FM Broadcast Tuner (where shown on the sub-contract drawings)
- f. Background music cartridge players with recording facility. (where shown on the sub-contract drawings)
- g. Background music compact disc player
- h. Two-channel voice recorder
- i. One manual zone selector panel
- j. Equipment rack located at Fire Command Centre

The system to be installed in public and office areas shall include speakers, matching transformers, isolating transformers, relays, power supply units, concealed conduit wiring, etc., that will work in complete satisfaction with the above equipment and guarantee proper output through the speaker system.

The microphones will be used to override and announce emergency and / or fire messages.

Where shown on the Sub-Contract drawings, cartridge / cassette players, compact disc player and an AM / FM Broadcast Tuner shall be supplied and installed at Reception Counter to play background music in public area as shown.

A tape recorder shall be provided to simultaneously record voice traffic on separate channels, under fire alarm condition, over the public address system.

There shall be individual zone volume control provided to control the volume level for the areas as indicated on the schematic drawings.

The entire system shall be backed up by a standby battery system for one hour (60 minutes) minimum.

In the Fire Command Centre, the message announcement cassette system will, in an emergency, automatically broadcast pre-recorded messages, giving reasons for lift capture and instructions upon arrival at homing floors, instructions for evacuation procedures on fire alarmed floors, or throughout the complete building.

The microphones will be used to override and announce emergency and/or fire messages.

Whenever a fire alarm is received, the background music will automatically be switched off to permit the loudspeakers to broadcast the pre-recorded messages.

The lift message and fire alarm messages will be broadcast simultaneously. Before any announcement or message is broadcast, a soft tone shall be sent to alert people and draw attention to the announcement.

Where shown on the Sub-Contract drawings, cartridge/cassette players, compact disc player and an AM/FM Broadcast Tuner shall be supplied and installed in the Fire Command Centre to play background music in all lifts and public areas as shown.

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A tape recorder shall be provided to simultaneously record voice traffic on separate channels, under fire alarm condition, over the public address system and the fireman intercom system.

There shall be individual zone volume control provided to control the volume level for the areas as indicated on the schematic drawings.

The entire system shall be backed up by a standby battery system for one hour (60 minutes) minimum.

5. AMPLIFIER

Amplifiers shall be solid-state high-power amplifiers and operate on 230V power supply. The power amplifiers shall each have a minimum power output of rating in r.m.s. as shown. They shall be capable of producing their rated power output at less than 2% distortion over the frequency range of 50 Hz to 20,000 Hz and be capable of producing full rated sine wave power output on a continuous basis with no undue heating of any component.

They shall have a frequency response of within ± 2 dB from 50 Hz to 20,000 Hz and a noise level at least 85 dB below rated output. The amplifier shall be provided with sufficient inputs, for each microphone and player included in the system. The impedance of the input circuit shall match with that of the microphone and players (otherwise an input impedance matching transformer shall be provided.) The total gain of the voltage amplifier stages shall be sufficient to raise the output of the microphones and players to the level required for the input of the power amplifier stages. If the gain is not sufficient, a suitable pre-amplifier shall be provided.

The output of the amplifier shall be suitable to feed a "constant voltage" distribution line system of 100V. The amplifier shall be provided with separate volume controls for the input channels, separate high and low tone controls, supply on/off switch and pilot light and other necessary switches and controls. The amplifier shall be complete with a power supply unit, comprising all necessary transformer, rectifier, filter, etc., suitable for rated electricity supply. The complete amplifier shall be housed in a sheet metal cabinet for rack mounting and all controls and switches shall be fixed in the front panel of the cabinet. The Sub-Contractor shall provide the amplifier with all flexible cords, sockets, plugs, including electricity supply for the system.

The amplifier shall also include an automatic and self-restoring protective circuit to protect against damage from prolonged or extreme overloads such as a shorted output line. This circuit shall be of the electrically controlled type which is not subject to instantaneous overloads. It shall automatically remove power from the amplifier when damage is threatened, and automatically restore the amplifier to operation when danger is past. Amplifier Monitoring Unit shall be provided. Amplifier rack shall be provided by the Sub-Contractor.

The amplifier shall also carry a full 5-year manufacturer's warranty. and be accepted by the Engineer before ordering.

6. AMPLIFIER SUPERVISORY UNIT

The amplifier supervisory unit shall be able to create an inaudible line signal which is fed to the power amplifier's inputs and continuously monitored at the output by evaluation logic circuitry. In the event of an amplifier failure, whereby there is a break in the line signal at the

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output, the amplifier supervisory unit shall be able to switch in the standby amplifier as a substitute for the defective amplifier. It shall also be provided with visual and audio indication of the defective amplifier.

In order to prevent overloading on the standby amplifier, due to failure of a second amplifier, the amplifier supervisory unit shall be equipped with interlocking protection circuit.

The technical performance shall meet with the following requirements:

- a. Supervisory frequency: 20 kHz - 35 kHz
- b. Supervisory signal level: 10mV - 1000mV
- c. Input signal level: 100V
- d. Power Supply: 24VDC
- e. Type of Indication: LED for visual; buzzer for audio.

7. PROGRAMME MONITOR PANEL

The programme monitor panel shall be capable of monitoring the total numbers of amplifiers or programme sources as indicated on the Sub-Contract Drawings.

It shall be equipped with:

- a. A large, easy to read Vu meter
- b. Controls :
 - i) Channel selector switch
 - ii) Monitor volume control
 - iii) Line voltage selector
- c. Speaker : Full range 5" speaker

8. LOUDSPEAKERS

Background music shall be provided in corridors, lifts and lift lobbies and can be changed to emergency messages. All emergency messages shall be announced first with soft tone. All loudspeakers shall be suitable for both voice and music broadcasting and shall be recess mounted in the false ceiling. Where there is no false ceiling, surface type shall be provided.

The loudspeakers shall be 200mm diameter in public areas having viscous-damped cone and ceramic magnet. They shall have a frequency range of 50 Hz to 20,000 Hz at rated output. Flux density shall be at least 10,000 gauss.

Unless otherwise specified, the loudspeakers shall have an output impedance of 8 ohms and a power output tapplings of 1 watts and 3 watts. The sound pressure level shall be at least 92 dB at 1W 1m

Each loudspeaker shall be equipped with a line matching transformer. Transformer shall be provided for each speaker with power tap settings for 100V lines. Insertion loss of the transformer shall not exceed 1 dB.

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Circular and recessed baffle grilles with torsion spring mounting shall be provided for each loudspeaker in public areas. Construction shall be a minimum of 2mm steel with a white finish trim, matt black baffle grilles and acoustic enclosure. A sample shall be submitted for acceptance by the Engineer.

9. BOX AND HORN SPEAKERS

All wall-mounted box and horn speakers shall come complete with matching transformer, connector and necessary mounting brackets. All metal parts shall be protected against rust and corrosion

The finishing colour of the box speaker shall be able to match with the wall and shall be approved by the Engineers.

The technical performance of the box and horn speakers shall meet with the following specification :-

- a. Sound Pressure Level : Input 1W, 92 dB at 1 metre
 - i. Box Speaker : Input 1W, 92 dB at 1 metre
 - ii. Horn Speaker : Input 1W, 104dB at 1 metre
- b. Coverage angle : 120 - 180 degrees
- c. Frequency response :
 - i. Box Speaker : 150 - 13 kHz
 - ii. Horn Speaker : 350Hz - 10 kHz
- d. Power Output at max :
 - i. Box Speaker : 4.5 W
 - ii. Horn Speaker : 15W

10. MICROPHONES

Microphones shall be of the cardioid dynamic type with a frequency response of 50 Hz to 15,000 Hz and sensitivity rating of 140 dB at low impedance. The diaphragm shall be shielded from dust and magnetic particles.

Filters shall be used to minimize wind effect.

Microphones shall have sound cancelling entrances for rejection of unwanted noise and minimum feedback. Microphones shall be furnished with length of cable and appropriate connectors.

Microphone Console shall be provided with the system. The technical performance of the Microphone Console shall meet with the following:-

- a. Priority : Programmable
- b. Indicators : Busy, chime and speech on LED indication

Extra Low Voltage Installation Public Address System

- c. Zone Switch :Individual zone SW are latched type.
:All call & press to talk switch are non-latch type

11. BACKGROUND MUSIC CARTRIDGE/CASSETTE PLAYER

Where shown on the Sub-Contract drawings, two solid state cartridge/cassette tape deck players with one working and one standby shall be provided at Fire Command Centre for generation of background music. The tape player shall incorporate a tape magazine mechanism for loading pre-recorded music into the player. Each tape magazine shall be capable of four hours of non-repetitive music at a minimum tape speed of 50mm/sec.

The tape player shall include automatic tape reversing, separate treble, bass and volume controls and a power amplifier with a minimum output power as specified on the drawings. Wow & flutter shall not exceed 0.1% maximum.

The Sub-Contractor shall make available to the Employer a list of available 2-hour or 4-hour tapes, of which four shall be included as a requirement of this Specification. The equipment supplier shall make available to the Employer, a purchase plan to include a minimum of two new tapes per month. The equipment must be accepted by the Engineer before ordering.

12. MESSAGE ANNOUNCEMENT CASSETTE SYSTEM

A solid state random access message announcement cassette system shall be provided in the Fire Command Centre for automatically broadcasting pre-recorded emergency messages to the building as shown on the Sub-Contract Drawings. The unit shall be of solid state electronic design and operate on a minimum speed of 50mm/sec.

Minimum peak power output shall be as specified on the drawings and wow and flutter shall not exceed 0.2% maximum.

Cassettes for up to 50 messages shall be provided as specified with a playing time of up to two minutes of each message. An automatic shut off conductive strip shall be included for each unit. A low impedance dynamic microphone shall be provided for recording messages on the recorder.

The unit shall have instant access to any cassette at any time from the external contact signal as provided by Fire Indicator Board. Manual operation of any cassette shall also be accomplished by the operator at the unit. Indicator lights shall also be provided on the front panel for visual run status of all cassettes at all times. All necessary power supply units suitable for 230V shall be included in the Sub-Contract.

13. EMERGENCY VOICE RECORDER

A solid-state cassette recorder having the ability to record voice traffic on one track from the Public Address System and voice traffic from the Fireman Intercom System on a second track shall be provided in the Fire Command Centre. Cassette recorder shall be automatically activated whenever a fire alarm is raised in the building.

Cassettes shall have minimum recording time of 2 hours. The cassette recorder shall be locked into the equipment rack and cassettes shall only be removable by authorised persons. Removal of the cassette shall activate an alarm signal at the control console.

14. ZONE CONTROL PANELS

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Zone control panels for manual zone control shall be provided by the Sub-Contractor. The number of zones required are as shown on the Sub-Contract Drawings.

The Sub-Contractor shall wire the public address system on a zone per floor basis as shown on the Sub-Contract Drawings. The entire system shall be installed in concealed conduit.

15. BATTERIES

The batteries shall be of a heavy-duty industrial type designed for standby power service. Nickel cadmium batteries of chloride alkaline make or equivalent to Fire Services Department's approval shall be provided. The batteries offered shall not require direct ventilation to open air as required by Fire Services Department. The cells shall be of the translucent boxes type in order that the electrolyte levels can be checked easily. The ampere-hour rating will be sufficient to supply the direct current to the inverter for the emergency period of sixty minutes minimum.

16. EQUIPMENT RACK

All equipment such as power amplifiers, line amplifiers, tape deck, tuner, etc., shall be mounted onto a proprietary made equipment rack. All input units shall be of an interchangeable modular type such that the individual modules can be mounted in mixer frames, or in mixed power amplifiers. All system and peripheral units shall be properly matched with the equipment rack and provided compact neat installation.

Forced ventilation fans shall be incorporated for the equipment rack. All wiring within the rack shall be fixed securely without strain by means of approved nylon/PVC cable ties. For the purpose of identification, all wires should be numbered and/or colour coded. The wiring shall be formed in a neat and systematic manner, with cable supported clear of panels and without crossovers.

All incoming and outgoing signal sources from the equipment racks to the microphone station and speaker zone shall be inter-connected via approved type of plugs and sockets

17. INSTALLATION

The Sub-Contractor shall engage specialist P.A. sub-contractor for carrying out the installation work.

The Sub-Contractor shall include for the purchase and delivery to site of all equipment, their storage, safe keeping pending unpacking, their complete assembly, erection, connection, testing and handing over in a clean, working condition at the end of the Sub-Contract Period.

The Sub-Contractor shall adhere closely to the requirements in respect of wiring and cabling standard described elsewhere in this Specification, and shall note that concealed conduit installation is required.

Speaker and control wire shall be 1mm² tinned copper standard and twisted, polyethylene insulated, aluminium polyester, stranded tinned copper ground drain wire, chrome vinyl jacket.

Wiring from the Equipment Room/Fire Command Centre Room to the roof of the vertical riser shall be run in fire-resistant cables in G.I. conduit and the horizontal wiring from the vertical riser to each of the speakers shall be run in PVC cables in G.I. Conduits.

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Pigtail leads on speakers, etc., shall be connected to cables by means of connectors to Singapore standard with backing screws, or soldered and taped. Wire nuts are not acceptable.

The speaker and control wires from the amplifiers shall be run in zones through relays and contactors to control panels. From these panels, the wires shall distribute the signal to the various speakers and/or groups of speakers. Measures and care shall be taken to avoid any signal pick up along the communication route and interference with other services.

18. SUBMISSIONS

In addition to submission requirements as detailed elsewhere in this technical specification, the Sub-Contractor shall submit a fully detailed schematic wiring diagram showing all component units with type references, gain or loss, designed to operate to give the system performance as specified.

The Sub-Contractor shall submit full technical and mechanical description of every piece of equipment and cables used, including manufacturer's technical literature.

The Sub-Contractor shall provide a description of the methods proposed to show that the actual performance is in accordance with the specifications for technical performance including necessary test methods, procedures and equipment that will be used.

The Sub-Contractor shall submit samples of the following items for acceptance by the Engineer prior to installation:

- a. Amplifiers, filters, relays, etc.
- b. Two 1-m samples of each type of cable to be used
- c. Volume controls, loudspeakers, etc.

19. TESTING, COMMISSIONING AND GUARANTEE

On completing the installation, the Sub-Contractor shall engage specialist proprietary P.A. supplier/contractor to test all speakers and demonstrate the perfect operation of the system to the satisfaction of the Employer and Engineer.

The Sub-Contractor shall carry out an output level measurement at each and every loudspeaker and shall ensure that the requirements, as specified in the Code of Practice are met. The exact method of measurement shall be proposed by the Sub-Contractor and agreed and witnessed by the Engineer.

All measuring equipment shall be provided by the Sub-Contractor.

In the event of component units and/or cable failure in such tests and/or the system proposed cannot meet the requirements specified herein due to the usage of inconsistent component units or cables, the Sub-Contractor shall redesign the system or replace with proper component units or cables and re-submit to the Engineer for final acceptance before the installation is commenced. Any extra costs incurred by such redesign or replacement of component units and cables including additional component units and cables shall be borne by the Sub-Contractor without charge to the Employer.

Extra Low Voltage Installation Public Address System

20. SPARE PARTS

The Sub-Contractor shall provide the following spare parts:-

20 Nos. 200mm ceiling mounted loudspeakers complete with speaker boxes.

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Fan Coil Unit

1. Description

This Section specifies the fan coil units which shall form part of the Works as shown on the Drawings.

2. Manufacture

All fan coil units and accessories shall be supplied by a single manufacturer experienced in the design and construction of similar equipment and who have made fan coil units of similar duties from the source factory for at least ten years.

3. 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 particular, the duty of each unit must be checked to satisfy the latent cooling loads given (larger SH factors are acceptable).

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 maximum chilled water flow rates through coils as indicated on the Drawings will not be increased to permit manufacturers to offer "narrow" coils. Coil depths (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 as specified in Noise and Vibration Section during operation; should these be excessive and not within normal acceptable standards, additional or adequate vibration isolation and sound attenuation as recommended and required by the Engineer shall be provided at no cost to the Employer.

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

4. 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 an acceptable authority such as the ARI/ASHRAE, BS of USA or BS standard or local Authorities.

Materials shall comply with the local authorities requirements and the Various British Standards, listed elsewhere in this Section.

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 Authorities.

5. General

Fan coil units shall be provided in the positions shown on the Drawings, and shall comprise quiet running, direct-driven centrifugal fans, cooling coil, and filter.

Air-Conditioning and Mechanical Ventilation Installation

Fan Coil Unit

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

The fan coil unit shall be constructed from minimum 1.6mm thick galvanized steel sheet rated corrosion – resistant.

The casing panel shall thermally/acoustically lined from side, bottom and top to provide a rigid box formation.

6. Fans

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

The fan coil shall fix with resilient mounting fixed assembly to eliminate vibration transmission.

7. Coils

The duties of all cooling coils are shown on the Drawings.

Cooling coils shall be constructed with copper tubes, and unless otherwise specified, aluminium fins with 560 fins/metre maximum. The coil face velocity shall not exceed 2.5 m/s.

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.

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

The rated working pressure of coils shall be suitable for the maximum working pressure expected, and the test pressure shall be 1½ times the rated working pressure.

8. Motors

Fan motors shall be of the "Split-Capacitor" type suitable for single phase electrical supply. The motor shall be resiliently mounted to the fan tray or scrolls. The motor/fan tray assembly itself shall be 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 (plus off) and shall be of adequate capacity to prevent overloading at any speed and duty of the fans.

9. Plenum

Unless specifically mentioned elsewhere, all horizontal ceiling hung units shall have manufactures supply and return air plenum casings. As a standard arrangement, these plenums shall be provided for air duct connections at the back and front of the units. The

Air-Conditioning and Mechanical Ventilation Installation

Fan Coil Unit

design and construction of the casing shall be such that the standard arrangement may be reversed, if required, to provide bottom return air by simply moving the rear panel to the bottom of the unit.

Casing/Plenum shall have sufficient access doors for filter, coils, fans, etc.. Access to filters for cleaning shall generally be by opening the central core of the return air grille. The mounting frame for the grilles shall include for fixing the filter.

Casing/Plenum shall be insulated with 25mm thick, 48kg/m³ density fiberglass with perforated aluminium foil finish.

10. Drain Pans

Each fan coil unit shall be provided with galvanized mild steel drain pan situated beneath the cooling coil and arranged so that all moisture will collect in and drain from the pan.

Drain pans for cooling coils shall extend under the isolation and valves and shall be of at least 1.2mm galvanized steel with watertight brazed joints and insulated to prevent condensation.

Drain pans shall be painted internally and externally with two coats bitumastic paint and insulated with a minimum of 25 mm elastomer or equal. Within ventilated ceiling voids all insulation shall comply with local Authorities' requirements.

Each drain pan shall be fitted with a drain pipe which shall be connected via suitable runs (correctly laid to fall) to the drainage system as shown on the Drawings. Drain pans shall have copper male connectors for connection to the condensate drain.

11. Filters

Filters shall be of the disposable type with a minimum thickness of 25mm.

Filters shall be as specified in the "Filters" Section of this Specification.

Temporary filters of the throwaway type shall be provided for all units in the factory. These filters shall be fixed in position during installation and testing and shall only be replaced with the final filters after the completion of commissioning.

12. Coil Connections

Pipe connections to each unit shall be fitted with isolating valves on the flow and return, double regulating valve with pressure sensor tappings and a control valve.

Pipe connections shall be joined with soft copper U-tubes for testing and flushing the systems before making final connections to the units.

Coil connections shall be made in copper pipe employing steel to copper adaptors with union connectors at the coil and all joints shall be rated at 1,600 kPa working pressure and 2,400 kPa test pressure.

13. Casings

Air-Conditioning and Mechanical Ventilation Installation

Fan Coil Unit

Where units are mounted within false ceilings or other concealed areas, then casings shall be of mild steel sheet hot dip galvanized after manufacture.

Where units are mounted in an exposed location, then casings shall be of the decorative type on mild steel with a baked enamel finish. Decorative casings shall be supplied by the fan coil unit manufacturer and shall be finished in an approved colours selected by the Engineer. Supply and return air grilles shall be of extruded aluminium anodized. The supply air grille shall be of the double deflection type with the front bars horizontal and fixed. Return air grilles shall be hinged bar type giving access to the filter frame. Valve box shall be provided.

14. Insulation

The interior of casings shall be lined with insulation as approved and shall be sealed to prevent any condensation whatsoever. Insulation shall also be protected against migration of fibres in the air stream.

Where imported casings are provided, the manufacturer's standard insulation provisions may be acceptable provided that details of these are submitted for checking prior to order.

15. General

The limited space within false ceilings shall be noted. These ceiling spaces cannot be increased under any circumstances.

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

16. Mounting

The fan coil units shall be located as indicated on the Drawings. The fan coil units shall be suspended on frames as shown on the Drawings.

To supply and install support angles, support legs, platforms, hangers and anchor bolts required for the proper installation of the units as recommended by the manufacturer.

17. Finishes

All finishes to factory assembled casings shall be factory applied in accordance with the manufacturer's recommendations and to an approved colour schedule.

The fan coil unit shall be protected during transportation and storage until ready for installation.

Any damage to finishes which may have occurred during transit, storage, installation otherwise shall be made good in the manner recommended by the manufacturer and to the satisfaction of the Engineer.

18. Identification

Air-Conditioning and Mechanical Ventilation Installation

Fan Coil Unit

All fan coil units shall be provided with an identification plate showing the code number for each unit as indicated on the system schematics. This plate shall be securely fixed to the fan coil unit in a prominent position.

All fan coil units shall bear the manufacturer's nameplate giving manufacturer's name, serial and model number and date of manufacture.

Construction of identification plates and labels shall be as specified in the "Miscellaneous Provision" Section of this Specification.

Air-Conditioning and Mechanical Ventilation Installation

Variable Air Volume Equipment

1. GENERAL

a. Description

This Section specifies the purpose manufactured air distribution equipment for V.A.V. systems which shall form part of the -Contract Works as shown on the Contract Drawings.

b. Manufacture

All V.A.V. equipment and components shall be supplied by manufacturers experienced in the design and construction of similar equipment and who have made and tested V.A.V. equipment for similar duties for at least five years.

c. Selection

The Contractor shall select all V.A.V. terminal units suitable for the scheduled duties.

The duties scheduled on the Contract Drawings include maximum flow rate, supply volume range, static pressure range, maximum generated noise level, etc.

The Contractor shall correctly relate manufacturer's information for V.A.V. terminal unit selections to the requirements given on the Contract Drawings and in this Specification.

Where the terminal unit cannot be supplied to meet the specified noise criteria, secondary attenuation shall be provided together with the unit. The Attenuation shall comply with the relevant sections of this Specification.

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

d. Standards

All V.A.V. terminals and diffusers shall be of the highest commercial standard and shall be designed constructed, rated and tested in accordance with an approved authority such as ADC (Air Diffuser Council) or ASHRAE of U.S.A..

Materials shall comply with the relevant British Standards or other approved international Standards.

All factory applied acoustical and thermal insulation, including facing and adhesive is to be fire resistant and is to conform to the requirements of N.F.P.A., B.C.A. & FSSD.

The equipment specified here shall also comply with the relevant standards specified in the "Ductwork and Fittings" Section of this Specification.

e. Equipment

Variable air volume boxes shall be the pressure independent type containing a self balancing element of a mechanical nature, which does not depend upon duct sensors for pressure independence and is independent of the control function of the box.

Air-Conditioning and Mechanical Ventilation Installation

Variable Air Volume Equipment

The variable volume control shall be achieved by means of a damper powered by a low voltage electric motor responding to the output signal of the temperature controller. Externally mounted dials for adjusting the maximum and minimum air volume shall be provided.

Air leakage shall be less than 2% at maximum pressure and calibrated volume settings shall be available down to 10% of peak volume with an accuracy of + 5%. The control damper shall fail to the normally closed position.

The box casing shall be painted matt black internally and internally lined with a minimum of 24mm of fibreglass insulation which complies with BS 476 Part 6. The insulation shall be able to withstand high velocity resist damage and lined with fire resistant cloth backed sound absorption properties.

The damper shall be heavy gauge construction with blades pivoted in self-lubricating bearings. The blades shall seal with less than 2% air leakage. All boxes shall be capable of handling a maximum of 155 mm Wg duct static pressure. All control components and parts shall be supplied, assembled and tested by the VAV manufacturer before shipment to ensure proper performance of the entire VAV unit as specified.

The description of VAV boxes control shall refer to Automatic Control system in this Specification.

2. INSTALLATION

a. General

The Contractor shall note the limiting dimensions within false ceilings as shown on the Contract Drawings.

Boxes serving public areas shall be on a separate control circuit to boxes serving offices to enable each areas to operate on a different time schedule.

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

b. Mounting

The V.A.V terminal units shall be located as indicated on the Contract Drawings. The units shall either be bolted directly to the slab or shall be suspended on angle frames as shown on the Contract Drawings.

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

c. Finishes

All finishes to factory assembled casings shall be factory applied in accordance with the manufacturer's recommendations and to an approved colour schedule.

Air-Conditioning and Mechanical Ventilation Installation

Variable Air Volume Equipment

Any damage to finishes which may have occurred during transit, storage, installation or otherwise shall be made good in the manner recommended by the manufacturer and to the satisfaction of the Engineer.

d. Identification

All V.A.V. terminal units shall be provided with an identification plate showing the code number for each unit as indicated on the system schematics. This plate shall be securely fixed to the unit in a prominent position.

All V.A.V. terminal units shall bear the manufacturer's nameplate giving manufacturer's name, serial and model number and date of manufacture.

Construction of identification plates and labels shall be as specified in the "Miscellaneous Provision" Section of this Specification.

Air-Conditioning and Mechanical Ventilation Installation

VRV System

1. The System

The Contractors shall supply and install as shown on the Drawings air conditioning equipment with inverter system. The units shall be air-cooled, VRV type consisting of:-

- a. One outdoor unit and multiple indoor units, each having the capability to cool independently of requirements of the rooms.
- b. The compressor shall be equipped with inverter controller, enabling it to reduce minimum load down to 10%.
- c. Unit shall be suitable for mix-match connection of Multi-flow ceiling Mounted Cassette Type, Built-In Ceiling Type, Wall Mounted Type, Ceiling Concealed Ducted Type and Floor Mounted Type Indoor Units, as shown on the tender drawings.
- d. The refrigerant piping shall be extended up to 100 m with maximum 50 m level difference without any oil traps.

2. VRV Condensing Unit

The VRV Condensing Unit shall be a factory assembled unit housed in a sturdy weatherproof casing constructed from rust-proof mild steel panels coated with a baked enamel finish

The condensing unit shall be designed to operate safely when connected to multiple fan coil units which have a combined operating nominal capacity varying from 10% to 130% of nominal compressor capacity.

The noise level shall not be more than 57 dBA measured horizontally 1 m away and 1.5 above ground.

The condensing unit shall have the flexibility to connect the piping circuit from three places, front side and bottom of the unit to provide for greater freedom of layout.

The condensing unit shall come equipped with 2 nos. of hermetically sealed scroll compressors.

The condensing unit shall be modular in design and should be allowed for side by side installation.

3. Compressor

The compressor shall of highly efficient hermetically sealed scroll compressors an equipped with inverter control capable of changing the speed linearly in accordance to the room load requirement. It shall be cable to vary the load from 10% to 130% of its normal capacity.

4. Condenser Assembly

The VRV condenser shall be constructed with copped tubes mechanically bonded to aluminum fins to form a cross fin coil.

The condenser shall have a large face area to minimise noise and to give a high EER for heat transfer. Condensers shall have waffle louvre fins and tubes, design for high efficiency performance.

Air-Conditioning and Mechanical Ventilation Installation VRV System

The condensing unit shall be chemically coated with anti-corrosion P.E.finishes.

5. Condenser Fan and Motor

The condenser fan shall be of multi-blade low speed low noise level type made from pressed out aluminum and dynamically and statically balanced for minimum noise and vibration.

The condenser fan shall be directly coupled to an induction motor. The condenser fan and motor shall be of high efficiency type with minimum power consumption. The fan motor shall be equipped with pole-change control so that it can be stepped down to low speed when the requirement is low.

6. Refrigerant Circuit

The refrigerant circuit shall include an accumulator, liquid and gas shut off valves solenoid valves and an electronic expansion valve. All necessary safety devices shall be provided to ensure the safety operation of the system.

7. Accumulator

The cylindrical accumulator shall be constructed from mild steel plates pressed into shape. The accumulator shall have sufficient capacity to prevent any liquid refrigerant from flowing back into the compressor suction.

8. Safety Devices

High pressure switch, fuse, crankcase heater, fusible plug, over current relay for compressor, thermal protectors for compressor and fan motors, and recycling guard timer shall be provided.

9. Oil Recovery System

The units shall be equipped with an oil recovery system to ensure stable operation with long refrigerant piping.

10. Fan Coil Units

Each fan coil shall be of the Ceiling Mounted type, or Ceiling Concealed Ducted type, or Ceiling Suspended type, Ceiling Mounted Cassette Corner type, or Wall Mounted type or Floor Mounted type as specified in the Drawing.

Each fan coil unit shall be equipped with a self diagnostic remote controller and having the features of settling room temperature (with digital indicator of room temperature). Timer, air discharge direction (for cassette units), fan speed selection self diagnostic circuit with malfunction code display.

Cross Fin Evaporator

The cross fin evaporator coil shall be constructed from strong clean copper tubes bonded to aluminium fins suitably spaced to ensure maximum heat transfer.

Air-Conditioning and Mechanical Ventilation Installation VRV System

The inlet of the coil shall be factory brazed to an electronic control valve. The face velocity shall be exceptionally low to ensure quiet operation.

The cross fin coil shall be of waffle louver fins and Hi-X tube design to ensure highly efficient performance. Fin pitch shall not be less than 2.0 mm.

Electronic Control Valve

An Electronic expansion valve shall be factory brazed to the inlet of the coil. It shall modulate the refrigerant volume continuously in response to load variations of the room, to maintain a precise constant temperature of +/- 0.5 degree Celsius.

Evaporator Fan

The evaporator fan shall be of the dual suction multi-blade type with its length designed to match the coil width.

The fan shall be statically and dynamically balanced to ensure low noise and vibration free operations.

11. Condensate Drain Pipe and Insulation

Condensate drain pipes shall be UPVC to BS 3506 or equivalent and insulated with 25mm closed cell.

12. Refrigerant Pipe and Insulation

Refrigerant pipework shall be copper to BS 2871 Part 2 and jointing shall be by capillary joints. The pipes shall be insulated with minimum 25mm thick closed cell type elastomeric insulation material through out the entire pipe run, with a K value of 0.035 W/mk and rated Class O fire rating to BS 476 Part 7.

13. Controls

The control system should be connected by using 2-wire multiplex transmission system links to single outdoor unit to multiple indoor unit with a 2-core cable. In addition, the control system must come equipped with automatic address setting function. An automatic checking function for connections error of wiring and piping shall be standard with the system.

Computerised control shall be used to maintain a correct room temperature with minimum consumption. The unit shall be equipped with its own 2 speed fan controller, timer on/off switch, thermostat and LED indicators.

Its shall also be equipped with a self diagnosis circuit for easy and quick maintenance and service. It shall be able to indicate at least 40 malfunction code displays.

14. Soft-Start (Starters)

All condensing units shall have soft starters to ensure low starting current.

Air-Conditioning and Mechanical Ventilation Installation VRV System

The inverter compressor shall be able to start at the minimum load and gradually increased to the required frequency according to the actual load requirement.

A recycling guard timer shall be provided to prevent the compressor to restart again immediately after it was stopped.

Air-Conditioning and Mechanical Ventilation Installation

Air-Cooled Split Air Conditioning Unit

1. GENERAL

The quantity and capacity of split-type air conditioners shall be in accordance to the "Schedule of Equipment" shown on the drawings. The split type air-conditioners offered shall be completely factory assembled and matched in capacity between the air cooled condensing unit and the direct expansion fan coil(s) or air handling unit(s). Unit shall be of single and/or multiple compressor(s) type each coupled to an individual fan coil unit for independent on/off and programmable temperature control.

All equipment and refrigerant gas must conform to the requirements for GREENMARK Assessment compliance.

2. AIR-COOLED CONDENSING UNITS

The air-cooled condensing units shall be of single and/or Multiple Compressor(s) type completely factory assembled including internal wiring of control, fan assembly, compressor(s), and weather armour cabinet and condenser coil.

Selection of air-cooled condensing unit shall match with corresponding Fan Coil Unit selection for the duties specified.

Power consumption of the selected condensing unit shall not exceed the power input given in schedule.

The unit offered shall be of minimum vibration and noise level during operation, should these be excessive and not within the normal acceptable standard, the contractor shall be responsible for provision of adequate vibration isolation and noise attenuation as recommended and required by Engineer.

All units shall be completely factory assembled, piped, wired, tested and delivered to site complete with all starting gear, controls, instructions and safety devices.

Liquid line solenoid valves shall be provided for condensing units with multi-step unloading for proper oil return based on manufacturer's recommendation.

All condensing units shall be complete with all necessary controls factory wired, including low pressure cut-out.

a. CABINET

The Cabinet shall be constructed from steel of minimum 18 gauge casing with 117 gauge base and specially treated for corrosion protection and finished with baked enamel paint.

b. COMPRESSOR

The compressor shall be Hermetic type having internal vibration isolation. Units shall be equipped with thermal and current sensitive overload device to protect the compressor. Suction and discharge service valves shall be provided. Starting devices shall be provided to ensure that the starting current does not exceed 2.5 times the normal current.

Compressors shall have casings of high strength cast iron hydrostatically tested before and after assembly.

Air-Conditioning and Mechanical Ventilation Installation

Air-Cooled Split Air Conditioning Unit

Casing design shall be such that bearings, seals and oil pump are accessible without major dismantling.

Each compressor shall have an automatic capacity control system, designed to enable the compressor to start unloading and to match the load by loading and unloading cylinders.

Compressors shall be furnished with the following equipment and fittings.

High/Low pressure controller.

Oil pressure safety controller.

Crankcase heater.

Discharge, suction services shut off valve vibration isolation mounting and flexible connections.

Compressors shall be automatically sealed and refrigerant cooled and reversible oil pump.

Each compressor shall unload in response to suction pressure down to 50% of full capacity in step for partial load operation.

Multi compressor units shall have stop-start fans and oils.

c. CONDENSER

The air cooled condenser shall be of copper tube type with mechanically bonded aluminium fins and factory pressure-tested against leak.

d. CONDENSER FAN

The condenser fan shall be of propeller type statically and dynamically balanced and directly coupled to a motor and protected by heavy gauge metal guard.

e. CONDENSER FAN MOTOR

The fan motor shall be of totally enclosed air-cooled and weather-proof type with inherent protection, resilient mounting and suitable for 230V/1 Phase/50Hz or 415V/3 Phase/50Hz. The motor bearings shall be permanently lubricated type.

f. CONTROL AND PROTECTION

The control system shall be factory wired and consists of compressor contactor, compressor motor overload protection, high-low pressure cut-outs, fan motor relay, starting and running capacitors, time delay relay to prevent compressor from frequent start/stop, control circuit fuse and terminal blocks, all prewired and factory tested.

The air cooled condensing unit shall be suitable for 230V/1 Phase/50Hz or 415V/3Phase/50Hz electricity supply, as specified in the schedule.

3. DIRECT EXPANSION FAN COIL UNIT

Air-Conditioning and Mechanical Ventilation Installation

Air-Cooled Split Air Conditioning Unit

The fan coil units shall be of direct expansion type with capacities as stated in the "Schedule of Equipment".

The units shall be suitable for either installation as ceiling concealed type; cassette type or wall mounted type as shown in the drawings.

a. **CABINET**

For exposed fan coils, the fan coil cabinet shall be of metal construction and colour painted to high standard finishes. Supply air discharge grille shall be of deflection adjustable type for horizontal and vertical deflection. The built-in return air grille shall be complete with suitable air filter. The complete cabinet shall be adequately insulated to prevent condensation.

b. **COOLING COIL**

The direct expansion cooling coil shall be of seamless copper tubes with mechanically bonded aluminium fins. Refrigerant expansion valve shall be fitted to the cooling coil distributor and the expansion valve sensor bulb shall be strapped to the suction line for refrigerant control. Condensing units having more than one compressor shall have separate refrigerant circuit for each compressor.

c. **DRAIN PAN**

Condensate drain pan shall be adequately insulated to prevent condensation. Drain tube connection shall be provided at both ends of the pan with provision to plug off the connection not in use.

d. **FAN**

The fan wheels shall be of centrifugal type double inlet double width, forward curved blade design and constructed of aluminium or plastic. The fan wheels shall be statically and dynamically balanced. Fan housing shall be constructed of galvanised steel or plastic.

e. **FAN MOTOR**

The fan motor shall be three speed shaded pole type with permanent lubricated bearings, built-in inherent overload protection with automatic reset. Motors shall be suitable for 230V/1Phase/50Hz electric supply.

f. **CONTROLS**

The remote control unit for the fan coil shall consist of IC thermostat for precise temperature control, and a 3 speed switch for air volume control.

There shall also be facility for timer control.

g. **NOISE LEVEL**

All fan coil units shall be of low noise level type and the fan speed should not exceed 1450 rpm at high speed selection.

The noise level of the fan coil unit at high speed selection shall not exceed 35NC measured from a position of 2 metres from the fan coil unit.

Air-Conditioning and Mechanical Ventilation Installation

Air-Cooled Split Air Conditioning Unit

4. PIPE & ACCESSORIES

a. REFRIGERANT PIPES

All refrigerant pipes shall be seamless copper tubing sized as shown in the tender drawings. All pipes shall be new and in one continual length without any intermediate joint. Pipes of short length joint together will not be acceptable

Copper pipework shall be for pressure systems to B.S. 13017 Table 1, cleaned, degreased and hermetically sealed to B.S. 2871 Part 2. Fittings shall be copper compression fittings to B.S. 8174 : 1971, Part 2.

b. CONDENSATE DRAIN PIPES

The condensate drain pipes shall be of UPVC pipe AW class size as shown in the tender drawings.

Any condensate pipes terminated to the floor trap hopper, shall make good to the connection and joint.

c. PIPE TERMINATIONS

All pipe terminations shall be properly sealed and terminated in standard PVC KO boxes for electrical switches with blank PVC covers. Additional length of pipes shall be coiled and remain in the KO boxes wherever possible for future connection to air-conditioning equipment.

d. PIPE INSULATION

All refrigerant pipes and UPVC condensate drain pipes shall be insulated with minimum 9.5 mm (3/8") thick armaflex sectional pipe insulation material.

All condensate drain pipes discharge to floor trap, the floor trap shall be insulated throughout the horizontal run to the vertical stack.

e. CABLE CONDUITS

All power and control cables shall be run in PVC conduits along side with refrigerant pipes and terminals in PVC KO boxes with blank PVC cover for future connection between the fan coil unit and condensing unit.

f. PVC TRUNKING

Where refrigerant pipes, drain pipes and electrical conduits are exposed to view, adequate size white PVC trunkings shall be installed to conceal the pipes. Type of trunking shall be submitted for Engineer/Engineers' approval before installation.

g. TESTING & COMMISSIONING

All pipework shall be free from all dirt before connection to equipment.

The Sub-Contractor shall charge in sufficient refrigerant as recommended by the manufacturers to achieve the cooling requirements of the space.

Refrigerant supply and labour to charge shall be provided throughout the Defects

Air-Conditioning and Mechanical Ventilation Installation

Air-Cooled Split Air Conditioning Unit

Liability Period should the need require, and as requested by the Engineer.

Air-Conditioning and Mechanical Ventilation Installation Filters

1. GENERAL

a. DESCRIPTION

This Section specifies the air filters which shall form part of the Works as shown on the Contract Drawings.

b. MANUFACTURE

All filters shall be the products of a single overseas manufacturer who is experienced in the manufacture and testing of air filtering equipment.

c. SELECTION

The Contractor shall select all filters and all components and accessories suitable for the scheduled duties of the air systems of which they form a part. Fan static pressure shall be designed to accommodate the average pressure drop across filter, except in the case of variable air volume systems where the maximum filter pressure drop shall be used.

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

Maximum air face velocities at the inlet to any type of filter cell shall not exceed 2.5m/sec. or the figure recommended by the manufacturer whichever is the lower.

d. STANDARDS

All filters and accessories shall be of the highest commercial standard, and shall be designed, constructed, rated and tested by a recognised authority.

All filters and media shall be U.L. approved and shall be fire-resistant to conform to the requirements of US Federal Standard and Fire Safety Bureau.

Materials shall comply with the various British Standards, listed elsewhere in this Section or other approved international Standards.

The Contractor shall submit test certificates giving overall efficiency & arrestance and pressure loss against percentages of the rated airflow from a recognised test laboratory to verify performance of air filters (efficiency, dust holding capacity, etc.)

2. EQUIPMENT

a. GENERAL

All supply air systems shall be provided with a filtering system unless specifically noted on the Contract Drawings.

Filters for AHUs shall be electronic air cleaners. Filter frames and boxes shall be manufacturer's standard units and should be rigid. Filter frame fabricated by parties other than the filter manufacturer shall not be accepted.

All filter modules shall be selected to have a nominal 600 x 600mm face area, as far as possible.

Air-Conditioning and Mechanical Ventilation Installation Filters

b. ELECTRONIC AIR FILTERS

The Electronic Air Filters shall be designed to be mounted at Air Handling units and shall come in module form. Manufacturer of this equipment shall have supplied installed and commissioned these filters for the past 5 years.

The filters shall be UL listed as a complete assembly.

The Electronic Air Filters shall comprise two ply of fiber glass with a conductive center screen of Aluminium or activated carbon mesh. The complete assembly shall be housed within a Aluminium filter frame and screen, the filter frame being supplied and installed by AHU manufacturer. The four frames shall hinged together and have two pivoting latches to hold them together when closed. The two miniaturized electronic supplies (power head) shall be mounted in a channel on the frame of filter in a non-conductive housing. The two fiber glass media pads shall be placed between the outside grounded frame / screens and the center frame / screen. The center mesh shall carry the high DC voltage from the power head. The filter frames shall be hinged to allow easy access to the media pad for replacement. Neoprene foam strip shall be used on the mating faces of the filters in a row to block the flow of air between filters.

The rated pressure drop through the clean filters shall not exceed 150 Pa and the maximum face velocity at inlet to filter shall not exceed 2.5 m/s.

The 24VAC power supply shall be a UL or CSA certified transformer class "2" type which permit one side of the secondary output (24V) to be attached to electrical ground.

The electronic air filters shall have a 'Power on' lamp and equipped with a high-voltage resistor to de-energize the filter when power is shut off. Each power head shall have an input and output so that the power head of each filter may plug into the next. The power heads will be connected in parallel and will have no effect on failure of one of these head in the row.

The efficiency of the electronic air cleaners shall be at least 67% (atmospheric dust spot efficiency) to ASHRAE 52 - 76.

The principle of operation of electronic air cleaners uses electronically enhanced polarized media filter. The filter shall be non-ozone producing and non-ionizing. The power heads shall be capable of converting 24 VAC to 6.5 KVDC required to energize the filter. The power head shall draw no more than two watts of power. The power head shall be insulated from the filter frame and it shall transmit the 6.5 KVDC to the center screen of the media pad through a titanium filament.

The fiber glass media shall be fabricated from a constant filaments so that any shed fibers are not respirable. The fiber glass shall be minimum of class "2" fire rating.

The Contractor is to note that the carbon filters shall be replaced with completely new carbon filters at the end of the Maintenance (Defects Liability) Period.

The following function/indications shall be provided at the local AHU Control Panel:

- i. Normal Operation of solid state supply - ON

Air-Conditioning and Mechanical Ventilation Installation Filters

- ii. Malfunction (low output voltage) - FAULT
- iii. Excessive pressure drop equivalent of dirt accumulation or reduced output current - FILTER DIRTY

3. INSTALLATION

a. GENERAL

Filter media shall be adequately stored and protected during shipping and construction and shall not be fitted into the filter frames until necessary for the commissioning of the filters.

During initial testing and cleaning of all air handling equipment, temporary filter media shall be provided to clean air entering fans and coils.

Once commissioning has been fully completed, filter media of the correct type shall be installed in each unit/system. One spare set of media shall be provided for each unit/system.

During the commissioning stage the Contractor shall simulate all filter pressure drops as being in a half dirty condition i.e. panel filters at 110 Pa and electronic filters at 250 Pa.

b. MOUNTING

The filter units shall be located as indicated on the Contract Drawings.

All filters shall be erected and sealed within the air stream such that no air leakage around the filter bank or individual filters shall occur.

c. FINISHES

Each panel filter shall be arranged for front top or side withdrawal as indicated.

All units shall be factory painted in accordance with the manufacturer's recommendations.

Any damage to finishes which may have occurred during transit, storage, installation or otherwise shall be made good in the manner recommended by the manufacturer and to the satisfaction of the Engineer.

In addition, the units may require to be insulated and given another finishing coat (or coats) as may be specified elsewhere to match the Engineer's colour coding for the plant room.

Construction of identification plates and labels shall be as specified in the "Miscellaneous Provisions" Section of this Specification

Air-Conditioning and Mechanical Ventilation Installation Ductwork and Fittings

1. DESCRIPTION

This Section specifies the ductwork and fittings for the various systems which form part of the Sub-Contract works as shown on the Drawings.

Unless specifically stated otherwise, the term "ductwork and fittings" when used in a general context shall mean all ductwork, fittings, diffusers, dampers, supports, gauges and all other components and accessories required for the complete installation of the system as shown on the Sub-Contract Drawings.

2. MANUFACTURE

All ductwork and fittings delivered to site shall be new and shall be clearly and indelibly stamped to identify different grades, materials and manufacturer.

All ductwork shall be manufactured as far as practicable to site dimensions taken by the Sub-Contractor. Where site dimensions cannot be taken in advance, dimensions shall be taken from Engineerural/structural detail dimensioned drawings and the Sub-Contractor shall make suitable provisions to accommodate any discrepancies that may occur between the Sub-Contract drawings and the site dimensions.

All dampers, air grilles, diffusers, louvres and other fittings shall be proprietary imported products unless otherwise stated.

Locally made air supply, return, intake and exhaust fittings shall only be used where specifically called for in this Specification or the Sub-Contract Drawings.

All fittings including air distribution equipment, fire dampers, regulating dampers and access doors shall be imported proprietary products for which established performance data is available.

All flexible ductwork and accessories for uninsulated services shall be non-combustible and approved by FSSD.

All fire resistant ductwork shall be asbestos free and approved by FSSD.

3. SELECTION

All ductwork, fittings, accessories, joints and jointing materials shall be suitable for the service and shall not deteriorate due to atmospheric action.

All duct sizes shown on the Sub-Contract Drawings are clear internal sizes unless otherwise noted and due allowance shall be made for the thicknesses of internal or external linings when dimensioning ductwork and selecting fittings and accessories.

Air quality shown on the Drawings are only given as a guide. The Sub-Contractor shall make necessary adjustments on site to suit the space, headroom, temperature and NC level required.

The selection of diffusers and the location of these diffusers shall also achieve an Air Diffusion Performance Index (ADPI) of not less than 80% as defined, and as per parameters laid down by ASHRAE. (Fundamentals Handbook, latest edition).

Air-Conditioning and Mechanical Ventilation Installation

Ductwork and Fittings

4. DUCTWORK

All ductwork and fittings shall be constructed in accordance with the recommendation in the latest edition of the Sheet Metal & Air-conditioning Contractor National Association (SMACNA), USA, unless otherwise specified in this Specification.

Generally, all ductwork shall be of hot dipped galvanized steel sheet to B.S. 2989: 1975 grade Z2, Coating Type C.

Where specified, black steel ductwork shall be constructed from cold reduced steel sheet to B.S. 1449 Grade CR4 GP. Surfaces of completed section shall be treated.

The Sub-Contractor shall ensure that no other services are allowed to be suspended from the ductwork, unless otherwise approved by the Engineer.

Duct Construction

- a) All ductwork shall be fabricated in the Sub-Contractor's own workshop prior to delivery to site for assembly and installation. All ductwork shall be fabricated and run in sizes shown and in positions as indicated on the Drawings and shall be constructed of highly corrosion-resistant hot dip galvanised sheet metal. All ducts shall conform accurately to the dimensions indicated in the Drawings and shall be straight and smooth on the inside with all joints neatly finished.
- b) All ducts shall be free of waves or buckles and shall be machine bent. Ductwork in which the galvanising of the inside surface has been damaged will not be accepted.
- c) All ducts shall be installed and anchored accurately to the building in an approved manner as to be completely free from vibration under all conditions of operation.
- d) The Sub-Contractor is to take all precautions to ensure that the air distribution system is silent in operation and does not create draft.
- e) No free or cut edges of ductwork shall appear within ducts, and where seams or joints protrude into duct air stream, they shall be arranged in the direction of the air flow.
- f) No ductwork joints, bends or other fittings will be permitted within the thickness of the wall, floor or ceiling structures and below structural beams.
- g) Sheet metal ducts shall be properly braced and reinforced. The internal ends of all slip joints shall be installed in the direction of the flow. All ducts shall be constructed with the minimum possible number of seams.
- h) Curved elbows shall have a centre line radius equal to 1½ times the radial width of the duct. Air turns shall be installed in abrupt elbows. The air turns shall consist of curved metal blades or vanes arranged to permit the air to make abrupt turns without appreciable turbulence.
- i) Double thickness aerofoil turning vanes shall be provided for all right angle elbows extending over at least 50% of the whole curvature of the elbow. The turning vanes

Air-Conditioning and Mechanical Ventilation Installation

Ductwork and Fittings

shall have a flange covering the whole base and shall be riveted to the duct at not more than 60 mm centres. The double thickness aerofoil vanes shall be constructed of the same material of the duct enclosing them and shall be of two gauges heavier than the duct material.

- j) Ductwork longitudinal joints shall be of an approved air-tight self-locking type. For high velocity and pressure construction, the joints shall be flange type.
- k) All ductwork cross joints shall be of an approved flanged joints. Flanges shall be of rolled structural angles welded at the corner and shall be riveted to the duct. Spot welding is not acceptable. The downstream end of the duct shall be bent round the face of the flange. The upstream end of the duct shall be inserted 50 mm into the down stream duct so that the overlap is in the direction of the flow. Flanges shall be jig drilled or drilled to template to minimum clearance over bolt diameter. A 5 mm rubber insertion gasket shall be used.
- l) Rivets shall be spaced at not more than 65 mm centres. All ducts joints shall be airtight.
- m) Sleeves

Where ducts pass through walls or partitions, suitable galvanised sheet steel sleeves of a gauge not less than the duct concerned shall be supplied and located into place and shall not protrude more than 13 mm over the finished wall surface. In the case of insulated ductwork the sleeves shall be over-sized to allow the insulation and vapour seal to be continuous through them. The annular space between the inside surface of the sleeve and the outside surface of the duct/insulated ductwork shall be filled up with approved materials.

- n) Fitting of Ductwork

The Sub-Contractor shall take note of the positioning of the ductwork and associated fittings in areas where space is limited. If necessary, the Sub-Contractor shall allow for prefabricating, assembling, and insulating sections of the ductwork in lengths suitable for installation on site. No further allowances will be made later for negotiation of additional space than that generally shown on the Drawings.

- o) Longitudinal Seams

Where the perimeter of the duct does not exceed the width of the sheet metal, ducts shall be constructed with one longitudinal seam only. Flat double longitudinal seams shall be used in all ducts.

5. HANGERS AND SUPPORTS

- a) The Sub-Contractor shall furnish and install hangers, hanger brackets and miscellaneous support as are required for the installation of all ductwork, pipe work, equipment, etc. Supports, hangers, brackets, etc. shall be attached to concrete and masonry walls, ceilings and floors in an approved substantial manner by means of inserts of expansion shields of adequate size and number to support the loads to be imposed thereon. All hangers, brackets and miscellaneous support shall be hot dipped galvanised steel.

Air-Conditioning and Mechanical Ventilation Installation

Ductwork and Fittings

- b) All rectangular ductwork shall be hung with rod hangers. Where angle stiffeners have been provided on the underside of the duct, the hanger rods may pass through the ends of those angled stiffeners for supporting the duct. If these angle stiffeners are not located properly for the hangers, angle across the underside of the duct shall be furnished and installed for fastening to rods. The size of angles shall be the same as the stiffening angles. All hanger rods shall be supported from the floor above. Hanger rods for horizontal duct shall be spaced as follows:-

Cross-sectional Perimeter of duct (m)	Maximum Spacing Between hangers (m)
Less than 1.5	2.4
1.5 to 2.5	1.8
Exceeding 2.5	1.2

Vertical Ducts shall be rigidly supported at not exceeding 1.8 m spacing.

- c) Support Rod and Angle Size

The support rod sizes shall be as follows:

Duct Width (Longest Side)/ Diameter	Minimum Rod Size
Up to 300 mm	6 mm diameter
325 mm to 750 mm	6 mm diameter
775 mm to 1500 mm	10 mm diameter
1525 mm to 2100 mm	10 mm diameter
Above 2100 mm	12 mm diameter

- d) Support Angles

The support angles shall be as follows:

Duct Width (Longest Side)/ Diameter	Minimum Angle Size
Up to 300 mm	19 x 19 x 3 mm
325 mm - 750 mm	25 x 25 x 3 mm
775 - 1500 mm	38 x 38 x 5 mm

Air-Conditioning and Mechanical Ventilation Installation

Ductwork and Fittings

1525 - 2100 mm

50 x 50 x 6.5 mm

Above 2100 mm

50 x 50 x 6.5 mm

All angle supports shall be rolled steel sections.

- e) Support for fire rated duct shall be protected by approved fire rated material, and or as approved by testing Authority and FSSD.

6. DUCT THICKNESS

- a) Duct construction shall be in accordance with the recommendations for duct construction as set forth in the Sheet Metal and Air Conditioning Contractors' National Association's (SMACNA) Guide.
- b) The Drawings do not attempt to show all off-sets in the ductworks. The Sub-Contractor shall make such off-sets as necessary for the installation cost. Where off-sets are required, the angle of the off-sets shall be as small as possible.
- c) Duct construction and sheet metal thickness shall be as shown in the following table:

Maximum Size of Duct	British SWG Sheet	Type of Transverse Joint Connection	Type of Bracing
Up to 300 mm	24 (0.60 mm)	25mm x 25mm x 3mm angle iron joints	25mm x 25mm x 3mm angle 1.7 m from joints
301 mm to 460 mm	25mm x 25mm x 3mm	24 (0.60 mm) angle iron joints	25mm x 25mm x 3mm angle 1.7 m from joints
461 mm to 760 mm	22 (0.80 mm)	25mm x 25mm x 4mm angle iron joints	25mm x 25mm x 4mm angle 1.7 m from joints
761 mm to 1070 mm	22 (0.80 mm)	25mm x 25mm x 4mm angle iron joints	25mm x 25mm x 4mm angle 1.7 m from joints
1071 mm to 1400 mm	20 (1.0 mm)	38mm x 38mm x 4mm angle iron joints	38mm x 38mm x 4mm angle 1.7 m from joints
1401 mm to 2150 mm	20 (1.0 mm)	38mm x 38mm x 4mm angle iron joints	38mm x 38mm x 4mm angle 0.7 m from joints
Above 2150 mm	18 (1.20 mm)	38mm x 38mm x 4mm angle iron joints	38mm x 38mm x 4mm angle 0.7 m from joints

For ductwork used for smoke control purposes, the thickness of the sheet metal shall be minimum 1.2 mm (SWG 18). The internal insulation of non-combustible material or Class O rating to be provided.

Air-Conditioning and Mechanical Ventilation Installation Ductwork and Fittings

7. FLEXIBLE DUCTWORK

Flexible ductwork shall be supplied and fitted where shown on the Drawings.

Flexible ductwork shall be of the acoustic type with the equivalent of 50 mm thickness fibreglass insulation of density 32 kg/cu m. with a relatively smooth internal finish. It shall be non-combustible.

For connection to the linear diffusers, the length of the flexible ducting shall be long enough to connect to either side of the light fittings, but not less than a minimum of 1.5 meters of its natural length so as to allow for relocation of the diffusers at a later date.

Flexible ducting shall be continuous between connections and shall be capable of bending, twisting, stretching under installation conditions, without denting or cracking.

Flexible ducting shall be constructed of a flame-retardant vinyl coated, woven fibreglass fabric bonded to a vinyl coated spring steel wire helix.

Flexible ducting shall comply with the requirements of all statutory authorities approved by BCA and FSSD.

Flexible ducting shall be fixed to the sheet metal duct and diffusers or linear diffusers by means of an approved self-locking worm-drive stainless steel clips. Each point shall be taped with 50 mm self-adhesive, and fire resisting PVC tape to ensure complete air-tight joint.

8. SMOKE PURGING/EXTRACT/PRESSURISATION DUCTWORK

All ductwork serving smoke purging, smoke extract and pressurization system purposes shall be constructed of 1.2 mm thick heavy gauge galvanised steel.

All smoke extract, smoke purging and pressurization ducts shall either be enclosed in structure or be fire rated to give minimum two (2) hour fire resistance.

All smoke extract and pressurization ducts traversing beyond the fire compartment zone shall be fire rated to give at least two (2) hour fire resistance.

All smoke purging/extract and pressurization ductwork shall be of High Velocity - Medium Pressure type. The construction details and methods shall be in accordance with SMACNA standard.

9. FIRE RATED DUCTWORK

Staircase pressurization, fire lift lobby ductwork or where shown in the Drawings shall be fire-proof to give a minimum of 2 hours fire rating inside and 2 hours fire rating outside.

The fire rated ducts shall be either of the following systems:

- i) Ductwork shall be formed from minimum 1.2 mm thick galvanized sheet metal, with all seams welded and all connections fully complete with gasket.

Air-Conditioning and Mechanical Ventilation Installation Ductwork and Fittings

- ii) All seams shall be cold galvanised after welding to make good the surface protection. The duct shall be surrounded by a fire rated material, which shall be approved by PSB/FSSD.
- iii) The duct shall be constructed of fibre-cement core and faced with 0.5 mm thick perforated galvanised steel sheet. This composite shall have neat thickness of 9.5 mm. Its integrity shall be 4 hours rated to BS 476 Pt 8:1972, combustibility to BS 476 Pt 4 : 1970 and insulation to 120 minutes. It shall not be weakened by moisture nor lose its strength and fire integrity when saturated. It shall be able to withstand hose stream action without loss of integrity and disintegration.

The staircase pressurisation and fire lift lobby ductwork shall be directly connected to the sheet metal ductwork with no flexible connection.

The Sub-Contractor shall engage the services of the supplier's Professional Engineer (PE) for endorsement, inspection on site and submission to Authorities of the fire rated duct system for this project.

10. KITCHEN EXHAUST DUCTWORK

All concealed kitchen exhaust ductwork shall be constructed of 1.6mm (16gauge) galvanised steel. The ducts shall be flanged jointed for all duct sizes and shall be made air tight with an approved oil- and grease-resistant sealant. All longitudinal joints shall be double seamed.

All exposed kitchen exhaust ductwork shall be constructed of 1.22 mm (18SWG) stainless steel sheet. Longitudinal and lateral joints stainless steel ducts shall be of flanged construction to prevent leaks. A flange joint made air tight with an approved gasket shall be provided such that the length of the duct section between flange joints is not more than 3.0m.

11. DUCT INSULATION

All insulation materials used shall satisfy flame spread test to BS 476 or approved equivalent standards. Vapour barrier used shall comply with the requirements of the Fire Safety and Shelter Department (FSSD).

All air conditioning ductwork shall be insulated with fibreglass or mineral wool with field applied or factory applied vapour barrier. The vapour barrier shall consist of double sided aluminum foil with glass fibre reinforcements and kraft paper.

All ductwork exposed to weather shall be insulated with 50 mm thick rockwool insulation which shall be protected by aluminum cladding and painted to Engineer's approval.

The insulating material shall have a K factor of 0.0332 W/°k or better at 24° mean temperature. The insulation thickness shall be 50 mm for supply and 25 mm for return ducts and shall be of 32 kg/m³ (2 lb/cu ft) nominal density. For return duct located below the roof and passing through non-air conditioned areas, the insulation thickness shall be 50 mm.

All duct surfaces shall be cleaned and given one coat of flinkote before the application of the insulation material. A further layer of flinkote shall be applied on the insulation before they are wrapped with the vapour barrier which shall have a minimum of 75 mm overlap at all

Air-Conditioning and Mechanical Ventilation Installation Ductwork and Fittings

joints and securely sealed with cover strips and adhesive duct tape to form a perfect vapour barrier. Anti-corrosion treated steel tape shall be strapped around the insulated ductwork at 1 m centres to prevent the insulation from sagging.

Where indicated in the Drawings or elsewhere in this Specification, the materials used for internal insulation shall be mineral wool of 50 mm thick and 112 kg/cu m (7 lb/cu ft) density. The material shall be protected by a layer of fibrous cloth to prevent shedding of the mineral wool or fibre glass particles into the air stream. The cloth together with the insulation material shall be wrapped in perforated aluminum sheet securely fastened to the ductwork. Alternatively, the internal insulation may be closed cell polyurethane (impregnated foam) non-flammable acoustic insulation of 25 mm(minimum) thick and 100 kg/cu m density. All the internal insulation material shall be securely fastened to the ductwork using (perforated mineral wool is used) aluminum sheet. The insulation material shall be Class O to BS476:Pt 6& 7, self extinguishing to ASTM635 and has a thermal conductivity of not more than 0.0465 w/mK at 25°C mean temperature.

The internal insulation shall be supplied around the inside of the duct such that the insulation is continuous. The insulation and the duct corners shall be either butt joint or mitered and the aluminum lamination shall overlap but not less than 10 mm and glued securely by an approved adhesive. The studs shall be brazed to the ducts at spacing specified hereinafter, and shall have a length of not more than 1½ times the thickness of the internal insulation which it holds.

The clips shall be galvanised and of the self-locking type of not more than 25 x 25 mm in size. The centre to centre spacing of studs shall be as follows:

Duct Wall Centre Spacing (mm)

Top Side 150 mm

Vertical Side 200 mm

Bottom Side 300 mm

Internally lined ducts shall be inspected before installation. Duct walls shall not be punctured when securing the internal insulation.

Where the internal insulation terminates, the insulation shall be tapered in ratio of 1 in 3. The aluminum lamination shall extend, over by 100 mm and taped securely to the duct. An overlap of 300 mm shall be provided where the insulation changes from internal to external

The supply ducts leaving air handling units and return duct to the AHU shall be lined internally for a minimum distance of 6 m.

12. CLEANING OF DUCTWORK

During installation, properly fitted sheet metal covers shall be provided at all times to prevent ingress of rubbish. Rags, newspaper and like materials will not be accepted as a suitable covering.

Should existence of rubbish be found in air ducts, the ductwork shall be dismantled as necessary to ensure complete removal of rubbish.

All ducts shall be cleaned of dust before starting of fans.

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All ducts constructed shall be provided with airtight access openings at regular intervals to allow for duct cleaning in future. The Sub-Contractor shall ensure that these openings are properly constructed to prevent any possible air leakage through these openings. The Sub-Contractor shall submit the details of these openings (dimensions/locations) for Engineer's approval.

13. DUCT TEST OPENINGS

Openings shall be provided in ducts for testing purposes with a velometer or Pitot Tube on the supply and discharge side of air handling units major fans, major ducts and other necessary positions in accordance with B.S. 848.

The test openings are to be 150 mm centres across one side of the duct. Each opening shall consist of a 25 mm trap screw brazed into a 40 mm x 5 mm bar. The bar shall be riveted to the duct across its width and each trap screw is to be fitted with a plug.

Where test openings are fitted to internally insulated ducts, the duct insulation is to be protected with perforated metal internally for a distance of 600mm ahead of and 150mm past the test opening position.

14. FLEXIBLE CONNECTIONS

Flexible connection shall be provided at all ductwork connections to the suction and discharge openings of fans, FCUs, AHUs and where shown on the Drawings. These shall be made of approved flame retardant fabric of not less than 100 mm long.

Flame retardant fabric connections shall be made of fibre glass cloth impregnated with a lead loaded vinyl. The surface density shall not be less than 5 kg/m². They shall be to the approval of FSSD.

Flexible connections shall be so constructed to ensure that there is no air leakage. Connections shall have 50 mm to 100 mm length free of stress to permit renewal of fabric without disturbing ductwork or other part of equipment.

15. ACCESS DOORS

The Sub-Contractor shall provide access doors on all ductwork connections, either upstream or downstream of coils, upstream of fans, fire dampers, filters etc. for inspection, cleaning and maintenance purposes in accordance with SMACNA recommendations.

Access doors shall be of double skin construction with insulation of the same general character as adjacent sections of ductwork. The door panel shall be of not less than 1.0 mm sheet metal and shall have not less than 12 mm wide neoprene rubber gasket around their entire perimeter. It shall have the same fire ratings as the adjacent construction.

Access doors shall be hung on heavy brass plated flat hinges and shall be secured in the closed position by means of wedge type catches. All hinges shall be so placed to enable the doors to remain open without additional support. All doors will be hinged with two hinges and two catches will be required on doors over 400 mm x 400 mm. Where it is impractical to use hinged doors, the access doors may be fixed in position with wedge type catches on two opposite sides, with a minimum of 4 catches per door.

16. DUCT LEAKAGE TEST

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The Sub-Contractor shall, at the beginning of the work construct, erect and leak test a representative sample of the duct construction to use at medium pressure class (500 Pa and above). The sample specimen shall include at least five transverse joints, typical seams, an access door and at least two typical branch connections plus an elbow.

The leakage amount shall not exceed the allotted amount for the pressure class or the allotted amount for that portion of the system, whichever is applicable.

Leakage test procedures shall follow the outlines and classifications in the SMACNA HVAC Duct Leakage Test manual.

If the specimen duct fails to meet allotted leakage level, the Sub-Contractor shall modify to bring it into compliance and shall retest it until acceptable leakage is demonstrated. Tests and necessary repair shall be completed prior to concealment of ducts.

The Sub-Contractor shall conduct separate leakage tests for 10% of total ductwork. The Sub-Contractor shall submit detail leakage test proposals for consultant approval at least two (2) months before the intended Leakage Test date.

17. AIR DIFFUSING EQUIPMENT

17.1. General

All grilles, diffusers, louvres and registers used for the purposes of supply and return of conditioned and/or unconditioned air and associated accessories required for the complete air conditioning and mechanical ventilation systems shall be provided under this Sub-Contract. All diffusers, registers, grilles and louvres shall be of 16 gauge extruded anodised aluminum with powder coated to the colour finish to Engineer's approval.

All air diffusing equipment shall be selected for quiet operation when handling the specified volume of air and shall be arranged to provide uniform velocity across the face of the air diffusing equipment. Supply air diffusers shall be selected to achieve the required air mixing but shall give air velocities of the occupied level of not more than 0.25 metres per second. When the finish of the air diffusing equipment is not specified, the finish shall be taken to be spray painted with quality enamel paint of colour, which shall be determined by the Engineer. All internal surfaces of air diffusers and any parts of the ductwork thereof, which is visible, shall be painted matt black.

All diffusers shall be subjected for approval and samples shall be submitted for inspection.

Openings in ducts to receive air diffusers shall be reinforced around the perimeter. Reinforcement shall be in the form of welded frames or double folded seams. Care shall be taken and gaskets shall be used for all diffusers and grilles to ensure that leaks do not occur at the necks or from around the air diffusers. Air diffusers shall be fixed to the ceiling, wall or any other building structure and no fixing screws shall be visible.

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Air quantity as shown in Drawings is only given as a guide, the Sub-Sub-Contractor shall adjust it on site to suit the space temperature and NC level requirement.

17.2. Construction

All side throw supply and return air grilles shall be frameless linear bar grilles.

All supply, exhaust grilles and diffusers shall be fitted with opposed blade volume control dampers of approved construction.

For the side discharge register, the front set of blades shall be vertical and rear set of blades shall be horizontal. Concealed sheet metal screw fixing shall be used through the register collar into the duct spigot. Screw fixing through the register face flange shall be rejected. Maximum neck velocities shall not exceed 2.5 m/s.

Louvres shall be of the recessed, flanged or removable frame type with one set of fixed horizontal blades. The method of fixing shall be as specified for side discharge registers.

Side extract air grilles shall be supplied and installed as specified for louvres. Ceiling extract/return air grilles shall have 13mm x 13mm x 25mm aluminum grids (egg crate type) and shall be of recessed, flanged or removable type.

Outdoor air louver shall be weatherproof type, extruded aluminum complete with gasket seal, bronze birdwide mesh screen, opposed blade damper and removable air filter with frame. Screening shall not be larger than 10mm mesh.

Correct performance of all air diffusers shall be the full responsibility of the Air Conditioning and Mechanical Ventilation Sub-Contractor. All diffusers and grilles shall be of reputable make and their performance shall be tested and certified.

17.3. Linear Diffusers

Linear diffusers shall be provided at locations and of capacities as shown on the Drawings. All ducted return and supply air linear diffusers shall be complete with an insulated air plenum box for connection to flexible duct.

Plenum box for linear diffuser shall be constructed of galvanised steel of minimum 20 gauge. Each plenum box shall have an inlet collar for connection to flexible duct. The internal surfaces of the plenum box shall be acoustically and thermally insulated with minimum 25 mm thick, 32kg/m³ density fibreglass or scrimed mineral wool. Internal surfaces shall be treated to prevent corrosion. The exterior surfaces shall be suitably prime etched to prevent rusting.

Volume control dampers shall be provided for all supply air linear diffusers at the air inlet collar of the plenum box. In addition, the supply air linear diffusers shall come with 2-way directional louvres.

Suitable diffuser with correct number of slots shall be selected to ensure that the NC level comply with the specified requirement.

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Diffusers shall be of minimum 2 slots linear diffuser, high induction ratio type and shall operate from design airflow of 100% to 10% without air dumping. Performance of diffuser shall be based on actual factory tests and published catalogue data. The Sub-Contractor shall ensure all diffusers operate at low noise level at all conditions. Diffusers shall be selected to supply 120% of design flow rate at low noise.

Diffuser shall be of anodised aluminum, not less than 1.5 mm with finishing colour as specified. Approximate length of each diffuser shall be shown on the Tender Drawings. However, final length of the linear diffuser shall be coordinated with the ceiling system. For the purpose of Tender, the Tenderer shall assume that the length may vary by ± 100 mm from that indicated and all incidental cost for such adjustment to the diffuser length shall be included in the Sub-Contract price.

The Sub-Contractor shall obtain from the manufacturer a noise level guarantee in writing before placing the order and submit it to the Engineer for approval.

The Sub-Contractor shall submit airflow characteristic of the diffusers showing clearly the diffusion air pattern for each type of diffuser for 100%, 75%, 50% and 40% of the designed air quantities.

The Sub-Contractor shall make available within four weeks from the date of award of the Sub-Contract, the size, shape and constructional details of the diffusers. All details shall be provided to ensure an accurate coordination with the ceiling grid system.

Exposed surfaces of slot(s) shall be finished to a colour approved by the Engineer

17.4. Ceiling Diffusers

Ceiling diffusers shall be of anodised aluminum construction and of the louvre face type suitable for surface mounting. The diffusers shall be rigidly constructed, and unless otherwise specified shall have not less than four (4) louvre vanes per 150mm. The external surface of the diffuser plenum box shall be insulated with 15 mm closed cell insulation completion with vapour barrier.

Volume control dampers shall be provided for all ceiling diffusers at the air inlet collar of the plenum box.

Unless otherwise stated, ceiling diffusers mounted directly on the underside of the ductwork shall be provided with a multi-blade stream splitter damper. The stream splitter damper shall be constructed as specified in this section.

Air velocities at neck of ceiling diffusers shall not be more than 2.5m/s unless otherwise shown.

For discharge of supply air from a ceiling height greater than four (4) metres, variable twist/swirl diffusers with high induction, radial jets shall be used. The discharge direction shall be able to be continually adjustable from horizontal to vertically downward. The diffusers shall have an outer cylinder with round exit, built-in coaxially movable swirl cylinder and the twist vane inserted between the core chamber and the

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cylinder sleeve. The swirl cylinder shall be manually adjustable by an adjustment screw. The diffuser shall be made of galvanised sheet steel or aluminum and shall be proprietary made. The colour shall be subject to Engineer's approval. Where required, the circular diffuser shall be set onto a square fascia to match the type of ceiling used.

18. DAMPERS AND SPLITTERS

All dampers shall be as specified below. All screw and adjustment mechanism shall be of galvanised steel. All blades for dampers shall be constructed at minimum gauge 18 extruded aluminum in double streamlined sections.

The volume control dampers shall be of aluminum, opposed blade type and consist of self-lubricating nylon bushings and actuator parts assuring smooth operation of blades and capable of being adjusted externally and fixed in position with screw.

Splitters shall be used as shown on the Drawings or where necessary for balancing of air distribution. Splitter damper shall be fitted with a hand lever and quadrant in accessible positions capable of being locked in any position. The OPEN and SHUT positions shall be stamped on the quadrant or marked on the duct by means of engraved labels. When an adjustable quadrant is fitted over the vapour seal, a 16 gauge galvanised steel plate of sufficient size shall be provided to avoid breaking the vapour seal.

Except where it is specifically stated on the Drawings, all duct branches and supply air collars or take offs of more than 1.0 metre in length shall be fitted with a fixed blade air stream splitter dampers. The Sub-Contractor shall take special care to ensure that all dampers are free from vibration and rattles under all operating conditions.

The damper unit shall be complete with soft rubber sponge gaskets of not less than 6 mm thickness for connection to ductwork and grilles.

Damper adjustment mechanism shall be of approved type and shall be of rigid construction with no slack when opening or closing of the damper. The adjustment mechanism shall be concealed.

The multi-blades splitter damper shall be of steel frame construction with extruded aluminum, right angle curved blades, suitably spaced.

Dampers shall be adjusted by an adjustment mechanism.

19. OUTSIDE AIR AND EXHAUST AIR LOUVRES

Unless otherwise shown in the Drawings, all outside air and exhaust air louvres for air intake and air exhaust shall be supplied and fixed by the Sub-Contractor to the Engineer's details.

Louvre blades shall be horizontal and constructed of or extruded aluminium set in rigid frame. Blades shall be set at approximately 50 mm apart and at an angle of 30° to the horizontal. The louvres shall be weatherproof type.

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All fresh air and exhaust air louvres and openings shall be fixed with 12 mm mesh matt black painted galvanised insect screen on the inside.

All outside air louvres shall have insect screens, air filters and adjustable volume control dampers. All exhaust air louvres shall have insect screens.

20. FIRE DAMPERS

Fire dampers shall be installed as specified on the Drawings and at locations required by the FSSD. Fire Dampers shall be approved by SPRING/TUV. The Sub-Contractor shall be responsible for any letter of undertaking as required by FSSD that the fire dampers are installed correctly and bear the SPRING label.

In general, where air conditioning ducts pass through floors or firewalls other than party walls, fire dampers with fusible links as specified hereinafter shall be installed. Such fire dampers shall be so arranged that the disruption of the duct will not cause failure to protect the duct opening. Access panels shall be installed in such a location so that inspection and resetting of the fire damper is possible. All fire dampers shall be installed to meet the requirements of the FSSD.

Fire dampers shall be constructed and tested in accordance with FSSD and SPRING's requirements, and shall be suitable for the fire rating of the surrounding construction, but not less than two hours and shall be installed in strict accordance with the manufacturer's recommendation.

Fire dampers shall be of the multi-blade type except for ducts less than 350 mm (height) where single-blade type may be used.

Air-Conditioning and Mechanical Ventilation Installation Pipework and Fittings

1. GENERAL

a. DESCRIPTION

This Section specifies the pipework and fittings for the various systems which shall form part of the Works as shown on the Drawings.

Unless specifically stated otherwise, the terms "pipework and fittings" or "pipes and fittings", when used in a general context, shall mean all pipework, fittings, valves, gauges, strainers, hangers, supports and all other components and accessories required for the complete installation of the system as shown on the Drawings.

b. MANUFACTURE

All pipework and fittings of the same material shall be supplied by a single manufacturer to ensure uniformity of standards and composition between services installations. Pipework and fittings employed throughout this project shall be of EEC, North American or Japanese origin.

All pipework delivered to site shall be new and shall be colour banded at the factory to identify different grades, materials and manufacturers. Mill certificate shall be submitted before delivery of each batch of pipework to site, these shall certify the standards of the manufacture and testing.

c. SELECTION

All valves for isolation and regulation shall be the product of a single manufacturer.

All pipework fittings, accessories, joints and joining media used shall be suitable for the substance conveyed in the pipes and shall not deteriorate due to chemical or atmospheric action.

All pipework, fittings and valves must be suitable for the system test pressures.

2. EQUIPMENT

a. STANDARDS

All pipework and fittings shall comply with the appropriate British Standard as listed in the relevant Table of this Section.

All personnel engaged on welding operations must possess a certificate of competence issued by an approved authority. These certificates must be produced for inspection by the Engineer before any welding is undertaken and renewal certificates must be provided every six months.

Each weld shall be given a suitable mark in order that the operative concerned may be identified. This will be rigidly enforced.

The Engineer reserves the right to order at random the cutting out of 2% of the welded joints for inspection and testing. Should any one of the above welds prove faulty in materials or workmanship, further removal of welds may be ordered up to a total of 4% of the welded joints. If the number of welds failing the tests within the above 4% is sufficient to suggest that an operative is not consistent in his standard,

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the Engineer may order any number of that operative's welds to be removed. The cutting out and repair of all such welds for inspection shall be at the cost of the Sub-Contractor.

Oxy-acetylene and metal arc welding of steel pipework shall be Class 2 to B.S. 2640, B.S. 2971 or B.S. 4515.

Fusion welded joints in copper shall be to B.S. 1077 and bronze welding by gas shall comply in every respect with B.S. 1724.

Gas welding of steel pipework of 65mm and above shall not be permitted unless prior permission is obtained.

Welding shall not be permitted on galvanized pipework under any circumstances.

No locally made ductile iron pipework, flanges or fittings will be accepted.

Generally, all ferrous piping systems shall comply with B.S. EN 806.

All screwed joints shall be made in compliance with B.S. EN 10226-1 using jointing compounds carefully selected to suit the type of service.

All flanged joints shall be made in compliance with B.S. 4505 and all fittings valves etc. shall be compatible with sub flanges. Flanges shall have raised faces and a uniformity of flanges shall be employed between each service installation. All pipework, fittings and plant flanges shall be suitable for the system pressures. All capillary fittings shall comply with B.S. 864-3.

b. MATERIALS

Table A lists the material classes for the various piped services forming part of the Works. These classes are referred to in the various Tables of standards and specifications used in this Section.

Table B lists the materials specifications for the various classes of pipework.

c. JOINT AND JOINTING

Table C lists the joints and jointing materials to be used on straight runs of pipework for the various classes of pipework. No hemp shall be used for jointing.

Table D lists the joints and jointing materials to be used for connections to items of equipment and adjacent to valves, strainers and other pipeline accessories. In addition, sufficient joints of this type shall be provided in all plant rooms to ensure that access to equipment for maintenance, removal and replacement can be effected without dismantling large sections of pipework or adjacent plant.

Table E lists the type of flanges and method of attachment for use where flanged joints or connections are specified.

Where pipework is connected to items of equipment having flanges of a dissimilar metal to the pipework, then isolating flanges of a proprietary brand shall be used with plastic bolt inserts.

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d. FITTINGS

Table F lists the type of fittings which shall be used with the various classes of pipework.

Long sweep bends shall be used in preference to round elbows wherever practicable. Square elbows or lobster backed bends shall not be used.

Tees shall be of the easy sweep or twin elbow pattern except where square tees are required for venting or draining, etc.

Bushes shall not be used and where a reduction in pipe size is required, reducing sockets or tees shall be used. Eccentric reducing sockets shall be used wherever necessary to ensure proper drainage or elimination of air pockets.

e. SUPPORTS

Table G lists the maximum allowable spacings of support centres for the various classes of pipework.

Pipe supports shall be provided as required for the stable and sufficient support of the pipework as per BS3974.

Pipe supports shall allow free movement for expansion and contraction and shall be graded to required levels for air elimination and drainage.

To ensure free movement, proprietary PTFE slide bearing pads shall be provided, either welded or screwed to the support member.

Ferrous pipes shall have ferrous brackets and copper pipes shall have brass or gunmetal brackets. For ferrous pipework the pipe brackets shall be hot dip galvanised after manufacture.

Additional supports shall be provided adjacent to mixing valves and every turn of the pipework, and other large pipeline mounted items to prevent undue strain on adjoining pipework. Additional supports shall also be provided adjacent to pump connections, etc., to prevent undue strain on plant.

f. AIR VENTS

Key operated air vent cocks of an adequate size shall be provided at all high points on water supply pipework.

g. DRAIN POINTS

Adequately size key operated drain cocks shall be provided at all low points on liquid circulation Systems.

h. PIPELINE STRAINERS

Water strainers shall be installed in all pipelines upstream of all plant and elsewhere as indicated on the Drawings.

For pipelines of nominal bores between 15mm and 50mm inclusive strainers shall

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Pipework and Fittings

be screwed gunmetal or bronze body 'Y' type with stainless steel screen.

For pipelines of nominal bores from 65mm and above, strainers shall be flanged to B.S. EN 1092 to the appropriate Table for the material with 'Y' type bronze body, stainless steel screen.

i. VALVES

Valves for the various classes of pipework shall be as indicated in the following Tables.

Table H - Isolating Valves.

Table I - Regulating Valves.

Table J - Check Valves.

Table K - Drain Cocks.

Table L - Strainers

Table M - Ventcocks

The Tables listed are included for guidance only. Suitable types of valves for a particular service and pressure listed shall be selected.

All valves necessary for the proper completion, working, isolation, regulation and control of the installations shall be provided.

All valves shall be of heavy-duty type with bodies and seats suitable for the working hydraulic and test pressures and installed with the valve stems truly vertical or horizontal.

Where flanged valves, etc., are specified, details of flanges shall correspond to the appropriate specification. Valve flanges and counter flanges shall be to the same British Standard and a common flange type and rating shall be employed throughout except where system pressures required flanges rated higher than PN10.

In addition to pressure gauge locations, gunmetal test cocks 10mm or 15mm size shall be fitted on incoming and outgoing pipes for testing.

Valves of 150mm diameter and above located 2,200mm or more above floor level within plant rooms shall have a chain operating gear descending to 1,000mm above floor level.

Plugs for gland cocks shall be ground-in. A loose key of forged mild steel shall be provided with each gland cock.

Air cocks shall be nickel-plated, of the Spoutless pattern and with screwed taper thread. At least two loose keys shall be provided for each installation.

j. PRESSURE GAUGES

Pressure gauges shall be of Bourdon type with brass syphon and cock, and piping

Air-Conditioning and Mechanical Ventilation Installation Pipework and Fittings

connection to the measuring point; size to be 100mm diameter dial, conforming to B.S. 1780. All gauges shall have black pointer, red over run indicators, and red mark at normal working pressure.

The pressure gauges shall be of the order of 150% of the known working pressure expected at the tapping point, disregarding any hydrostatic pressure as specified in the "Testing and Operation" Section. Pressure gauges shall have scales with divisions not exceeding 0.5 bar and a minimum scale value of 2,500 kPa.

Pressure gauges shall be mounted directly on pipework and shall be labelled as specified elsewhere.

An isolating valve/cock shall be provided for each pressure gauge.

Pressure gauges shall be installed where shown on the Drawings; and whether shown on the Drawings or not, in the flows and returns connection of all pumps and chillers.

3. INSTALLATION

a. GENERAL

Provide all labour and material to form complete pipework systems and shall leave the installation adjusted to the designed flow rates.

All pipe runs shall be installed generally in accordance with the Drawings but full allowance shall be made for the detailed development and co-ordination of the scheme and for the future removal and dismantling of sections of the Works.

All pipework shall be free from burrs, rust and scale and shall be thoroughly cleaned before installation.

During the course of the installation, all open ends shall be plugged or capped to prevent ingress of dirt and on completion each system shall be thoroughly flushed out with clean water. Wooden bungs shall not be used for plugging pipework.

Where two or more pipe runs follow the same route, care shall be taken to ensure that all are parallel to each other and to the building structure, except for the required allowance for venting, etc. Pipework which is to be subsequently insulated shall be so spaced to allow an individual finish to each.

Air relief valve shall be provided at all high points where venting may be required, whether shown on drawings or not.

b. FALLS

Pipework shall be installed with correct falls to ensure adequate venting and draining.

c. JOINTS

Pipework installed for all particular type of joints are specifically called for in this section.

Air-Conditioning and Mechanical Ventilation Installation Pipework and Fittings

d. ANCHORS

No pipe joints shall be permitted within the thickness of walls or floors, etc.

Joints shall not be closer than 1.0m except where necessitated by fittings.

Anchors shall be positioned in association with pipework change in direction and propriety expansion compensators, etc., such as to absorb the stresses due to pipework expansion and internal pressures by transmission of such forces to the ground or structure at appropriate points.

In addition to serving the purpose of constraining the pipeline, the anchors may be used in connection with testing of pipework, and at such times, it will be necessary to have the extreme ends of the main being tested held with the anchors to prevent the pipeline drawing apart due to the thrust pressures exerted at the end of the pipe.

Adequate pipe anchors shall be provided whether or not shown on the Drawings and shall be constructed from structural steel channel sections secured to the building structure.

e. GUIDES

Guides shall be of mild steel riders welded to the pipes on roller or PTFE sliding supports restrained with U-bolts on brackets or as otherwise detailed on the Drawings.

f. 15.19 FLEXIBLE AND EXPANSION COUPLINGS

The couplings shall be arranged such that torsional, co-axial stress and lateral stress caused by expansion and/or settlement shall not be transmitted to the flanged connections of the plant.

To ensure that the expansion joints are adequately tied, anchored or removed to avoid damage to the bellows during sectional testing.

Wherever necessary, due allowance shall be made for the expansion and contraction of pipework by change in direction of pipework, or expansion loops, whether shown on the Drawings or not.

At building expansion joints, and wherever else necessary, additional allowance shall be made by the provision of stainless steel axial or articulated bellows type expansion compensators complete with all necessary guides, etc., as recommended by the manufacturer to give a working life of not less than twenty years.

Each compensator shall maintain at least the same cross-sectional area as adjoining pipework for its entire length.

On larger diameter steel, ductile and grey iron pipes (150mm diameter and above) judicious use of "dresser" couplings or other equal flexible couplings shall be made in connection to all plant items.

Flexible couplings shall be fitted to pump suction and delivery connections and where indicated on the Drawings or schematics.

Air-Conditioning and Mechanical Ventilation Installation

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Flexible couplings shall be line size, made from a multi-ply nylon fabric carcass with wire reinforced collars and stainless steel liners designed to suit the fluid conveyed and the working, test, and shock pressures that will be experienced in the various systems.

Manufacturers shall be alerted, and consideration shall be given to the possibility of variations of service (e.g. on/off pump operation shock pressures, etc.) to ensure correct selection of items for the particular application.

g. PIPE SLEEVES

To supply and install pipe sleeves where pipe pass through walls, floors, etc.

Where pipes pass through walls, floors or ceilings rendered liquid-tight puddle flanges shall be supplied and installed.

Sleeves for cast iron, copper and steel pipes shall be galvanised steel. For plastic pipes, the sleeves shall be plastic.

Where sleeves are fitted through floors, they shall extend to at least 50mm clear of finished floor.

Sleeves shall be of sufficient size to allow free movement of pipes and where pipes are insulated, the sleeves are to be oversized to allow the insulation to be carried through the sleeves.

Details of pipes through walls and floors to be submitted for checking before installation.

Where exposed pipes pass through walls, ceilings and floors, hinged mild steel escutcheon rings are to be used. All plates are to be chromium plated steel and samples of such plates are to be submitted to the Engineer for checking.

Pipe sleeves shall also be provided where piping penetrates external walls and roofs. The space between pipe sleeves and the pipe or insulation shall then be completely caulked with a soft, non-setting waterproof mastic compound giving an air and watertight seal.

Penetrations through roofs shall also be provided with a weatherproof apron and up stand curb or other provisions as may be specified elsewhere or shown on the Drawings.

Where pipes pass through fire walls and floor slabs, a metal fire stop is to be welded or bolted around the pipe. This shall be in the form of a 6mm thick flange located in the centre of the slab/wall thickness and welded/screwed to the pipe, the flange being of the same diameter as the internal bore of the pipe sleeve.

h. TESTING

All pipework systems shall be tested in accordance with the "Commissioning and Testing" Section of this Specification.

i. FINISHES

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Pipework insulated and covered with aluminium foil or insulated pipework within false ceilings and pipe shafts need not be painted.

All other exposed pipework including UPVC pipes, galvanized steel pipes and copper pipes shall be painted. All cast iron pipework shall be painted.

Painting shall be as described in the "Insulation and Painting" Section of this Specification.

All equipment forming part of the pipework system or connected to the pipework will be painted as specified.

Any damage to factory applied finishes shall be made good on site in the manner recommended by the manufacturer and to the satisfaction of the Engineer.

All pipework systems shall be colour coded and marked with directional arrows in accordance with BS EN 1710.

j. IDENTIFICATION

All pipework, valves and fittings shall be provided with identification markings and labels as specified in the "Insulation and Painting" Section of this Specification.

Construction of identification labels shall be as specified in the "Miscellaneous Provisions" Section of this Specification.

TABLE A - PIPEWORK CLASSES	
Piped Service	Pipework Classes
Chilled Water	A
Condenser water, cooling towers	B
Make-up water pipe, (chilled water system)	B
Make-up water pipe, cooling towers	E
Condensate drainage, down pipes	E
Condensate drainage, in false ceilings	E
Water treatment chemicals	C or D
Tanks vents, overflow and drains	E
Refrigerant pipework	F
Condensate drainage, in cabinets	E

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TABLE B - PIPEWORK SPECIFICATIONS			
Pipework Class	Nominal Bore (mm)	Minimum Wall Thickness (mm)	Specification
A	15-150	-	Black steel to BS EN 10255-3 Black carbon steel, electric resistance (ERW 410) using 410 MPa grade steel BS MA 49 and BS EN 10217-1
	200	4.9	
	250	6.3	
	300	6.3	
	350	8.0	
	400	8.0	
	450	8.8	
	500	8.8	
B	15-150	-	Seamless galvanized steel to BS EN 10255-3 Galvanizing to be carried out by pipe manufacturer. As for Class A, but pipe shall be seamless & galvanized by manufacturer.
	above 150	-	
c	10-200	-	Unplasticized PVC to B.S.3506 : 1969, Table 1, Class D.
D	15-100	-	Rigid A.B.S. to B.S.539-1:2006 To Table 1, Class E. To Table 1, Class D. To Table 1, Class C.
	150		
	200		
E	6 - 150		Light gauge copper tube to BS 2051-1
F	10 - 200	-	Copper pipe for pressure systems to BS1306, Table I, cleaned degreased and hermetically sealed to BS MA 60.

TABLE C - JOINTS IN STRAIGHT RUNS OF PIPE		
Pipework Class	Nominal Bore(mm)	Joints and Materials
A	10 – 50	Black malleable iron, bronze to iron spherical seat unions with jointing material to BS 6956
	65-1000	Welded joints.

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TABLE C - JOINTS IN STRAIGHT RUNS OF PIPE

Pipework Class	Nominal Bore(mm)	Joints and Materials
		Alternatively dresser couplings or other mechanical joints shall be used as required and where shown on the Drawings or specified
B	15 – 50	Galvanized malleable iron, bronze to iron spherical seat unions with jointing material to BS 6956.
	65-150	Galvanized malleable iron, bronze to iron spherical seat unions with jointing material to BS 6956 <u>or</u> galvanized screwed boss flanges to BS EN 1092-3
	Above 150	Galvanized steel flanges to BS EN 1092 or Grooved mechanical joints
C	10 - 200	Solvent welded joints to BS 6464 using solvent cements to BS 6464
D	15-200	Solvent welded spigot and socket fittings to BS 5392-1
E	6 – 50	Capillary joints to BS 864-3.
	65-500	Weld on stub flanges to BS EN 1092
F	6 - 200	Welding with silver base alloy having melting point greater than 540°C. Fittings shall be of cast red brass or wrought brass.

TABLE D - JOINTS FOR EQUIPMENT CONNECTIONS

Pipework Class	Nominal Bore(mm)	Joints and Materials
A	10 – 50	Black malleable iron, bronze to iron spherical seat unions with jointing material to BS 6956-1 and BS 6596-5
	65-1000	Black mild steel welding flanges to BS EN 1092-3 Alternatively on pipework 100mm diameter and above dresser couplings or other mechanical joints shall be used as required and where shown on the Drawings or specified
B	15 – 150	As for straight pipe runs.
	Above	As for straight pipe runs.

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TABLE D - JOINTS FOR EQUIPMENT CONNECTIONS

Pipework Class	Nominal Bore(mm)	Joints and Materials
	150	
C	10 - 200	Mechanical joints to BS 5955-6
D	15-200	As for straight pipe runs.
E	6 - 500	As for straight pipe runs.
F	6 - 200	As for straight pipe runs.

TABLE E - FLANGE DETAILS

Pipework Class	Nominal Class Bore(mm)	Flange Type and Method of Attachment
A	15-50	Screwed on steel boss flanges with taper threads to BS EN 10226-1 Flanges to B.S.4504:1969:Part 1, Table 6/4.
	65-150	For oxy-acetylene welding: Type 7 slip-on steel boss welding flanges. Class 2 welding to BS 2640 : 1982. For metal arc welding: Type 6 Slip-on welding flanges. Class 2 welding to BS 2971 : 1991
	200-1000	Type 6 slip-on welding flanges. Metal arc welding to BS 4515 : 2009. Flanges to BS 2971 : 1991
B	15-150	Screwed on galvanized steel boss flanges with taper threads to BS EN 10226-1, pipe expanded into flange. Galvanized flanges to BS 2971 : 1991
	200-1000	Type 6 slip on welding flanges. Method arc welded to BS 4515:2009 using Flanges to BS 2971 : 1991 All black steel and galvanized after welding. Care must be taken to ensure the Flange face is not twisted or defaced during the galvanized process.
C	10-200	Flanges equivalent to BS 2971 : 1991 Solvent welded using solvent cement to BS EN 1452

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TABLE E - FLANGE DETAILS		
Pipework Class	Nominal Class Bore(mm)	Flange Type and Method of Attachment
D	15-200	Flanges equivalent to BS EN 1092-3 : 2003 Solvent welded to manufacturer's recommendation.
E	6-500	Flanges to BS 1560-3.2 : 1989 copper slip-on flanges for brazing to BS EN14324 : 2004 or welding to B.S. 1724 : 1990.
F	6-200	Flanges to BS 1560-3.2 : 1989 Type 22 Copper slip-on flanges for brazing to BS EN 14324 : 2004 or welding to BS1729

TABLE F - PIPE FITTINGS		
Pipework Class	Nominal Bore(mm)	Fittings
A	10 – 50	Black malleable iron screwed fittings to B.S.143 and 1256 : 2000 or purpose made heavy weight welding fittings to BS 2971 : 1991
	65-1000	Heavy weight welding fittings to BS 2971 : 1991
B	15-150	Galvanized malleable iron screwed fittings in BS 143 and 1256 : 2000
	Above 150	Galvanized iron fittings to B.S. 4772 : 1971.
C	10-200	Unplasticized PVC injection moulded fittings to B.S.4346:1969:Part 1, Solvents to BS EN 1452-3 : 2000
D	15-200	A.B.S. solvent welding fittings to BS 5392-1: 2006
E and F	6 – 50	Copper compression fittings to BS EN 1254-2 : 1998 Dezincification Resistant (D.Z.R)
	65-500	Flanged fittings to BS EN 1092-3

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TABLE G - MAXIMUM SUPPORT SPACINGS		
Pipework Class	Nominal Bore(mm)	Support Centre (m)
A	10 – 15	2.0
	20	2.4
	25 – 32	2.7
	40	3.0
	50	3.4
	64 – 80	3.7
	100	4.1
	125	4.4
	150	4.4
	200	4.4
	250	4.4
	300 – 500	4.4
B	15 -150	As for Class A Pipework.
	Above 150	As for Class A Pipework.
C	10 – 20	0.9
	25 – 32	1.1
	40 – 80	1.4
	100	1.9
	150	2.1
	200	2.4
D	15 - 200	As for Class D pipework.
E and F	15 – 20	1.4
	25 – 32	1.7
	42 – 67	2.0
	76	2.4
	108 - 500	2.7

TABLE H - ISOLATING VALVES				
PIPED SYSTEM : CHILLED WATER AND CONDENSER WATER				
VALVE TYPE :	Gate	Gate	Gate	Gate
NOMINAL BORE : (mm)	15 - 80	100 – 500	15 – 80	100 - 500
WORKING :	10 bar	10 bar	16 bar	16 bar

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TABLE H - ISOLATING VALVES				
PIPED SYSTEM : CHILLED WATER AND CONDENSER WATER				
PRESS./(TEMP)	100 deg. C	100 deg. C	100 deg. C	-10 to 65 deg.C
BODY :	Gun-metal	Cast of Iron	Gun-metal	Cast BS 1452 Grid 14
SPINDLE :	Gunmetal inside screw non- rising stem	Stainless Steel	Gunmetal inside screw non- rising stem Gun-metal solid wedge	Stainless Steel
GATE :	Gun-metal solid wedge	Stainless Steel	Brass	Stainless Steel
GLAND :	Brass	Stainless Steel	Bronze	13% Cr Stainless Steel
DISC :	Bronze	Steel	Bronze	Steel
SEAT :	Bronze	Stainless steel	BS 21 1985	Stainless steel
TAPPING/ FLANGE :	BS 21 1985	Flanged to BS 4504 (PN 10)	Body unpolished bonnet & gland machined	Flanged to BS 4504 (PN 10)
FINISH :	Body unpolished bonnet & gland machined	-	Aluminium Painted spoked handwheel or lock-shield	-
HEAD :	Aluminium Painted spoked handwheel or lock-shield	Cast of Iron	BS 5154 PN 25 Series B	Cast of Iron
BRITISH STANDARD :	BS 5154 PN 10 Series B	BS 5150 PN 10		BS 5150 PN 16

TABLE H - ISOLATING VALVES			
PIPED SYSTEM: ALL SYSTEM			
VALVE TYPE :	Stop cocks	Stop cocks	
NOMINAL BORE :	15 - 150	15 - 150	
WORKING PRESSURE :	10 bar	10 bar	
BODY :	Gun-metal	Cast steel	
SPINDLE :	Gun-metal rising stem	13% Cr stainless steel	
GATE :	Gun-metal	13% Cr stainless steel	

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TABLE H - ISOLATING VALVES		
PIPED SYSTEM: ALL SYSTEM		
GLAND :	-	-
DISC :	-	-
SEAT :	Gun-metal	Cast Steel
TAPPING/FLANGE :	Flanged or compression	Flanged or BS 4504
FINISH :	-	-
HEAD :	-	-
BRITISH STANDARD :	BS 1010 Part 2	-

TABLE I - REGULATING VALVES		
PIPED SYSTEM : CHILLED WATER AND CONDENSER WATER		
VALVE TYPE :	Globe	Globe
NOMINAL BORE :	15 - 80	65 - 300
WORKING PRESSURE :	10 bar	10 bar
BODY :	Gun-metal	Cast steel
SPINDLE :	Bronze	13% Cr stainless steel
GATE :	-	-
GLAND :	Brass gland packed, repackable under pressure	Stainless steel
DISC :	Bronze	Stainless steel
SEAT :	Brass	Stainless steel
TAPPING/FLANGE :	BS 21 (1985)	Flanged BS 4504 (PN 16)
FINISH :	Body unpolished, bonnet & gland machined	As Cast
HAND WHEEL :	Aluminium painted spoked hand-wheel	-

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TABLE I - REGULATING VALVES		
PIPED SYSTEM : CHILLED WATER AND CONDENSER WATER		
BRITISH STANDARD :	BS 5154 PN 10 Series B	BS 5154 PN 10 Series B
VALVE TYPE :	Double Regulating	Double Regulating
NOMINAL BORE : (mm)	15 – 50	80 - 500
WORKING PRESSURE : (Temp.)	10 bar	10 bar
BODY :	Bronze	Cast iron
SPINDLE :	Bronze	Stainless steel
GATE :	-	-
GLAND :	PTFE	Graphited mineral
DISC :	Bronze	Stainless steel regulating disc
SEAT :	Bronze	Stainless steel
TAPPING/FLANGE :	BS 21 (1985)	Flanged BS 4504 (PN 10
FINISH :	-	-
HAND WHEEL :	Aluminium wheel or lock-shield	Pressed steel
BRITISH STANDARD :	-	-

TABLE J - CHECK VALVES	
PIPED SYSTEM: CHILLED WATER FEED AND CONDENSER WATER	
VALVE TYPE :	Check (Anti-water hammer type)
NOMINAL BORE : (mm)	65 - 500
WORKING PRESSURE :	16 bar 120 deg. C

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TABLE J - CHECK VALVES		
PIPED SYSTEM: CHILLED WATER FEED AND CONDENSER WATER		
(Temp.)		
BODY	:	Grey Cast Iron
SPINDLE	:	-
GATE	:	-
GLAND	:	-
DISC	:	Grey Cast Iron Gun-metal faced
SEAT	:	Gun-metal
TAPPING/FLANGE	:	Flanged BS 4504 (PN 10)
FINISH	:	As Cast
HINGE	:	Gun-metal
BRITISH STANDARD	:	BS 5152

TABLE K - DRAIN COCKS		
PIPED SYSTEM : ALL SYSTEMS		
VALVE TYPE	:	Drain cocks
NOMINAL BORE (mm)	:	15 – 50
WORKING PRESSURE (Temp.)	:	10 bar 100 deg. C
BODY	:	Bronze hose union outlet
SPINDLE	:	-
GATE	:	-
GLAND	:	Packed
DISC	:	-
SEAT	:	-
TAPPING/FLANGE	:	BS 21 BS 2779
FINISH	:	Unpolished
HEAD	:	Diamond with loose key
BRITISH STANDARD	:	-

Air-Conditioning and Mechanical Ventilation Installation Pipework and Fittings

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TABLE L - VENT COCKS		
PIPED SYSTEM : ALL SYSTEMS		
VALVE TYPE	:	Vent cocks
NOMINAL BORE (mm)	:	15 – 150
WORKING PRESSURE (Temp.)	:	10 bar 100 deg. C
BODY	:	Gun-metal
SPINDLE	:	-
GATE	:	-
GLAND	:	Packed
DISC	:	-
SEAT	:	-
TAPPING/FLANGE	:	-
FINISH	:	-
HEAD	:	-
BRITISH STANDARD	:	-

TABLE M - STRAINERS			
PIPED SYSTEM : ALL SYSTEMS			
VALVE TYPE	:	Strainers	
NOMINAL BORE (mm)	:	15 - 50	65 - 500
WORKING PRESSURE (Temp.)	:	10 bar 100 deg. C	10 bar 100 deg. C
BODY	:	Cast Bronze	Cast Iron
SPINDLE	:	-	-

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TABLE M - STRAINERS			
PIPED SYSTEM : ALL SYSTEMS			
GATE	:	-	-
GLAND	:	-	-
DISC	:	-	-
SEAT	:	-	-
TAPPING/FLANGE	:	Stainless steel	Stainless steel
FINISH	:	Threaded to BS 21 BSF	Flanged to BS 4504
HEAD	:	Unpolished	Unpolished
BRITISH STANDARD	:	-	-
		-	-

Air-Conditioning and Mechanical Ventilation Installation Insulation and Painting

1. DESCRIPTION

This Section specifies the thermal insulation, painting and other finishes of all plant and materials shown on the Drawings and provided as part of Contract Works.

2. MANUFACTURE

All materials supplied of the same type shall be supplied by a single manufacturer to ensure uniformity of standards and appearance.

All materials delivered to site shall be new, and where appropriate, colour coded and labelled at the factory to identify different grades, sizes and types.

3. SELECTION

The Contractor shall select all insulating, finishing and painting materials from types suitable for the surfaces to which they are applied and for the environmental conditions in each area.

No asbestos based insulation shall be used.

4. STANDARDS

All materials and techniques used shall be of the highest commercial standard and shall comply with British Standards where applicable in particular with regard to definition, physical characteristics and tests for thickness.

All equipment and materials used shall be fire resistant and shall comply with the requirements of the Authorities including the Fire Safety & Shelter Department.

Insulation shall comply with provisions of B.S. 1334 and B.S. 5422 as appropriate.

Pipework insulation shall generally comply with British Standard Code of Practice C.P. 3005 or B.S. 5970.

5. INSULATION CLASSES

Table 16.1 lists the insulation classes for the various systems and equipment which require to be insulated as part of the Contract Works. These classes are referred to in the various Tables of Standards and Specifications used in this Section.

6. INSULATION MATERIALS AND FINISHES

Table 16.2 lists the insulation thickness, materials codes and classes of finishes for the various classes of insulation. In this Table, the following location definitions apply:

Plantroom

All areas specifically nominated to accommodate plant or equipment. This shall include plantrooms for other services installations in which this Contractor may be required to work.

Internal

Air-Conditioning and Mechanical Ventilation Installation Insulation and Painting

All areas within the building where plant or materials are installed and are hidden from view, i.e. in false ceilings, riser shafts, etc..

Exposed

All areas within the building where plant or materials are installed and are exposed to view.

External

All areas in or around the building where plant or materials are installed and are exposed to the weather and ambient conditions.

Table 16.3 lists the materials and application techniques to be used for the various material codes listed in Table 16.2.

Table 16.4 lists the materials and application techniques to be used for the various classes of finishes to be applied to the insulated plant and materials.

7. EXTENT OF INSULATION

Where a pipework or ductwork system or item of equipment is listed in the schedules in this Section or otherwise requires to be insulated, then the entire system or item shall be insulated to prevent condensation and reduce heat loss or gain.

All cold surfaces liable to condensation under operating conditions shall be insulated at least to Class GA as listed in the Tables of this Section or in the case of specialist machinery (refrigerant lines in A/C units, chiller evaporators, etc.) as described under the relevant Clause of this Specification or in accordance with the manufacturer's standard, subject to the approval of the Engineer.

All ductwork insulation shall extend over external flanges and stiffening.

All ductwork carrying conditioned air shall be provided with a vapour barrier. On glassfibre insulation, this may be aluminium foil sealed at joints with aluminium adhesive tape. Alternatively in ventilated ceiling glass cloth faced insulation may be employed subject to this satisfying FSSD requirements.

All flexible ductwork carrying conditioned air shall be externally or internally thermally insulated with 25mm fibreglass blanket wrapped around the flexible ductwork with at least a 20mm overlap at joints. The fibreglass shall be externally covered with aluminium or glass cloth vapour barrier. The flexible ducts shall be independently supported from the underside of the concrete slab by 25mm wide galvanized mild steel straps. Under no circumstances should the flexible ductwork rest on the ceiling tiles or suspension system.

All flexible ductwork shall complete with butterfly damper.

8. INSULATION OF SUPPORTS

Cold ductwork shall be insulated from hangers and support generally as indicated in HVAC Specification DW/142.

Air-Conditioning and Mechanical Ventilation Installation Insulation and Painting

At the point of ductwork and pipework support high compressibility phenolic foam shall be employed with the vapour barrier carried over this. The use of hardwood blocks shall not be permitted.

Drainage piping for condensing water shall be insulated free from its hangers and support.

9. LABELLING AND IDENTIFICATION

All piping, plant and equipment provided under the Contract is to be labelled in English as to duty or services. All such labelling to correspond to schedules, diagrams, etc., as specified in the individual Sections of this Specification.

Labels shall be as specified in the "Miscellaneous Provisions" Section of this Specification.

All pipework and ductwork (whether insulated or not) shall have identification discs/bands, generally as B.S. 1710 : 1975, Appendix D, Optional Colour Code Indications for General Building Services and CP 13 : 1980. These indications are generally as shown on Table 16.5 together with additional services and colour codes not specifically listed in B.S. 1710 : 1975.

Table 16.6 lists the B.S. colour reference, based on B.S. 4800 for all colour codes listed.

Colour banding shall be provided at intervals not exceeding 5m and wherever necessary at bends, tees, etc., and where pipes pass from one room or zone to another. Where two or more pipes run in parallel, then the colour banding for each pipe shall be at the same locations.

Colours not covered by this Specification must be agreed with the Engineer before work commences on site.

At intervals agreed with the Engineer on straight pipes and adjacent to valves and tees, coloured arrows are to be stencilled to the insulation or pipework to indicate direction of flow. In addition, the pipe mains are to be painted using stencils to indicate the circuit system. Where the finish is unpainted, metal bands and discs are to be fitted for colour identification specified above.

Supply, recirculation and extract ducts shall be differentiated by coloured discs of 150mm diameter at intervals agreed with the Engineer. Additionally, adjacent to the discs, the ducts are to be painted using stencils to indicate the particular system.

The Contractor shall supply all necessary identifying items, paint, stencils, etc., to comply with this Section.

10. EXTENT OF PAINTING

All plant, materials and equipment forming part of the Works are required to be painted as specified in this Section, with the sole exception of items specifically excluded in this Specification.

Items which do not require to be painted shall include:

- Insulated ductwork with decorative aluminium or stainless steel finish.

Air-Conditioning and Mechanical Ventilation Installation Insulation and Painting

- Copper pipework and fittings; (except where specifically stated).
- Galvanized pipework, ductwork, conduit, trunking or cable trays where concealed within duct shafts or false ceilings.
- Materials with a factory applied anodized, baked enamel or painted finish, provided that the colours are selected by the Engineer prior to application.
- Insulated pipework or ductwork concealed within duct shafts or false ceilings.

The requirement for painting of all pipework and ductwork is in addition to the colour coding or banding specified in this Section.

11. FACTORY PAINTING

All factory assembled plant or equipment shall be factory painted in accordance with the manufacturers' normal practice and to a standard suitable for the duty and location of the plant. The colour of the finishes shall be selected by the Engineer.

Where factory applied finishes are applied, the Contractor must obtain from the plant manufacturers touch-up paint kits and detailed instructions for making good after completion any damage to finishes which may occur during transportation, storage, installation or commissioning.

12. SITE PAINTING

All plant and materials requiring to be painted on site shall generally be painted with one coat of an primer, one coat of an undercoat and two coats of an high gloss finishing coat. The paint and workmanship shall be of the highest quality and standard.

13. GENERAL

The Contractor shall allow for all thermal insulation, fixings, finishings, paint and any other materials or labour required for the complete insulation, finishing and painting of all plant and materials installed under this Contract.

All insulation, finishes and painting shall be supplied and applied by the skilled workmen of a Specialist Contractor whose name and experience shall be submitted to the Engineer for comments prior to entering the Contract. Approval by the Engineer shall in no way absolve the Contractor of his responsibility for compliance with this Specification.

All materials including the thermal insulation itself, together with adhesives, paint, bands, sheeting, etc., shall be supplied with a reasonable margin for cutting, wastage and making good damage and loss. All materials shall be stored in a suitable manner so as to protect them from damage or deterioration before fixing.

No insulation shall be applied until pipes, plant and ductwork have been tested as specified.

14. APPLICATION OF INSULATION

Air-Conditioning and Mechanical Ventilation Installation Insulation and Painting

All insulation shall be applied so as to give a smooth, homogeneous and lineable surface. All rigid sections shall be concentric, and accurately matched for thickness. Steps and undulations in the surfaces shall not be acceptable. Any sections or slabs having damaged ends or edges shall be rejected.

All insulation shall fit tight to surfaces to be covered, and all slabs and sections shall be built up close, butting edges being mitred, chamfered or shaped as necessary. Any minor interstices left in insulation shall be filled and sealed.

Any surface to be insulated, which shows any signs of rusting or damages shall, prior to insulating, be thoroughly scraped and wire brushed as necessary to remove all rust, scale, etc.. Surfaces shall then be solvent cleaned to remove all oil grease and dirt prior to the application of a coat of primer. Application of primer shall be as specified in the Painting Clause of this Specification.

Where thermal insulation is applied to rectangular ductwork, it shall be glued to the clean duct surface with an adhesive and held firmly in place by means of plastic pins glued to the duct face.

Only clean and dry insulation shall be used. Insulation shall generally be applied in accordance with the manufacturers' recommendations.

A complete sealed vapour barrier shall be provided for all insulation on cold surfaces. The vapour barrier shall be sealed around all hangers or other projections through the insulation.

Continuous insulation shall be provided through all sleeves and insulation joints shall be staggered with respect to joints on the associated pipework or ductwork systems.

On long runs of pipework (every 5m), an effective vapour seal shall be applied to the joint faces to prevent the effects of damaged insulation from affecting the complete run.

For continuous adhesion of aluminium foil sealing tape, a coating shall first be applied to the bonding surface. All excess adhesive shall be cleaned off.

Generally, all factory assembled plant shall be insulated in the factory in accordance with the manufacturer's normal practice.

Insulation on fan casings and ductwork shall be neatly finished round access doors, handholes and the like. Access doors to be separately insulated.

Where valves, flanges, strainers, etc., are specified to be insulated, insulation shall be in conformity with the pipework in which they are incorporated, and to the same thickness, and shall be provided with insulated split boxes, arranged for easy removal. The boxes shall enclose valve handles and shall have lids for valve access.

The insulation on the pipes immediately adjacent to such flanges, etc., shall be neatly swagged off to allow for easy removal of bolts. An insertion shall be provided to allow the insulated boxes to be removed without damage to the pipe insulation.

Where plant, fittings or accessories require to be insulated, then they shall have the same standard of finishing as the pipework or ductwork system of which they form a part.

Air-Conditioning and Mechanical Ventilation Installation Insulation and Painting

15. PAINTING

Prior to painting, all metallic surfaces except galvanized surface shall be thoroughly scraped and wire brushed as necessary to remove scale, rust and swarf. Surfaces shall then be solvent cleaned to remove all oil, grease and dirt.

When the surfaces to be painted are clean and dry, one coat of an approved primer shall be evenly applied over the entire area. After surfaces have been primed, the Contractor shall notify the Engineers so that an inspection of the primed surfaces can be made prior to the application of the finishing coats.

When the priming coat has been approved, one coat of an approved flat undercoat shall be applied. Before applying the finishing coats, the Contractor shall ensure that the undercoated surface is rubbed flat and smooth. Finally, two coats of an approved high gloss finishing coat shall be applied when all dust has been removed.

Each successive coating shall be completely dry prior to the application of the next coat.

All surfaces shall be suitably protected during painting to prevent dust and other impurities entering the paint or adhering to the painted surface. "Wet Paint" signs shall be prominently displayed and protective barriers shall be provided where necessary.

All paints shall be prepared and applied in accordance with the manufacturers' recommendations.

All galvanized metal surfaces shall be properly etch-primed to ensure correct adhesion of the paint to the surface. Materials for etch-priming shall be as recommended by the paint manufacturers. Sequent painting of galvanized surfaces shall comply with this Specification.

Air-Conditioning and Mechanical Ventilation Installation Insulation and Painting

TABLE 16.1

INSULATION CLASSES

Service or Item	Insulation Class
Chilled Water Pipework	PB
Chilled Water Condensate Pipework	PC
Refrigerant Pipework	PE
Air Conditioned and Return Air Ductwork in Internal and Exposed Locations	DA
Air Conditioned and Return Air Ductwork in Plantrooms and External Locations	DB
Fresh Air Supply Ductwork within Air Conditioned Space	DC
Kitchen and High Temperature (above 500 °C) Exhaust Air Ductwork	DD
Kitchen Supply Air Ductwork inside building	DE
Chilled Water Pumps, Valves and Other Pipeline Equipment or Fittings	GA

Air-Conditioning and Mechanical Ventilation Installation Insulation and Painting

TABLE 16.2

INSULATION THICKNESS, MATERIALS AND FINISHES

Insulation Class	Nominal Size (mm)	Insulation Thickness (mm)	Material Code	Class of Finishes			
				Plantroom	Internal	Exposed	External
PB	Below 50	25	PF1	2	1	2	7
	65 – 250	35	PF1	2	1	2	7
	Above 250	45	PF1	2	1	2	7
PC	All	25	EM1	2	6	2	7
PE	Below 25	20	EM1	2	6	8	7
	32 – 100	25	EM1	2	6	8	7
	Above 100	32	EM1	2	6	8	7
DA	All	25	FG2	-	1	2	1
DB	All	32	PF2	2	-	-	7
DC	All	12	FG2	2	1	2	-
DD	All	25	CS1	3	6	4	3
DE	All	12	FG2	2	1	5	-
GA	All	32	PF2	2	1	2	2

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TABLE 16.3 - INSULATION MATERIALS AND FIXINGS

Material Code	Material	'K' Value (w/m ⁰ K)	Fixing Method
FG1	Pre-formed Fiberglass rigid Sections Min. density 70 kg/m ³	0.035	Secure in position with aluminium, Clips and bands
FG2	Pre-formed Fiberglass rigid Sections or boards	0.035	Secure in position with adhesive and fixing pins with retaining washers. Areas of flat insulation with any dimension greater than 1200mm shall have galvanized z-bar fixings of depth equal to the thickness of the insulation. These fixings shall be secured to the duct surface with self- sealing aluminium pop riverts to provide rigid fixings for finishes .
CS1	Calcium Silicate Boards	–	Rigid boars with butt joints, held in place with aluminium band and tapes.
RW1	Rock Wool slabs	–	Expanded metal mesh supported on 25mm mild steel air spacing steel strips, plus 50mm rock wool mats or sections secured with aluminium bands and tapes.
PF1	Rigid preformed phenolic foam 35 kg/m ² Class 'O' fire rated	0.020	Secure in position with adhesive. Apply aluminium foil and flat bands over finished installation. Butt joints to be sealed with mastic and taped.
PF2	Rigid phenolic foam foams boards on blocks 35 kg/m Class 'O' fire rated	0.020	Secure in position with adhesive plus fixing pins on ductwork and flat bands on heat exchanges. Butt joints to be sealed with mastic.
EM1	Celluber elas-tomeric pipe sections Class 'O' fire rated	0.039	Lubricant to be applied to interior and the section evenly sheathed pipework. Butt joints to be sealed with manufactures adhesive and taped with self adhesive elastomeric tape.

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TABLE 16.4 - FINISHING MATERIALS AND FIXINGS

Class of Finishes	Materials and Fixings
1	Aluminium foil as integral backing to the insulation with joints and seams sealed with 50mm wide adhesive applied aluminium foil tape. The whole to provide a completely vapour-proof barrier external to the insulation.
2	As Finish Class 1 above but with additional finish of 0.8mm thick hammered finish aluminium cladding firmly secured with aluminium or stainless steel band clip evenly spaced at 40mm centres.
3	0.8mm thick hammered finish aluminium cladding firmly secured with "Pop" rivets evenly spaced at 50mm centres.
4	0.8mm thick stainless steel cladding. Joints shall be of the grooved seamtype, or any approved equal, to ensure ease of cleaning the duct surface.
5	As Finish Class 1 with stainless steel cladding as Finish Class 4.
6	Self-finish of insulation without further cladding.
7	P.I.B. or isogenopak Jacketing with solvent welded seams and butt joints, 0.7mm thick minimum. U.U. Stable colour to be selected by the Engineer.
8	Painted with manufacturers approved paint to a colour selected by the Engineer.

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TABLE 16.5 - COLOUR CODES FOR BUILDING SERVICES INSTALLATIONS
(Based on B.S. 1710 : 1975 Appendix D)

Pipe Contents	Basic Colour	Colour Code Indication			Basic Colour
	150mm	50mm	50mm	50mm	150mm
Water	Green	Blue	Blue	Blue	Green
Drinking	Green	White	White	White	Green
Cooling (Primary)	Green	Crimson	White	Crimson	Green
Boiler feed	Green	Crimson	Em. Green	Crimson	Green
Condensate	Green	White	Em. Green	White	Green
Chilled	Green	Blue	Crimson	Blue	Green
Central heating 100°C	Green	Crimson	Blue	Crimson	Green
Central heating 100°C	Green	White	Blue	White	Green
Cold, down service	Green	White	Crimson	White	Green
Hot water supply	Green	Salmon	Salmon	Salmon	Green
Hydraulic power	Green	Pink	Pink	Pink	Green
Sea, river, untreated	Green	Green	Green	Green	Green
Fire extinguishing	Green	Safety Red	Safety Red	Safety Red	Green
Compressed air	Light blue				
Vacuum	Light Blue	White			Light Blue
Steam	Silver Grey				
Drainage	Black				
Electrical conduits And ducts	Orange				
Town Gas	Yellow ochre	Emerald green			Yellow ochre
Manufactured gas					
Natural gas		Yellow ochre			
Oil	Brown	White			Brown
Diesel fuel		Brown			
Furnace fuel		Emerald green			
Lubricating		Salmon pink			
Hydraulic power		Crimson			
Transformer					
Acid and alkalis	Violet				
Oxygen	White	Black			White
Nitrous Oxide	White	Light blue			White
Refrigerant	Orange	White*			Orange

*With refrigerant no. stencilled in black, in accordance with B.S. 4580.

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TABLE 16.6

REFERENCE COLOURS FOR CODING PURPOSES
(Based on B.S. 4800)

Colour	Colour Reference
Green	12 D 45
Silver-grey	10 A 03
Brown	06 C 39
Yellow Ochre	08 C 35
Violet	22 C 37
Light Blue	20 E 51
Black	Black
Orange	06 E 51
Crimson	04 D 45
Emerald Green	14 E 53
Salmon Pink	04 C 43
Yellow	10 E 53
Red	04 E 53
Yellow	08 E 51
Auxiliary Blue	18 E 53

Air-Conditioning and Mechanical Ventilation Installation

Sound and Vibration Control

1. General

This Section covers the general requirements that constitute the attainment of acoustically comfortable environment within the building. The requirements stipulated in this part of the Specification shall be in addition to any other requirements which have already been specified elsewhere.

The complete requirements shall be considered as minimum requirements. All equipment shall be installed in a balanced and aligned condition and that the operation will not result in noise and vibration levels beyond the specified limits.

The Contractor should bring to the Engineer's attention should any of the requirements, in his opinion, is not attainable, otherwise the Contractor shall guarantee the equipment will operate within the criteria, or bear all costs of remedial work to achieve design objectives.

The requirement based on the usage of the spaces in the building are as follows:-

<u>SPACE</u>	<u>NOISE CRITERIA (NC)</u>
Office	38
Lobbies	40
Toilets	45
Car Park	55

2. Noise And Vibration Control Requirements

All noise and vibration control equipment shall be supplied from approved suppliers. Where necessary or if doubt arises, letters of origins must be produced. stitution is not allowed without the approval from the Engineer.

The Contractor shall guarantee all equipment will be installed in balanced and aligned conditions to meet the specified noise criteria of various spaces.

No pumps shall have speed greater than 1500 rpm unless approved by the Engineer.

All these specified criteria shall apply to all areas as measured at a level 1.5m above the floor. Where AHU Rooms are encountered, the measurement shall be at similar height from the floor but at not less than 1m from the AHU Room walls. Where fan coil units are encountered, the highest noise levels measured under the units will only be recorded.

Where dispute arises over the classification of any area the Engineer's decision shall be final.

3. Spring Vibration Isolation System

All spring vibration isolators shall be free-standing, unhoused, laterally stable steel springs assembled into upper load plates and lower load plates and complete with minimum 8mm neoprene acoustical friction pads between the baseplate and the support. Where necessary multiple layers of neoprene pads shall be used.

Air-Conditioning and Mechanical Ventilation Installation Sound and Vibration Control

Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.

All mountings shall be rigidly bolted to the equipment.

Where restrained spring isolators are to be used, housing shall include vertical limit stops to prevent spring extension when weight is removed. A minimum clearance of 13mm shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operations. Mountings used outdoor shall be hot dipped galvanized, or equipped with weather covers.

4. Vibration Isolation Pads

Where waffle or ribbed neoprene pads are to be used, select Duro 50 or 60 pads to suit the required loading. Where multiple-layer pads are selected, the layers are to be separated by 1-1.2mm thick steel shims. The pads shall be laid in a cross-grid manner.

5. Double Deflection Isolators

Where double deflection isolators are to be used, select appropriate kind to meet minimum deflection required.

6. Pipe Hangers

All pipework connected to mechanical equipment in the plant room are to be isolated by isolation hangers.

All hangers in the plant room shall be of spring-rubber in series hangers. Beyond these hangers, double deflection neoprene in shear hangers may be used. At least the first three hangers in the equipment room shall be minimum static deflection of 50% of that specified for the equipment the pipeworks are connected to. The remaining hangers shall be of 25% or remain 50% as required.

Hangers shall be positioned to the highest possible location on the rods. Hanger rod shall be anchored to beams or joints. Anchorage to slabs, where possible, should be avoided. Parallel running pipework may be isolated on trapeze.

7. Air Handling Units

All A.H.U. shall be installed with vibration isolators as indicated in Schedule of Technical Requirements. The maximum sound power level of AHUs are indicated in the schedule "Maximum Allowable Sound Pressure Level for AHUs".

All connections between AHUs and ductwork shall be of flexible connections made of approved material such as lead vinyl or similar.

It is the responsibility of the Contractor to supply and install AHUs to meet the noise

Air-Conditioning and Mechanical Ventilation Installation Sound and Vibration Control

criteria specified, without modification of existing ductwork outside AHU Rooms.

All AHUs installed adjacent to offices shall not result in the noise levels as measured at 1m in any direction in the AHU rooms higher than 75dBA. Up to 78dBA is allowed for AHUs in Mechanical Plant Rooms.

Complete AHU build-up shall be rigid and void of low frequency panelling radiation as per AHUs Specification. Complete AHU casings shall be well damped to effect this requirement.

8. 17.8 Fan Coil Units

All fan coil units with capacity less than 1500 CFM may be suspended in the ceiling space with selected neoprene hangers. All units above 1500 CFM shall be suspended with minimum 4 number spring-neoprene hangers.

All pipes connected to fan coil units shall be isolated with isolation rubber sleeves, or flexible union connectors.

Discharge ducts (and return air duct if any) shall be installed with flexible connectors similar to that of AHU. Noise leak via the connectors must be insignificant, otherwise special lagging is required, as detailed.

The fan coil units sound power levels at no circumstance shall exceed the following:

SWL re 10^{12} watts, dB at octave frequency bands

Frequency (Hz)	63	125	250	500	1k	2k	4k	8k
Criteria of Space Served								
NR 35	65	55	48	41	38	35	34	32
NR 40	69	59	52	46	43	40	39	37
NR 45	73	63	56	51	48	45	44	42
NR 50	77	67	60	56	53	50	49	47

The Contractor is to supply the SWL rating of fan coil units selected.

Where any doubt arises, the Contractor shall arrange for at least two units of each model selected to be tested by recognised testing authority to substantiate the manufacturers sound power rating at his own expenses. Alternatively noise level measurement may be carried out on installed but similar units in any completed buildings in Singapore, to assess the acceptability of the Contractor's submission.

9. Ventilation Fans

Air-Conditioning and Mechanical Ventilation Installation Sound and Vibration Control

All ventilation fans shall be installed with vibration isolators as indicated in schedule of Technical Requirements. All fans lighter than 150Kg (including base) may be isolated on double deflation isolators. Others shall be on spring isolators.

All connections between fans and ductwork shall be flexibly connected. All fans shall kept to maximum velocity of 1500 rpm.

All air discharge to public accessible areas should not exceed 3m/s

10. Sound Attenuators (IF APPLICABLE)

Sound attenuators shall consist of an outer casing, aerodynamically designed splitters, sound absorbing material and supports. The casings shall be of galvanized steel of not less than 18g thickness. End flange shall be made from galvanized mild steel sheet or rolled steel angle. Duct sealing compound shall be furnished by the Contractor for sealing all silencers on site where necessary, as determined by the Engineer.

Sound absorbing material shall be fibreglass or mineral wool held in place with at least 5% compression to prevent voids due to setting, and faced with minimum 22g perforated galvanized sheet metal of minimum 20% open area. No perforated holes shall exceed 3mm diameter. Sound absorbing material shall conform to BS476 : Part 7 (1971) "Surface Spread of Flame" Classification 1 or combustion rating in accordance with ASTM E84.

11. Air Flow Velocity And Internal Ductwork Lining

All ductwork shall be rigid to prevent panelling. All joints shall be tight to prevent air leak noise. As a general guide, the air flow velocities should be designed not to exceed the following :-

- . Main supply duct 8m/s - 9m/s
- . Branch supply duct 6m/s
- . Outlet duct 3m/s

All duct lining indicated shall be of 50mm thick unless otherwise stated. The density of the liner shall be 40 Kg/m³ for fibreglass or R50 for rockwool batts, or with the following minimum. Noise Reduction Coefficient (NRC average of 250 to 2000 Hz) :

25mm	NCR 0.60
50mm	NCR 0.85

The material shall conform to BS 476 similar to sound attenuators. All rockwool or fibreglass shall be faced with 40-50% open area galvanised perforation.

12. Pipework

All pipework in the plant room equipment room shall be supported by vibration isolators. Hangers for pipe work shall be described in Pipe Hangers Section.

Air-Conditioning and Mechanical Ventilation Installation Sound and Vibration Control

All other supports at vertical pipe runs shall be of multiple layers of neoprene pads isolators of minimum 13mm deflection. The pads should be separated by 1mm steel shims. All pipe penetrating to critical areas shall be isolated with resilient sleeves and seals.

Construction details shall be as indicated in the attached drawings or as details proposed by the Contractor but approved by the Engineer.

13. Cooling Towers

Cooling towers and associated pipe works shall be correctly vibration isolated.

Generally, the overall sound pressure levels measured at the prescribed position shall not exceed 75dBA. The octave band sound pressure levels shall be as follows :

Frequency	63	125	250	500	1K	2K	4K	8K
-----------	----	-----	-----	-----	----	----	----	----

SPL dB	90	83	77	73	70	67	66	64
--------	----	----	----	----	----	----	----	----

The Contractor shall submit the type of cooling towers complete with the octave sound pressure levels re 2×10^{-5} N/m² emitted by each tower as measured at 2m from the tower casing and 1.5m above the roof level.

All pipework shall be vibrationally isolated from the roof slab with spring-neoprene vibration isolators, either by seating or by suspension, as detailed.

14. Inertia Block Base

The Contractor shall supply and install concrete inertia base to equipment as required.

The inertia base construction is generally as shown in the detail drawing. All perimeter members shall be steel channels with a minimum depth equal to one-twelve of the longest dimension of the base but not less than 150mm deep.

Inertia base is required for the following equipment.

The weight of the inertia base is to be determined by the inertia base/equipment mass ratio:

Compressor - reciprocal	2 x unit weight
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Floor mounted fans (> 750mm dia.)	1.5 x unit weight
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Pumps - electric	2 x unit weight
------------------	-----------------

15. Pumps And Motors Drives

All pumps shall be selected for the highest efficiency consistent with the specified duty.

Air-Conditioning and Mechanical Ventilation Installation Sound and Vibration Control

All rotating components of the pumps including impeller, shaft and drive couplings shall be dynamically balanced. All pumps shall be mounted on inertia bases and with proper vibration isolation as specified in the Schedule of Technical Requirements.

The design of inertia base and isolator should consider water pipe weight and all other fittings carried by the pump. Where necessary any T-shaped inertia base may be used.

All associated pipework shall be connect to the pumps with flexible connectors similar to twin-sphere flexi-connectors.

16. Pipework

All pipework connecting to vibration source shall be flexibly connected, and efficiency isolated form supporting structures. All pipe hangers shall be as described in the Schedule of Equipment, or described elsewhere.

Flow velocity in pipe smaller than 50mm internal diameter shall be restricted to maximum 1m/s. All others shall be limited to maximum 3 m/s.

All pipe penetration shall be acoustically sealed as detailed.

17. Enclosure

Where necessary, noisy equipment shall be installed with noise enclosure. This is typically applicable to suspended fans, as indicated in attached details.

All fan enclosures shall be constructed with one panel openable, preferably the bottom panel. Joints shall be sealed with noise leak.

Equipment such as AHUs may need special attention to the casing and internal absorption lining to form a better enclosure to the fans and motors. Where necessary, AHU motors shall be installed in the AHU casing. The casing shall be constructed with sufficient stiffening and damping to prevent panelling and low frequency rumbling.

The AHU room at the 2nd storey shall be lined with sound absorption material (to comply with the required sound rating) which is to be provided by the Contractor as the AHU units are site assembled type (without AHU casings and internal absorption lining).

18. Compliance Test

Compliance tests shall be carried out by the Contractor to ensure the installation fulfills the stipulated requirements and criteria. They shall be carried out when the mechanical equipment is at normal operating condition.

The measurements shall be witnessed by relevant parties. The Contractor shall submit the test program and schedule to the Engineer for review and approval.

Table A : Schedule of Technical Requirements

Air-Conditioning and Mechanical Ventilation Installation Sound and Vibration Control

Item No	Storey / Location	Equipment	Min. Static Deflection & Isolators Type	Inertia Block / Equipment Mass Ratio	Static Deflection Type of 1 st 3 pipe Hangers on All Pipe Hangers Nearest to the Equipment	Remarks
1	According to drawing	AHU	Min 75 mm Static deflection unhooused spring-neoprene in series isolators. The neoprene shall be of 2 layers 8mm friction pads, laid on cross grid and separated by 1mm steel shim.	-	-	- Flexibly connected to ductwork. - Motor built-in with fan in casing recommended.
2	According to drawing	Chillers	Min. 100mm static deflection restrained spring isolators in series with 2 layers 8mm thick friction pads laid on cross grid and separated by 1mm thick steel shim.	-	Min. first 3 pipe hangers shall be supported by min. 38mm static deflection spring-neoprene in series hangers	-
3	According to drawing	Chiller / Condensers water pumps	Min 75 mm Static deflection unhooused spring-neoprene in series isolators. The neoprene shall be of 2 layers 8mm friction pads, laid on cross grid and separated by 1mm steel shim	2:1	Min. first 3 pipe hangers shall be supported by min. 38mm static deflection spring-neoprene in series hangers	- Inertia weights design should consider pipe weight carried by pump.
4	According to drawing	Cooling Towers	Min. 100mm static deflection restrained spring isolators in series with 2 layers 8mm thick friction pads laid on cross grid and separated by 1mm thick steel shim.	-	All pipework shall be isolated from roof truss on pedestal with min. 50mm spring neoprene in series isolators.	- Isolators shall be galvanized fro weather protected. - All pipework on roof shall be supported as per details.
5	According to drawing	AHU & Energy Wheel	Min 75 mm Static deflection unhooused spring-neoprene in series isolators. The neoprene shall be of 2 layers 8mm friction pads, laid on cross grid and separated by 1mm steel shim	-	Flexibly connected to ductwork.	- Motor built-in with fan in casing recommended.
6	According to drawing	Water Treatment Tank	2 layers of 3mm neoprene pads laid in cross-grid separated by 1mm steel shim	-	-	-
7	According to drawing	Ventilation Fan	Min 50 mm Static deflection unhooused spring-neoprene in series isolators or hangers. Floor mounted units shall have isolators with 2 layers 8mm friction pads, laid on cross grid and separated by 1mm steel shim	-	-	- Flexibly connected to ductwork. Flexible or looped conduits. - Fans shall be mounted of rigid steel frames.

Air-Conditioning and Mechanical Ventilation Installation Electrical Installation

1. General

The electricity supply available will be provided and terminated in an isolator in the Pump rooms. The supply will be 400V, 3 Phase, 50 Hz. All conduits, trunking and cabling and the sub distribution equipment shall be provided by this Contractor. FR cables shall be used for emergency power distribution purposes.

The Contractor shall design, supply and install the motor control panel for electrical supply to the pump equipment. All control panels, circuit breakers contactors, relays, busbars and associated wiring shall fully comply with this section.

2. Electrical Works

All cables, trunkings, conduits and conduit fittings necessary for the circuits shall be installed in accordance with CP5 or latest edition - Code of Practice for the wiring of Electrical Equipment of Buildings.

All electrical work shall be carried out by Licensed Electrical Workers.

All socket outlets and isolators exposed to outdoor weather conditions shall be of the weatherproof type, complying with the appropriate Singapore or British Standard.

All exposed metalwork liable to become electrically charged shall be efficiently bonded and earthed complying with the latest edition of CP33 and CP5.

Each pump group shall have a guaranteed minimum power factor of not less than 0.85 (lagging) from half to full load conditions.

3. Conduit Systems

All conduits shall be heavy gauge hot-dipped galvanised longitudinally welded steel complying with B.S. 4568 : 1970, class 4 and of not less than 20mm diameter.

All conduit systems shall be installed fully in accordance with the requirements of CP5 or latest edition.

Surface mounted conduits shall be fixed with spacing saddles at intervals not exceeding 1.2m by means of screws and rawlplugs unless otherwise approved by the Engineer and total system shall be painted by the Contractor to match quality, finish and colour of the builder's paintwork in that area on to a colour code given by the Engineer. Conduit systems shall be electrically and mechanically continuous and watertight after installation but be arranged, wherever possible, to be self-draining to conduit outlet points for equipment. The system when installed, and before wiring, shall be kept plugged with wooden plugs and immediately before wiring, the complete system shall be thoroughly swabbed out until dry and clean.

All sets and bends in conduit runs shall be formed on site in bending machines. In surface mounted systems, inspection bends and tees may be permitted at columns, where large bends are to be avoided but approval from the Engineer shall be obtained prior to installation.

Runs 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. With conduits cross-expansion joints as indicated on the Drawings, special

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arrangements shall be made to allow relative movement to occur on either side of the joint. A separate earth continuity conductor of a size given by CP5 or latest edition shall be installed between the boxes on either side of the expansion joint.

The Contractor shall make good any damages to the finish of all conduits, including threads cut on site, where two coats of good quality lead paint shall be applied.

Conduits, where surface mounted shall be true to vertical and horizontal alignment.

Special consideration shall be given for conduits and outlets fixed in areas where waterproofing to building shall not be damaged.

Flexible steel conduit and solid type adaptors shall comply with B.S. 731 : Part I with a separate earth wire exposed for earth continuity. In outdoor or moist areas, the pliable conduit shall be of the metallic watertight pattern, PVC oversheathed. All pliable conduits shall be of an approved type and shall only be used for final connections to equipment unless otherwise specified.

The Contractor shall submit all conceal/surface conduit runs for approval by the Engineer before installation.

4. Conduit Boxes

All conduit outlets boxes and junction boxes shall be malleable iron and of standard circular pattern with spout to B.S. 4568.

Standard circular pattern boxes shall be used with conduits up to and including 25mm diameter. Rectangular pattern adaptable boxes shall be used for conduits of 32mm diameter and larger. For the draw-in of cables, standard pattern through boxes shall be used. All conduit boxes shall have a hot-dipped galvanized finish.

Adaptable boxes shall be of mild steel of not less than 2.50mm with galvanized finish. Boxes shall be not less than 50mm deep and of such dimensions as will enable the largest size of cable, for which the conduit run is suitable, to be drawn in without excessive bending of the cable. Covers of the same gauge as the base shall be provided and installed with brass fixing screws.

All such boxes are to be drilled for holes according to the conduit entries required.

Socket outlet boxes shall be constructed of sheet steel with galvanized finish and shall comply with B.S. 3676 and 1363. Socket and switch boxes shall be recessed into wall and suitable for flush mounting accessories. For sockets and switches mounted on structural columns, surface mounting type outlet boxes shall be used of the iron clad type.

All conduit entries to adaptable boxes, outlet boxes and switchgear shall be made with coupling and hexagon male brass bush.

5. Cable Trunking

Cable trunking shall be manufactured in minimum lengths of 1.8m from a minimum of 1.20mm hot dipped galvanized sheet steel finished with rust resisting primer and sprayed overall grey enamel. Covers shall be of the quick-fix pattern with centre captive screw or spring-on type. Any fixing arrangement employing self-tapping screws shall not be accepted. Trunking shall be terminated with end of flanges; which can and shall be bolted

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direct to distribution boards or other apparatus. Connecting pieces shall be used to connect together runs of trunking and shall employ special connecting pieces using cadmium plated mushroom head steel screws, nuts and shakeproof washers to give the trunking run connector rise. Each joint shall have a copper bond bolted to each adjacent trunking to ensure electrical continuity. All frayed and sharp edges shall be removed from trunking before installation and control to prevent rust forming.

Conduit entry to trunking shall be by coupling and male bush. Knockouts shall not be provided, and trunking shall be drilled on site.

In instances where the Contractor elects to use trunking to avoid a multiplicity of conduits following the same run, cables shall be installed so that a space factor of 40% is not exceeding and grouping factors as defined in CP5.

The trunking system shall be erected complete and thoroughly cleaned out before any cables are drawn in.

Where trunking crosses expansion joints, a trunking system shall be used which will allow for expansion and maintain earth continuity. The system used shall be approved by the Engineer prior to it being used.

Where trunking is turned through on angle exceeding 45°, mitred corner pieces shall be used to form a slow bend for cables.

All cables within the trunking shall be bunched and cleated in to separate circuits and/or cables running to a common point of supply at intervals of 3m for horizontal runs and 1m for vertical runs. In addition, vertical runs of cables shall have therein weight supported by clips of wooden blocks or steel pins fixed inside the trunking at intervals not greater than 3m.

All horizontal runs of trunking shall be fitted with cable retention straps to prevent cables dropping down from the trunking when additional wiring is being installed from the side or bottom of the enclosure.

6. Cables

The Contractor shall include for the supply, installation, testing and commissioning of all cables and accessories as specified herein .

All cables shall be manufactured to the appropriate British Standards Specification.

All PVC shall be flame-retardant.

The current carrying capacity shall be in accordance with CP5 : 1998 Wiring Regulations with rating adjusted to suit local conditions.

7. PVC Insulated Cables

All PVC insulated cables shall consist of annealed copper conductor complying with SS50 . The rated voltage of the PVC cables shall be 450/750 Volts.

Cables shall be rated in accordance with CP5 Wiring Regulations. Minimum cable size shall be 1.5mm² for small power or control circuits.

Neutral conductors shall have black insulation and live or phase conductors, red

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insulation with phase identification sleeves at each termination.

All cables shall pass SISIR type tests and batch tests or approved under SISIR quality certification scheme and have PUB's approval.

PVC insulated cores shall be sheathed with flame retardant PVC which shall serve as a bedding for galvanized single steel wire armouring. The armouring shall be covered with an outer flame retardant PVC sheath.

The Contractor shall include for provision, installation, testing and commissioning of all cables, conduits, trays, trunking and accessories specified herein.

Cables shall be enclosed in conduit or trunking in accordance with CP5 : 1998 Wiring Regulations of Electrical Equipment of Buildings for capacities of conduits and space factor for capacities of trunking.

All wiring shall be carried out on the loop-in system and the wires drawn into the conduits after the whole of the installation has been completed.

Joints or connectors shall not be installed in wiring cables.

Exposed ends of conductors of 6mm² and above not filled with sockets shall be sweated solid for connection to clamp terminals.

8. Flexible Cords

Flexible cords shall be multi-stranded copper conductors, high temperature, PVC insulated with flame retardant white circular PVC sheath 300V/500V grade to B.S. 6500.

Minimum size of conductor shall be 1.5mm² (30/0.25mm²)

9. PVC Insulated Armoured Cables

PVC insulated, PVC sheathed, Steel Wire armoured, PVC sheathed cables (PVC/SWA/PVC) shall be to B.S. 6346 : 1969, 600V/1000V grade with stranded, shaped, copper conductor cores of equal cross section and colour coded insulation.

10. Armoured Cables

The Contractor shall provide all the necessary sleeves, glands, shrouds, end boxes, clamps, compounds specialist tools, etc., necessary to install and make off the cables in accordance with good Engineering practice and as hereunder specified.

All cables shall be provided with identification labels at each end and at all positions where cables change direction. In instances where cables are multiple at 10m intervals. Labels shall be manufactured from metal disc engraved to show the size of the cable phase and the equipment being fed.

Where multicore cables are for indication, protection and control applications, each core shall have an identification number and engraved ferrules over the cable tails. The ferrules shall be numbered to correspond to a wiring diagram agreed by the Engineer. All wires shall be terminated with an acceptable type of clamp connector. Pinching screw type connectors shall not be acceptable.

All cables shall be installed in accordance with the CP5 : 1998- Wiring Regulations of

Air-Conditioning and Mechanical Ventilation Installation

Electrical Installation

Electrical Equipment of Buildings, the cables being run between their source and termination points installed on cable trays, in ducts, clipped to ceilings and wall.

Cables shall in general be supported by perforated cable trays. This tray shall be not less than 2mm mild steel, galvanized finish, and with returned edges. It shall be supported from the rib of structural slab, beams, etc, by mild steel rods, galvanized, and not less than 15mm in diameter, with underslung steel angle supports. Sample of the supporting bracket shall be submitted for comment.

The tray design and strength and/or the tray supports shall be spaced at such intervals to ensure that tray sag shall be not more than 1/500. Corrective measures shall be carried out to the Engineer's satisfaction

Cables run horizontally, shall be properly supported on perforated cable trays and cleated at intervals of not exceeding 2m directly to the tray. Where cables are installed vertically, they shall be cleated at distances not exceeding 1m. When cables are run in other exposed areas, they shall be protected with metal trunking. The cable tray and metal trunking shall be supported with rigid metal brackets.

Where cables are clipped to wall or ceilings, they shall be secured by means of spacer saddles at centres as recommended by I.E.E. Table 11A and not exceeding the bend radii given in Table 52C. The spacer saddles shall be of the hot dip galvanized steel deep spacer type fixed to the surface by means of "rawlplugs" or other equal manner. Each cable shall be fixed by a saddle at each point and fixed to its base by two cadmium plated fixing screws.

11. Cable Bushings, Transits Fire Stopping

In certain places, where cables pass through floors, walls or other partitions, bushing of an acceptable type shall be supplied and set in position by the Contractor; where necessary, split bushings may be used for convenience in running out cables. After running and cleating the cables, the bushing must be thoroughly grouted in or otherwise securely fixed in position.

12. Wiring Accessories

Where cables pass through interior walls or floors of the building, all openings and spaces remaining after installation shall be sealed by a fire resisting and stopping system, approved by the Fire Service Bureau, which has no deleterious effect on the Cable Sheathing and which remains easy to remove after installation to allow for future alterations.

The Contractor shall supply and install the wiring accessories, including lighting switches, switches for electrical appliances, fused spur units, etc., which form part of the Works.

All wiring accessories shall fully comply with this Section.

All wiring accessories shall comply with the appropriate Singapore or British Standard.

All wiring accessories shall comply with the Singapore or British Standard 3000. Wiring Regulations, and local Fire Services Bureau's requirements.

Fused spur units for the control of single phase supplies to fixed equipment shall be provided with separate outlet box allowing final connection of flexible conduits.

Air-Conditioning and Mechanical Ventilation Installation Electrical Installation

Indicating switches shall be 20A, double pole, flush mounted, all insulated, white colour, with noon pilot lamps, confirming to B.S. 3676.

Proper words shall be engraved on the cover plate to designate the equipment served. Mounting height shall be 1350mm above finish floor level, unless otherwise specified.

13. Testing

After completion of the electrical wiring installation, the Contractor shall carry out the following tests on the wiring installation : -

a. Verification of Polarity:

To ensure that all fuses and single pole control devices are connected in the live" conductor only, and that wiring has been correctly connected to the socket outlet terminals.

b. Test of Continuity of Protective Conductor:-

To be tested with alternating current in accordance with Item 3 of Appendix 15 of the CP5 - Wiring of Electrical Equipment of Buildings.

c. Tests of Effectiveness of Earthing:

To be made with loop-impedance test in accordance with Item 5 of Appendix 5 of the CP5.

d. Insulation Resistance Test for all power and control cables :

The testing method and values shall be in accordance with Regulations 613.6L, 613.7, 613.8 of CP5.

Air-Conditioning and Mechanical Ventilation Installation Miscellaneous Provisions

1. GENERAL

a. DESCRIPTION

This Section specifies the miscellaneous items which are required for the completion of the Sub-Contract Works as shown on the Sub-Contract Drawings.

b. MANUFACTURE

All materials shall be supplied by manufacturers experienced in the production of that material.

c. SELECTION

All materials and equipment shall be selected suitable for the purpose and environmental conditions encountered.

d. STANDARDS

All materials shall be of the highest commercial standard and shall comply with the appropriate British Standards and Authority requirements.

2. EQUIPMENT

a. FLAMEPROOF MATERIALS

Unless otherwise specified, all materials used for filter media, acoustic linings, insulation and finishes shall be flameproof as defined in this Clause.

Flameproof materials shall be as tested in accordance with B.S. 3122.

No test specimen shall continue to flame for more than eight seconds after the ignition flame has been removed.

Afterglow shall not spread beyond the area of material damaged by flame.

When washable type filters are offered or specified, they shall comply with the above requirements both before and after the washing treatment prescribed in B.S. 3120 : 1959, Appendix A.

b. IDENTIFICATION PLATES

Where specified, major plant and equipment shall be provided with an identification plate showing the equipment code number as indicated on the schematics and schedules.

The plates shall be of such a size as to be suitable for identification lettering of 50mm minimum height.

The plates shall be colour coded according to the type of equipment and service and all plate and lettering colours shall be agreed with the Engineer prior to manufacture.

c. SPECIFICATION PLATES

Air-Conditioning and Mechanical Ventilation Installation

Miscellaneous Provisions

All major plant and equipment shall be provided with a specification plate showing such details of the equipment duty, lubrication and maintenance requirements as may be specified or subsequently requested by the Engineer.

The plates shall be of such a size as to be suitable for lettering of 6mm minimum height.

d. MANUFACTURERS' NAMEPLATES

The plates shall generally be printed black on white or white on black unless otherwise requested by the Engineer.

Manufacturers' nameplates shall generally be provided for all plant and equipment and shall show serial and model numbers and date of manufacture.

Nameplates shall be attached at the manufacturers' works and shall generally be of the manufacturers' normal construction and material.

e. LABELS

All identification plates, specification plates, valve labels, labelling on control panels, etc., shall be made from laminated plastic engraved with English lettering.

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

All valves shall be fitted with labels in the form of black laminated plastic discs, not less than 50mm diameter, 1.50mm thick, with engraved numerals and/or lettering filled in with white composition.

Valve labels shall either be secured under the handwheel or fixed to the body of the valve by means of a brass chain.

f. SUPPORTING STEELWORK

The Sub-Contractor shall, design, supply, supervise and install all secondary structural steelwork required for access to and support of all plant installed under this Sub-Contract.

Design calculation for the steelwork supports shall be submitted by the Contractor's Professional Engineer to the Engineer.

Notwithstanding the form of steelwork indicated in the Sub-Contract Documents, final responsibility for the design and performance of structural steel supports under live load conditions shall remain with the Sub-Contractor and this should be specially noted where equipment installed is other than that originally specified.

The detailed Calculation of the supports duly certified by Registered Professional Engineer shall be submitted to the Engineer.

g. FIXINGS TO STRUCTURAL STEEL

Notwithstanding any form of fixing specified elsewhere in this Specification, the following shall apply wherever fixings are required onto structural steel for the purpose of supporting or restraining any item installed under this Sub-Contract.

Air-Conditioning and Mechanical Ventilation Installation Miscellaneous Provisions

Fixing to structural steelwork (installed by the Sub-Contractor) shall be by approved methods only. No welding to such steelwork will be permitted unless authorized in writing by the Engineer.

h. FIXINGS IN WATERPROOFED AREAS

The Sub-Contractor shall note that where waterproofing internal linings are applied to walls, floors or roofs, under no circumstances shall this waterproofing be penetrated after its application.

All fixings necessary for the anchoring or support of pipes or equipment into the structural concrete must be made prior to application of the waterproof layer.

The following methods for fixing are advised as suitable and the Sub-Contractor must ensure that sufficient fixings are accurately located to meet the requirements of the Contract.

i. FIXINGS TO REINFORCED CONCRETE

Casting-in of reinforcement cages leaving sufficient exposed metal to weld-on heavy weight supports the waterproofing layer being applied subsequently around the protruding steelwork. This method is particularly recommended where large forces must be restrained, e.g. for large pipework anchors.

Drilling and fixing of expansion bolts into the reinforced concrete structure prior to application of the waterproofing. This is only recommended for light loads and the positions of all such fixings must be agreed with the Engineer prior to commencement of any such work on site.

Where fixings are required to any reinforced concrete, other than in waterproofed areas, drilled and pre-cast fixings into reinforced concrete will be permitted at the discretion of the Engineer whose approval shall be sought at least three weeks prior to commencement of any such work on site.

j. BELT GUARDS

The Sub-Contractor shall include for the supply delivery and erection of galvanized wire guards over all belt drives, flexible couplings and other exposed moving parts of the apparatus. Belt guards shall be of substantial construction and must be fixed to the approval of the Engineer and in compliance with the requirements of Authorities.

All guards shall be removed but provision shall be made so that easy access to the ends of motors and shafts is available without removal of the guards.

k. SPARES

In addition to any particular spares specified elsewhere, the Sub-Contractor shall include in his tender for the provision of the following spares where applicable :-

- i. six valve packings for each type of valve installed;
- ii. spanners to fit all nuts on fans,
- iii. one fuse cartridge for each TP fuse switch or switchfuse; and

Air-Conditioning and Mechanical Ventilation Installation Miscellaneous Provisions

- iv. 20% of total quantities supplied of indicating lamps and push buttons of all colour and size.

The Sub-Contractor shall also provide sufficient lubricating oil in screwed top metal containers, suitable for all plant and equipment supplied under this Sub-Contract to last for a period of twelve months.

I. PIPE SLEEVES

The Sub-Contractor shall be responsible for the supply and installation of pipe sleeves in the slab & wall during the construction.

m. ENERGY AUDITING

Energy kWh meters for the monitoring of energy consumptions shall be provided to all incoming power supplies to the central air-conditioning systems (motor control centres)

n. LABELS

All identification plates, specification plates and other labels shall be attached to the plant or equipment in a prominent position.

Labels shall generally be secured to equipment casings with at least four chromium plated screws.

3. INSTALLATION

a. MOUNTING

All factory assembled equipment shall be mounted in accordance with the manufacturer's recommendations.

All equipment and materials shall be mounted and installed in the space provided, with adequate access allowance for maintenance.

Air-Conditioning and Mechanical Ventilation Installation Testing and Commissioning

1. GENERAL

In addition to all commissioning and testing called for elsewhere in this Specification, the Sub-Contractor shall carry out all necessary testing and commissioning procedures comprising tests at maker's works, site tests during construction, commissioning and acceptance tests all as specified below.

Tests shall be carried out in accordance with the Employer's Insurance Company requirements where applicable, the appropriate Singapore Standards or Codes of Practice and, FSSD and DBCD requirements.

All tests shall be witnessed by the Engineer, and in the case of pressure tests at the manufacturer's works, by the insurers or other parties nominated by the Employer. Not less than fourteen days' notice shall be given by the Sub-Contractor for this purpose.

All tests shall be properly certified in a manner to be agreed with the Engineer and triplicate copies of all certificates shall be issued to the Engineer on completion.

These test records, certificates and performance data shall be supplied for all tests, whether or not they have been witnessed by the Engineer. The information given on such test certificates and services shall be sufficient to identify the material or equipment to which the certificate refers, and shall also bear the Sub-Contract reference and heading given in equipment sections.

Only when the installations have been so certified and all test figures and other relevant information has been recorded in the prescribed manner and accepted by the Engineer should the works be considered fit for handing over to the Employer.

The Sub-Contractor shall include in his tender all costs associated with the above-mentioned testing and commissioning procedures including the cost of making good any defects arising out of such tests and having the work re-tested. Such costs shall also include the provision of all instruments necessary for the test.

The Sub-Contractor shall produce and circulate to the Engineer for comment a comprehensive commissioning procedure. This document shall outline all steps to be taken by the Sub-Contractor in testing, commissioning and setting to work the installations. Details of each instrument to be employed are to be provided.

The commissioning and testing of the systems shall be carried out by a specialist team of commissioning engineers employed by the Sub-Contractor.

It shall be necessary for the Sub-Contractor to demonstrate the competence of this team of engineers prior to commencement of the testing and commissioning. The Sub-Contractor shall submit full details of qualifications, commissioning experience and proposed duties of each member of the commissioning team for acceptance by the Engineer.

2. ACMV INSTALLATION

This Section specifies the requirements for commissioning and testing for the various systems which shall form part of the Sub-Contract Works as shown on the Drawings.

If, in the opinion of the Engineer, the Sub-Contractor has not properly balanced the system as specified, the Engineer reserves the right to appoint an independent balancing

Air-Conditioning and Mechanical Ventilation Installation Testing and Commissioning

agency to re-balance the entire system.

All costs involved in appointing such a balancing agency shall be entirely borne by the Sub-Contractor, and may at the Employer's discretion and without prejudicing the Employer's right to recover such costs by other means, be deducted from any monies payable to the Sub-Contractor under this Sub-Contract.

For the purpose of this Specification, the following definitions shall apply.

i. Commissioning

The advancement of an installation from the stage of static completion to full working order to the specified requirements. Commissioning includes setting to work and regulation of an installation.

ii. Setting-to-work

The process of setting a static system into operation.

iii. Regulation

The process of adjusting the rates of fluid flow in a distribution system within specified limits.

iv. Testing

The evaluation of the performance of a commissioned system.

All Commissioning, equipment shall be the products of overseas manufacturers who are experienced in the manufacture and calibration of such equipment.

The Works shall be commissioned and tested in accordance with manufacturer's instructions, the appropriate C.I.B.S Commissioning Codes and applicable insurance company or Government's requirements.

In particular the following testing and commissioning codes shall be applied throughout :-

C.I.B.S. Code A : Air distribution

C.I.B.S. Code C : Automatic Control

C.I.B.S. Code D : Refrigeration

C.I.B.S. Code W : Water Distribution

ACMV DW/143 : Ductwork Leakage Testing

All equipment required for the commissioning and testing of the Works shall be provided by the Sub-Contractor.

All instruments shall have been re-calibrated within six months of the start of commissioning or testing.

Air-Conditioning and Mechanical Ventilation Installation Testing and Commissioning

Calibration of all instruments shall be certified by the instrument manufacturer or an approved calibration agency.

v. Pressure Tests

1. Where specified in the relevant section, plant shall be pressure tested at the manufacturer's works to a minimum of 1-1/2 times the maximum system working head (or as specified in the schedule) for a period of not less than two hours. Test certificates in triplicate shall be forwarded to the Engineer.
2. All water pipework shall be hydraulically pressure tested to 1-1/2 times the maximum working pressure in the system for not less than 24 hours without leakage or loss of pressure. The maximum working pressure shall be deemed to be the static head plus the total pump head.
3. Ball bearing testing method shall apply for condensate drain pipe.
4. Where any plant will not accept the maximum pipework test pressure it shall be isolated during the pipework test, then that section of pipework and plant re-tested at the equipment test pressure.
5. In sections of pipework with expansion joints, care shall be taken not to exceed the design anchor load. The joint shall either be rigidly tied or removed for the hydraulic test and replaced by a spacer piece. When the expansion joint is re-introduced, that section of pipework shall be re-tested at the system working pressure.
6. All ductwork other than fan coil unit plenums and flexible ductwork shall be subjected to pressure tests prior to commissioning and balancing.
7. Test pressure shall be in accordance with the class of ductwork specified in DW143 and the air leakage limits shall relate to the system as a whole not just ductwork.

vi. Preliminary Commissioning Checks

1. The Sub-Contractor shall ensure that all equipment included under this Sub-Contract is thoroughly cleaned, lubricated and checked for service ability immediately before setting to work. Particularly attention is drawn to the removal of building debris from the air systems, motors, fan bearings and pipework.
2. All pipework shall be thoroughly flushed and chemically cleaned to ensure that all foreign matter is removed and internal surfaces are degreased. During all preliminary flushing, plant shall be isolated by means of bypasses to avoid deadlegs, and the systems shall be completely isolated from any existing systems to ensure contamination cannot occur.
3. Further flushing and chemical treatment shall be carried out on isolated systems by connection of a temporary diesel driven pumps to

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circulate water and dosing chemical. The Sub-Contractor shall allow for cross-connection of flow and return pipework at the extremities of risers and interface points with existing installation.

4. All automatic controls and safety devices shall be inspected and checked for service ability before the working fluid or electricity is applied to the system.

vii. Commissioning

When the preliminary commissioning checks have been carried out, the Sub-Contractor shall set to work, regulate and calibrate the installations in accordance with a programme to be agreed with the Engineer.

Special attention shall be paid to the items listed in this Clause.

All valves, dampers, switches, controls, etc., shall be regulated and capable of proper operation and in the case of valves shall be capable of tight shut off.

All apparatus shall be silent and vibration free in accordance with the requirements of this Specification.

All instruments shall be correctly calibrated and shall read accurately.

Each air handling and ventilation plant shall be operated with the air volumes for each individual space measured, regulated and correctly related and the plant set for the correct duty.

Each water system shall be set in operation with the water volumes to each unit measured, regulated and the plant set for the correct duty.

The Sub-Contractor shall ensure that chillers and all control systems are functioning correctly and are properly sequenced and interlocked.

Detailed certified records shall be kept by the manufacturer for the commissioning of all systems and equipment and copies passed in triplicate to the Engineer.

Air systems shall be regulated to the tolerances set out in Section A.3.5., Tables 1 and 2 of C.I.B.S. Commissioning Code Series A.

Water systems shall be regulated by flow measurement, although checks may be carried out using a heat balance. Tolerances shall be as follows:

Fan coil units and Air Handling +10%

Units, etc. - 0%

Testing shall be broken into two phases. Acceptance tests to demonstrate that the installation is in accordance with the Specification in respect to plant duties, performance and control stability, and Performance Tests to verify that the installation is capable of providing the required conditions.

Acceptance tests shall be carried out immediately commissioning is complete.

Air-Conditioning and Mechanical Ventilation Installation Testing and Commissioning

Should the results of any test show that any plant, system or equipment fails to perform to the efficiencies or duties as given in this Specification, the Sub-Contractor shall adjust, modify and if necessary replace the equipment without further payment in order that the required performances be obtained.

Should it be necessary for the Sub-Contractor to modify or replace any item of plant as described above, he shall be responsible for the cost for any damage or deterioration to the building or other services consequent on such modifications.

The Sub-Contractor shall allow in his cost for returning to site during the first year of operation to test equipment and systems under maximum design conditions.

The Sub-Contractor shall issue to the Engineer, in triplicate, the test results for each item of equipment and system under these conditions.

3. ELECTRICAL INSTALLATION

The Sub-Contractor shall be responsible for the testing of all switchboards, sub-main cabling, final sub-circuits, earthing, etc. Generally, tests shall include but not be limited to the following :

- a. Insulation resistance and continuity tests.
- b. Operation of protective relay circuits and system faults circuits for checking sensitivity and stability.
- c. Earthing system effectiveness tests.
- d. Phase sequence and polarity tests.
- e. Correct operation of interlocks, tripping, closing circuits and indications.
- f. Effective bonding of earth terminals in metal enclosures of all equipment.
- g. Measuring and sensing equipment accuracy.
- h. Any other tests as reasonably required by the Engineer.

The Sub-Contractor shall be responsible for the calibration and setting of all protection systems in the presence of the Engineer/Consultants. All settings shall then be permanently marked on the control equipment. All calibration procedures shall be properly recorded.

The Sub-Contractor shall submit Type Test and Test Certificates issued by recognised Testing Authorities on specific equipment as stated in this Specification. Controlled Goods as specified by SPRING Singapore shall be batch-tested and bear Safety Mark labels.

The Sub-Contractor shall make all necessary arrangements including paying any fees incurred for all tests required by the relevant Authorities before and after the installation turn-on. It is the responsibility of the Sub-Contractor to ensure that the tests are

Air-Conditioning and Mechanical Ventilation Installation Testing and Commissioning

scheduled to avoid delay in the turn-on and overall completion of the project.

The Sub-Contractors shall be responsible for arranging factory test/inspection of chiller plant at manufacturer site. The tests are to be witnessed by consultant and owner representative (1 each) and to be carried out in accordance with the recommendation of an approved testing authority and in compliance with other clauses of this section. All costs incurred are to be borne by the Sub-Contractor.

Fire Protection Installation Pipework and Fitting

1. DESCRIPTION

This Section specifies the pipework and fittings for the various systems which shall form part of the Works as shown on the Drawings.

Unless specifically stated otherwise, the terms "pipework and fittings" or "pipes and fittings", when used in a general context, shall mean all pipework, fittings, valves, gauges, strainers, hangers, supports and all other components and accessories required for the complete installation of the system as shown on the Drawings.

All pipework and fittings of the same material shall be supplied by a single manufacturer to ensure uniformity of standards and composition between services installations. Pipework and fittings employed throughout this project shall be of EEC, North American or Japanese origin.

2. MANUFACTURE

All pipework delivered to site shall be new and shall be colour banded at the factory to identify different grades, materials and manufacturers.

All valves for isolation and regulation shall be the product of a single manufacturer.

3. SELECTION

All pipework fittings, accessories, joints and joining media used shall be suitable for the substance conveyed in the pipes and shall not deteriorate due to chemical or atmospheric action.

All pipework, fittings and valves must be suitable for the system test pressures.

4. STANDARDS

All pipework and fittings shall comply with the appropriate British Standard as listed in the relevant Table of this Section, or an equivalent international standard.

All personnel engaged on welding operations must possess a certificate of competence issued by an approved authority. These certificates must be produced for inspection by the Engineer before any welding is undertaken and renewal certificates must be provided every six months.

Each weld shall be given a suitable mark in order that the operative concerned may be identified. This will be rigidly enforced.

The Engineer reserves the right to order at random the cutting out of 2% of the welded joints for inspection and testing. Should any one of the above welds prove faulty in materials or workmanship, further removal of welds may be ordered up to a total of 4% of the welded joints. If the number of welds failing the tests within the above 4% is sufficient to suggest that an operative is not consistent in his standard, the Engineer may order any number of that operative's welds to be removed. The cutting out and repair of all such welds for inspection shall be at the cost of the Sub-Contractor.

Oxy-acetylene and metal arc welding of steel pipework shall be Class 2 to B.S. 2640, B.S. 2971 or B.S. 4515.

Fire Protection Installation Pipework and Fitting

Fusion welded joints in copper shall be to B.S. 1077 and bronze welding by gas shall comply in every respect with B.S. 1724.

Gas welding of steel pipework of 65mm and above shall not be permitted unless prior permission is obtained.

Welding shall not be permitted on galvanized pipework under any circumstances.

No locally made ductile iron pipework, flanges or fittings will be accepted.

Generally, all ferrous piping systems shall comply with B.S. 806.

All screwed joints shall be made in compliance with B.S. 21 using jointing compounds carefully selected to suit the type of service.

All flanged joints shall be made in compliance with B.S. 4505 and all fittings valves etc. shall be compatible with stub flanges. Flanges shall have raised faces and a uniformity of flanges shall be employed between each service installation. All pipework, fittings and plant flanges shall be PN16 type unless otherwise stated or required by the system pressures.

All capillary fitting shall comply with B.S. 864.

All pipework, fittings and valves shall be of the approved type by the Fire Safety Department.

All pipework and fittings for the Sprinkler System shall comply with the requirements of Australian Standard AS 2118.

Pipework and fittings for the Wet Rising Mains, Dry Rising Mains and Hosereel System shall also comply with the requirements of Singapore Standard CP 25.

5. MATERIALS

Table A lists the material classes for the various piped services forming part of the Works. These classes are referred to in the various Tables of standards and specifications used in this Section.

Table B lists the materials specifications for the various classes of pipework.

6. JOINTS AND JOINTING

Table C lists the joints and jointing materials to be used on straight runs of pipework for the various classes of pipework. No hemp shall be used for jointing.

Table D lists the joints for equipment connections.

Table E lists the type of flanges & method of attachment for use wherever flanged joints or connections are specified, generally to be used for connections to items of equipment and adjacent to valves, strainers and other pipeline accessories. In addition, sufficient joints of this type shall be provided in all plant rooms to ensure that access to equipment for maintenance, removal and replacement can be effected without dismantling large sections of pipework or adjacent plant and no pipe joint shall be permitted within the thickness of walls or floors.

Joint shall not be closer than 1.0m except where necessitated by fittings.

Fire Protection Installation Pipework and Fitting

Where pipework is connected to items of equipment having flanges of a dissimilar metal to the pipework, then isolating flanges of a proprietary brand shall be used with plastic bolt inserts.

7. FITTINGS

Table F lists the type of fittings which shall be used with the various classes of pipework.

Long sweep bends shall be used in preference to round elbows wherever practicable. Square elbows or lobster backed bends shall not be used.

Tees shall be of the easy sweep or twin elbow pattern except where square tees are required for venting or draining, etc.

Bushes shall not be used and where a reduction in pipe size is required, reducing sockets or tees shall be used. Eccentric reducing sockets shall be used wherever necessary to ensure proper drainage or elimination of air pockets.

8. SUPPORTS

Table G lists the maximum allowable spacings of support centres for the various classes of pipework.

Pipe supports shall be provided as required for the stable and sufficient support of the pipework.

Pipe supports shall allow free movement for expansion and contraction and shall be graded to required levels for air elimination and drainage.

To ensure free movement, proprietary PTFE slide bearing pads shall be provided, either welded or screwed to the support member.

Ferrous pipes shall have ferrous brackets and copper pipes shall have brass or gunmetal brackets. For ferrous pipework the pipe brackets shall be hot dip galvanised after manufacture.

Additional supports shall be provided adjacent to valves and other large pipeline mounted items to prevent undue strain on adjoining pipework. Additional supports shall also be provided adjacent to pump connections, etc., to prevent undue strain on plant.

9. AIR VENTS

Key operated air vent cocks of an adequate size shall be provided at all high points, as well as at high points on every floor.

Each vent shall incorporate a lockshield valve and the discharge pipe shall be run to the nearest agreed drain point.

10. DRAIN POINTS

Adequately size key operated drain cocks shall be provided at all low points on liquid circulation.

Fire Protection Installation Pipework and Fitting

11. PIPELINE STRAINERS

Water strainers shall be installed in all pipelines upstream of all plant and elsewhere as indicated on the Drawings.

For pipelines of nominal bores between 15mm and 50mm inclusive strainers shall be screwed gunmetal or bronze body 'Y' type with stainless steel screen.

For pipelines of nominal bores from 65mm and above, strainers shall be flanged to BS EN 1092-1 and 1092-2 to the appropriate Table for the material with 'Y' type bronze body, stainless steel screen.

12. VALVES

Valves for the various classes of pipework shall be as indicated in the following Tables.

Table H - Isolating Valves.

Table G - Check Valves.

Table 3.10 - Drain Cocks.

Table 3.11 - Strainers

Table 3.12 - Vent Cocks

The Tables listed are included for the guidance of the Sub-Contractor in selecting suitable types of valves for a particular service.

Note that inclusion in these Tables shall not be taken as implying approval of the valve by the Fire Safety Bureau. The Sub-Contractor shall be entirely responsible for ensuring compliance with any Government requirements, for the testing, stamping of valves and for the payment of any fees levied.

The Sub-Contractor shall include for all valves necessary for the proper completion, working, isolation, regulation and control of the installations equipment & plant respectively to ensure that each item can be removed, replaced or repainted without withdrawing the pipework.

All valves shall be of heavy quality suitable for the working hydraulic pressure stated and installed with the valve stems truly vertical or horizontal.

Where flanged valves, etc., are specified, details of flanges shall correspond to the appropriate specification. Valve flanges and counter flanges shall be to the same British Standard and a common flange type and rating shall be employed throughout this Sub-Contract.

In addition to pressure gauge locations, gunmetal test cocks 10mm or 15mm size shall be fitted on suction and delivery pipes for testing.

Valves of 150mm diameter and above located 2,200mm or more above floor level within plant rooms shall have a chain operating gear descending to 1,000mm above floor level.

Plugs for gland cocks shall be ground-in. A loose key of forged mild steel shall be provided with each gland cock.

Fire Protection Installation Pipework and Fitting

Air cocks shall be nickel-plated, of the Spoutless pattern and with screwed taper thread. At least two loose keys shall be provided for each installation.

13. BALL FLOAT VALVES

All ball float valves shall be of cast iron valve body with nickel alloy and stainless steel working parts.

14. PRESSURE SWITCHES

Pressure switches shall have contact sets of silver, rated to suit the working voltage and current of the circuits controlled and shall have independent adjustments for the cut-in and cut-out point and for the operating differential.

The operating pressure range shall be 4 bar to 11 bar in general and the re-set pressure differential shall be between 0.5 bar and 1.0 bar. In any case, the maximum working pressure of the pressure switch shall be at least 3 bar above the maximum pressure of the water inside the pipework.

Isolating valves shall be provided to the pressure switches for maintenance purpose, and isolation purpose under hydrostatic pressure test conditions.

15. FLOW SWITCHES

Flow switches shall be of magnetic type having the water side completely separated by a bulkhead from the electrical side. Contacts shall be suitable for the working voltage and current of the circuits controlled and shall be of silver or alloy.

Flow switches shall be capable of withstanding a testing pressure of 16 bar for six hours without showing any sign of leakage.

They shall be so located that there is a straight horizontal run of five pipe diameters on each side of the flow switch. The flow switch shall be suitable for the pipe size and expected flow rate and shall be furnished with adjustable flow setting.

16. LEVEL SWITCHES

Water tank level switches shall be of floatless type having probe units, control unit, etc.

Contacts shall be suitable for the working voltage and current of the circuits controlled and shall be of silver.

The level switches shall be listed or equivalent.

It shall be used to automatically operate sequential pump sets and give low and high level alarms. However, provision shall be provided for manual override to enable manual operation of the pumps.

17. PRESSURE GAUGES

Pressure gauges shall be of Bourdon type with brass syphon and cock, and piping connection to the measuring point; size to be 100mm diameter dial, conforming to B.S.

Fire Protection Installation Pipework and Fitting

1780. All gauges shall have black pointer, red over run indicators, and red mark at normal working pressure.

The pressure gauges shall be of the order of 150% of the known maximum working pressure expected at the tapping point, disregarding any hydrostatic pressure as specified in the "Testing and Operation" Section. Pressure gauges shall have scales with divisions not exceeding 0.5 bar and a maximum scale value of 16 bars if the maximum pressure experienced at the point of measurement is 14 bar or less; and 25 bar otherwise.

Pressure gauges shall be mounted directly on pipework and shall be labelled as specified elsewhere.

An isolating valve/cock shall be provided for each pressure gauge.

Pressure gauges shall be installed where shown on the Drawings; and whether shown on the Drawings or not, in the discharge of pumps, and to the PUB Water Department FSSD requirements.

18. LEVEL INDICATORS

External level indicators shall be provided for all water tanks such that the maintenance personnel can easily view the water levels at the entrance of the pump rooms.

External level indicators shall be of glass tube type protected by metal tubing.

19. RATIO TYPE PRESSURE REDUCING VALVE

Ratio pressure reducing valves shall achieve a fixed ratio reduction in pressure irrespective of the water flow rate. In the reverse flow conditions, the valve shall operate as a positive non-return valve.

Materials of the valve shall be suitable for use with major components such as valve body, seat, etc., constructed of gunmetal.

The valves shall be designed for 4 bar to 25 bar (60 psi to 365 psi) inlet pressure range and shall be of PN 25 flanged connection to B.S. 4504 : Part 1 : 1969.

Pressure gauges c/w isolating valves shall be installed upstream and downstream of each ratio pressure reducing valve.

20. INSTALLATION

a. GENERAL

The Sub-Contractor shall provide all labour and material to form complete pipework systems and shall leave the installation adjusted to the designed flow rates.

All pipe runs shall be installed generally in accordance with the Drawings but full allowance shall be made by the Sub-Contractor for the detailed development and co-ordination of the scheme and for the future removal and dismantling of sections of the Works.

All pipework shall be free from burrs, rust and scale and shall be thoroughly cleaned before installation.

Fire Protection Installation Pipework and Fitting

During the course of the installation, all open ends shall be plugged or capped to prevent ingress of dirt and on completion each system shall be thoroughly flushed out with clean water. Wooden bungs shall not be used for plugging pipework.

Where two or more pipe runs follow the same route, care shall be taken to ensure that all are parallel to each other and to the building structure, except for the required allowance for venting, etc. Pipework which is to be subsequently insulated shall be so spaced to allow an individual finish to each.

b. FALLS

Pipework shall be installed with correct falls to ensure adequate venting and draining.

c. ANCHORS

Anchors shall be positioned in association with pipework change in direction and propriety expansion compensators, etc., such as to absorb the stresses due to pipework expansion and internal pressures by transmission of such forces to the ground or structure at appropriate points.

The Sub-Contractor should particularly note that in addition to serving the purpose of constraining the pipeline, the anchors may be used in connection with testing of pipework, and at such times, it will be necessary to have the extreme ends of the main being tested held with the anchors to prevent the pipeline drawing apart due to the thrust pressures exerted at the end of the pipe.

Adequate pipe anchors shall be provided whether or not shown on the Drawings and shall be constructed from structural steel channel sections secured to the building structure.

d. FLEXIBLE AND EXPANSION COUPLINGS

The couplings shall be arranged such that torsional, co-axial stress and lateral stress caused by expansion and/or settlement shall not be transmitted to the flanged connections of the plant.

During sectional testing, the Sub-Contractor shall ensure that the expansion joints are adequately tied, anchored or removed to avoid damage to the bellows.

Wherever necessary, due allowance shall be made for the expansion and contraction of pipework by change in direction of pipework, or expansion loops, whether shown on the Drawings or not.

At building expansion joints, and wherever else necessary, additional allowance shall be made by the provision of stainless steel axial or articulated bellows type expansion compensators complete with all necessary guides, etc., as recommended by the manufacturer to give a working life of not less than twenty years.

Fire Protection Installation

Pipework and Fitting

Each compensator shall maintain at least the same cross-sectional area as adjoining pipework for its entire length.

On larger diameter steel, ductile and grey iron pipes (150mm diameter and above) judicious use of "dresser" couplings or other equal flexible couplings shall be made in connection to all plant items.

Flexible couplings shall be fitted to pump suction and delivery connections and where indicated on the Drawings or schematics.

Flexible couplings shall be line size, made from a multi-ply nylon fabric carcass with wire reinforced collars and liners designed to suit the fluid conveyed and the working, test, and shock pressures that will be experienced in the various systems.

Manufacturers shall be alerted by the Sub-Contractor to the possibility of variations of service (e.g. on/off pump operation shock pressures, etc.) to ensure correct selection of items for the particular application.

e. GUIDES

Guides shall be of mild steel riders welded to the pipes on roller or PTFE sliding supports restrained with U-bolts on brackets or as otherwise detailed on the Drawings.

f. PIPE SLEEVES

Where pipe pass through walls, floors, etc. (including floors in ducts), the Sub-Contractor shall provide pipe sleeves.

Where pipes pass through walls, floors or ceilings rendered liquid-tight puddle flanges shall be supplied and fixed by the Sub-Contractor.

Sleeves for cast iron, copper and steel pipes shall be galvanised steel. For plastic pipes, the sleeves shall be plastic.

Where sleeves are fitted through floors, they shall extend to at least 50mm clear of finished floor.

Sleeves shall be of sufficient size to allow free movement of pipes and where pipes are insulated, the sleeves are to be oversized to allow the insulation to be carried through the sleeves.

Details of pipes through walls and floors to be submitted for checking before installation.

The Sub-Contractor shall set all sleeves in the shuttering of walls, floors, etc., before concrete is poured and in compliance with the Main programme. Where holes have to be cut through structure after concrete has been poured as a result of the Sub-Contractor's failure to provide the same, then all costs for this shall be to the Sub-Contractor's account.

Where exposed pipes pass through walls, ceilings and floors, hinged mild steel escutcheon rings are to be used. All plates are to be chromium plated steel and

Fire Protection Installation Pipework and Fitting

samples of such plates are to be submitted to the Engineer for checking.

Pipe sleeves shall also be provided where piping penetrates external walls and roofs. The space between pipe sleeves and the pipe or insulation shall then be completely caulked by the Sub-Contractor, with a soft, non-setting waterproof mastic compound giving an air and watertight seal.

Penetrations through roofs shall also be provided with a weatherproof apron and up stand curb or other provisions as may be specified elsewhere or shown on the Drawings.

Where pipes pass through fire walls and floor slabs, a metal fire stop is to be welded or bolted around the pipe. This shall be in the form of a 6mm thick flange located in the centre of the slab/wall thickness and welded/screwed to the pipe, the flange being of the same diameter as the internal bore of the pipe sleeve.

g. BURIED PIPES

All pipework buried in walls or slabs shall be wrapped with an impregnated protective tape such as Denso or equal.

h. IDENTIFICATION

Generally all sprinkler, wet riser, dry riser and hosereel pipes shall be painted red in accordance with FSSD's requirements.

Painting shall be described in the "Insulation and Painting" Section of this Specification.

All equipment forming part of the pipework system or connected to the pipework shall be painted as specified for pipework.

All pipework, valves and fittings shall be provided with identification markings and labels as specified in the "Insulation and Painting" Section of this Specification.

Construction of identification labels shall be as specified in the "Miscellaneous Provisions" Section of this Specification.

Fire Protection Installation Pipework and Fitting

TABLE A	
PIPEWORK CLASSES	
Piped Service	Pipework Category
Dry/Wet Riser	I
Sprinkler Systems	II
Overflow, Drain Pipes	II
Underground Sprinkler	III
Hosereel Pipe	IV

TABLE B			
PIPEWORK SPECIFICATION			
Pipework Category	Nominal Bore	Minimum Wall Thickness (mm)	Specification
I	15 - 150	-	Seamless heavy duty galvanized steel to BS EN 1055 heavy, galvanizing to be carried out by pipe manufacture.
II	15 - 150	-	Black Steel Medium Duty to BS EN 10255 medium
	200	4.9	Black carbon steel, electric resistance (FRW 410) using 410 Mpa grade steel BS EN 130, 1127, BS EN 1022 and BS EN 10216-1, BS EN 10217-1.
III	all sizes	-	Ductile iron pipe to BS EN 545 cold bitumen coated externally and internally to BS 3416.
IV	50 - 65	-	Copper tube to EN 1057 heavy duty
Note : All batches of pipework supplied for the Sub-Contract must be provide with mill certificates certifying compliance of the manufacturing standards and testing			

Fire Protection Installation

Pipework and Fitting

TABLE C		
JOINTS IN STRAIGHT RUNS OF PIPES		
Pipework Category	Nominal Bore (mm)	Joints and Materials
I	15 - 50	Galvanized malleable iron, bronze to iron spherical seat union with jointing material to B.S. 5292 : 1976.
	65 - 200	Proprietary grooved mechanical joints for roll grooved or cut grooved pipe ends, hot dip galvanized steel housing plated steel bolts.
II	15 - 50	As for Category I pipes
	65 - 200	As for Category I pipes
III	All Sizes	Proprietary groove mechanical joints for roll grooved or cut grooved pipe ends, suitable for ductile iron pipes.
IV	50 - 65	Capillary joints to BS EN 1254-1 and BS EN 1254-2. Weld on Stud flanges to BS EN 1092-3 (PN16).
Note : 1. All joints shall be suitable for system test and operating pressures. 2. All flanges shall have raised faces and shall be PN/6 or PN 25 to suit system test and operating pressures. 3. All grooved mechanical joints shall be suitable for system test and working pressures and shall be minimum rated at 2065 kPa.		

TABLE D		
JOINTS FOR EQUIPMENT CONNECTIONS		
Pipework Category	Nominal Bore (mm)	Joints and Materials
I	10 - 15	Black malleable iron, bronze to iron spherical seat unions with jointing material to B.S. 5292.
	65 and above	Dresser couplings or mechanical joints shall be used as for straight pipe runs.
II	15 - 50	As for straight pipe runs.

Fire Protection Installation Pipework and Fitting

TABLE D		
JOINTS FOR EQUIPMENT CONNECTIONS		
Pipework Category	Nominal Bore (mm)	Joints and Materials
	65 and above	As for straight pipe runs.
III	-	Not applicable
IV	50 - 65	Compression joints to BS.864:Part 2 dezincification resistant (DZR)
Note : 1. All flanges and mechanical joints shall be suitable for system test and operating pressures. 2. All flanges shall have raised faces. 3. All flanges and mechanical joints shall be PN16 or PN25 to suit system operating and test pressures.		

TABLE E		
FLANGE DETAILS		
Pipework Category	Nominal Bore (mm)	Flange Type and Method of Attachment
I	15 - 150	Screwed on galvanized steel boss flanges with taper threads to B.S. 21 : 1973, pipe expanded into flange. Galvanized flanges to B.S. 4504 : 1969 : Part 1, Table 16/4.
	200 and above	Type 6 slip on welding flanges. Methods are welded to B.S. 4515 : 1969 Part 1 Table 16/4. All black steel and galvanized after welding. Care must be taken to ensure the Flange face is not twisted or defaced during the galvanized process.
II	15 - 150	As for Class A pipe.
	200 and above	As for Class A pipe.
III	10 - 200	Flanges equivalent to B.S. 4504 : 1969 : Part 1, Table 6/5 or 6/3. Solvent welded using solvent cement to B.S. 4346 : 1974 : Part 3.

Fire Protection Installation Pipework and Fitting

TABLE E		
FLANGE DETAILS		
Pipework Category	Nominal Bore (mm)	Flange Type and Method of Attachment
IV	-	Not Applicable
Note : 1. All joints to be suitable for system test pressures. 2. All flanges shall have raised faces. 3. All flanges shall be PN16 or PN25 to suit system operating and test pressures.		

TABLE F		
PIPE FITTINGS		
Pipework Category	Nominal Bore (mm)	Flange Type and Method of Attachment
I	10 - 50	Black malleable iron screwed fittings to B.S. 143 and 1256 : 1968 or purpose made heavy weight welding fittings to B.S. 1965 : 1963 : Part 1.
	65 - 1000	Heavy weight welding fittings to B.S. 1965 : 1963 : Part 1.
I and II	15 - 150	Galvanized malleable iron screwed fittings in B.S. 1256 : 1968.
	Above 150	Galvanized iron fittings to B.S. 4772 : 1971.
IV	50 - 65	Copper capillary fittings to BS. 864:Part 2, dezincification resistant (DZR)
Note : 1. All joints and fittings to be suitable for system test and test pressures. 2. All flanges shall have raised faces. 3. All flanges shall be PN16 or PN25 to suit system operating and test pressures.		

Fire Protection Installation

Pipework and Fitting

TABLE G		
MAXIMUM SUPPORT SPACINGS		
Pipework Category	Nominal Bore (mm)	Support Centre (m)
I	10 - 15	2.0
	20	2.4
	25 - 32	2.7
	40	3.0
	50	3.4
	64 - 80	3.7
	100	4.1
	125	4.4
	150	4.4
	200	4.4
	250	4.4
	300 - 500	4.4
II	15 - 150	As for Category I Pipework.
	Above 150	As for Category I Pipework.
III	10 - 20	0.9
	25 - 32	1.1
	40 - 80	1.4
	100	1.9
	150	2.1
	200	2.4
IV	50 - 65	2.0

TABLE H							
ISOLATING VALVES							
Piped System	Valve Type	Nominal Bore (mm)	Working Press / (Temp)	Body	Spindle	Gate	Gland
Wet Riser/ Hosereel/ Sprinkler System	Gate	15-80	16 bar 100 °C	Gun-Metal	Gun-metal inside Screw non-rising stem	Gun-metal solid wedge	Brass
	Gate	100-500	16 bar 100 °C	Cast of Iron BS 1452 Grid 14	Stain-less steel	Stain-less steel	Stain-less steel

Fire Protection Installation Pipework and Fitting

TABLE H							
ISOLATING VALVES							
Sprinkler System (Moni-tred Valves)	Butterfly	65 to 500	16 bar 100 °C	High Duty Cast Iron	316 Stainless Steel	-	-
Piped System	Disc	Seat	Tapping/ Flange	Finish	Head	British Standard	
Wet Riser/ Hosereel/ Sprinkler System	Bronze	Bronze	BS 21 1985	Body Unpolished, bonnet & gland machined	Aluminium pitted, spoked	BS 5154 PN 16 Series B	
	Steel	Stainless steel	Flanged to BS 4504 (PN 16)	-	Cast of Iron	BS 5150 PN 16	
Sprinkler System (Moni-tred Valves)	Steel-less Steel	Bronze	Waffer or BS 21	Lock-ing trigger (with limit switches)	Lock Wrench	BS 5146 PN 16	
Note : 1. All joints shall be suitable for system test and operating pressures. 2. All flanges shall have raised faces. 3. All flanges shall be PN16 or PN25 to suit system operation and test pressures.							

Fire Protection Installation

Automatic Fire Sprinkler System (For A&A Work)

1. GENERAL

The automatic sprinkler system shall be designed and installed in accordance with Singapore Standard SS CP 52.

All equipment pipework and accessories shall be of the highest commercial standard and shall be designed, constructed, rated and tested in accordance with the requirements of FSSD, PUB and other approval authority. The basic requirements, of BS 336 and BS 5306 shall be complied with as far as applicable.

Materials shall comply with the various Singapore Standards Codes of Practice and British Standards, listed elsewhere in this Section or other equivalent international standards.

2. SPRINKLER SYSTEM

All additional pipework and fittings shall be new, and shall conform to the requirements of BCA, FSSD and the latest edition of CP 52.

Where new sprinkler heads are required as indicated on the drawings, they shall be the same model as the existing.

Sprinkler pipework shall be medium galvanised steel to BS EN 10255 suitable for screwed jointing, and for the working pressure required of the system. The Contractor is to ensure that the existing designed working pressure of the system is met for the Addition and Alteration works.

Pipe fittings shall be galvanised malleable iron banded screw fittings to BS 143 and 1256 rated for the system working pressure, compatible for use with the above pipework.

Pipes shall be supported at intervals of not more than 1.2 m.

Pipes shall be installed with correct falls to ensure adequate draining. Rules of the CP 52 shall be complied with for the complete installation.

Where pipes pass through R.C. walls and floors, pipe sleeves shall be provided and shall be galvanised steel.

All pipes and fittings shall be painted with zinc chromate primer, and one finish coat red paint before installation, and further painted with one more finish coat after installation.

Sprinkler heads c/w escutcheon plate shall be identical to those installed at the existing premises.

Sprinkler heads shall be glass bulb type, to match existing rated at 68 degree celsius, and of 15 mm dia. orifice.

The Contractor shall include for everything necessary to ensure that during the works, when the sprinkler valves are shut-off (isolated), means of temporary fire protection are provided. Fire extinguishers shall also be installed at strategic locations.

The Contractor shall be responsible for draining off of the sprinkler system for their works, and re-charging upon completion. The Contractor shall also be responsible for informing (at least 3 days in advance) the Building Owner and the Fire Brigade for the duration of the

Fire Protection Installation

Automatic Fire Sprinkler System (For A&A Work)

Works, when the alarm signal to the Main Alarm Panel is temporally disconnected.

The Contractor shall provide all necessary measures to protect existing Building Owner/Tenant's properties during the installation stage. The Contractor shall be responsible for any damages to existing properties/systems caused by them.

All existing pipework to be dismantled shall be removed from site by the Contractor. All connections where sprinkler heads have been removed shall be plugged up by the Contractor.

The water supply shall be taken from existing sprinkler distribution Main.

The Contractor shall propose the new sprinkler pipe route and it shall comply to the accepted Code of Practice. The Contractor shall submit as built drawings with hydraulic calculation for pipework if necessary.

Existing concealed sprinkler heads above false ceilings are to be adjusted as necessary to suit installation of new full height partitions.

3. AUTOMATIC FIRE ALARM SYSTEM

The automatic fire alarm system shall be designed and installed in accordance with Singapore Standard SS CP 10.

4. PORTABLE FIRE EXTINGUISHERS

Portable fire extinguishers shall be installed in accordance with the recommendations of BS 5306-3; and shall comply with FSSD's requirements and bear the PSB's PLS labels.

All portable fire extinguisher shall be supplied by manufacturer's experienced in the design and construction of similar equipment and who have made this type of equipment for at least five years.

All equipment and accessories shall be approved by the BCA and FSSD where applicable.

All equipment and accessories shall be of the highest commercial standard and shall be designed, constructed with the requirements of FSSD and other approval authorities. The basic requirements of SS 578 and SS EN 3 shall be complied.

All fire extinguishers shall be tested and approved by PSB and shall bear the PSB's PLS label.

The locations shown on the Drawings are diagrammatic only, and the Contractor shall allow for relocation of any portable fire extinguishers as may be requested by the inspection officer of FSSD.

5. TESTING AND COMMISSIONING

5.1. GENERAL

In addition to all commissioning and testing called for elsewhere in this Specification, the Contractor shall carry out all necessary testing and commissioning procedures

Fire Protection Installation Automatic Fire Sprinkler System (For A&A Work)

and site tests during construction, commissioning and acceptance tests all as specified below.

Tests shall be carried out in accordance with the Employer's Insurance Company requirements where applicable, requirements of all BCA, FSSD and Singapore Standard Code of Practice.

5.2. FIRE PROTECTION INSTALLATION

Only when the installations have been so certified and all test figures and other relevant information has been recorded in the prescribed manner and accepted by the Engineer shall the works be considered fit for handing over to the Employer.

The Contractor shall include in his tender all costs associated with the abovementioned testing and commissioning procedures including the cost of making good any defects arising out of such tests and having the work retested. Such costs shall also include the provision of all instruments necessary for the test.

Before commissioning or testing any of the installations, the Contractor shall produce and submit to the Consulting Engineer for comment a comprehensive commissioning procedure. This document shall outline all steps to be taken by the Contractor in testing, commissioning and setting to work the installations. Details of each instrument to be employed are to be provided.

5.3. FILLING OF SYSTEM

All parts of the water circuit shall be filled with water before hydrostatic pressure testing, and pump running tests for verification of pressure and flow rate, are conducted.

5.4. HYDROSTATIC TEST

Performing the hydrostatic test, the following system component status shall be fulfilled :-

All the main stop valves and subsidiary stop valves to provide isolated watertight sections of hydrostatic pressure testing.

The pressure switches shall be isolated by the relevant valves or cocks.

The test and drain valves shall be closed.

The sprinkler inlet isolating valve shall be closed.

The gate valve below the 3 mm or orifice of the water columning prevention devices shall be closed.

A hand jacking pump shall be applied to increase the system pressure to the Testing pressure as specified in the "Sprinkler System" Section for particular section of pipework and equipment which shall remain practically unchanged for six hours, as read from the gauge, without any further application of the jacking pump during this period.

Fire Protection Installation Automatic Fire Sprinkler System (For A&A Work)

Due to the extent of coverage of the site, hydrostatic test shall be performed section by section at the discretion of the Engineer.

The hydrostatic test shall be performed prior to the system running.

5.5. FSSD INSPECTION

The Contractor shall attend to and carry out, the tests according to the instruction of the FSSD Inspection officer and/or Registered Inspectors during FSSD / R.I. inspection.

5.6. CONSULTING ENGINEER'S ACCEPTANCE TEST

After the final FSSD Inspection for the application of the occupation permit, the Contractor shall perform the Consulting Engineer's Acceptance Test to the satisfaction of the Consulting Engineers.

This test shall cover any, or all of the test procedures undergone and any additional test arrangement upon the discretion of the Consulting Engineers if there is any defect during the FSSD / RI inspection.

The Consulting Engineers will issue the certificate of completion upon his satisfaction of this Test and receiving the complete set of test and Inspection reports as stated in this Specification.

Fire Protection Installation Fire Alarm System

1. GENERAL

A complete Automatic Fire Alarm System complying with Singapore Standard CP 10 and to FSSD's requirements shall be provided by the Sub-Contractor.

The system shall be designed & build supplied and installed by specialist manufacturers who have designed and installed such systems for the past 10 years.

2. GENERAL SYSTEM ENGINEERURE

The configuration shall be as shown on the Drawings. The basic components shall include, but not limited, to the following :

- a. Main Fire Alarm Panel.
- b. Fire Alarm Sub Panels.
- c. Alarm Initiating devices comprising, but not limited to :
 - i. Break glass call points.
 - ii. Photoelectric smoke detectors / heat detectors.
 - iii. Multi-Detector at private lobbies (combination of heat/smoke detector)
- d. Alarm Indicating Devices. (Bells, buzzers, etc.)
- e. Signal to initiate other essential M&E equipment on fire alarm e.g. electrically locked doors, lift homing, essential fans, etc.
- f. Connections to DECAM Centre, via leased line.
- g. Backup power supply via batteries.

The Fire Alarm Sub Control Panel, or SIB, and Main Alarm Control Panel shall be UL listed for use in conjunction with field devices like breakglass call points and smoke detectors offered.

The entire system shall be to FSSD's approval complying with SS CP 10. The wiring configuration shall be a 4-wire loop to connect all field devices.

3. SYSTEM OPERATION

The system shall be based on well proven electronic conventional principle of fire detection and alarm.

Fire alarm bells ringing shall follow FSSD's requirements and be initiated by the Fire Alarm Main Panels (FAPs) directly. In the event of a fire alarm, but not in a fault condition, the following action shall be performed automatically:

- a. An alarm shall sound throughout the development with information, including zone numbers / floor shown on the panel.
- b. All lifts initiated through the system will automatically be returned to their homing floor.

Fire Protection Installation

Fire Alarm System

- c. Smoke Control Fans will be operated automatically.
- d. Fire shutters shall close and automatic sliding doors open. Electrically operated doors shall be unlocked.
- e. Signal shall be sent automatically and directly to DECAM, via dedicated telephone line.

4. FIRE ALARM PANEL

a. MAIN FIRE ALARM PANEL

The Main Fire Alarm Panel (FAP) or Fire Indicator Board (FIB) shall function as a fully standalone panel.

The multi-detector at private lift lobbies shall be lined to independent private lift lobby Alarm System and shall not be linked to the Main Alarm Panel.

The FAP shall be dust proof and constructed of minimum 16 gauge thick mild steel, the complete panel shall be factory finished. The FAP shall be UL listed for use in conjunction with the sub panels, detectors and field devices proposed.

The Fire Alarm Panel shall be so designed and constructed to comply with FSSD's requirements and to CP 10.

All circuits shall be supervised.

FAPs shall provide general purpose inputs for monitoring low battery or AC power failure.

Fire (sprinkler flow switches, call points and detectors) alarms, supervisory alarms and trouble (fault) alarms shall be clearly distinguished from each other

It shall be possible to command test, reset and silence alarm from both the FAP and the central console.

Switches incorporated in the FAP shall allow authorized personnel to perform the following functions :

- i. Initiate a general alarm condition.
- ii. Silence the local audible.
- iii. Silence the alarm signals. It shall be possible to acknowledge (silence) the local FAP audible without silencing the alarm indicating devices (bells).
- iv. Reset all zones / points, after all initiating devices have returned to normal.
- v. Test all panel LEDs for proper operation without causing a change in the condition of any zone.

The panel shall work on a 230 V AC power supply and a system voltage of 24 V DC. Constant voltage charging circuitry shall be incorporated to ensure proper battery charging and system performance.

Fire Protection Installation

Fire Alarm System

The charging circuitry shall incorporate a self diagnostic system to monitor charger failure caused by high or low charging voltage, mains failure or blown fuse. Specific indications shall be provided to denote each type of failure to facilitate easier trouble shooting. The common supply from the main alarm panels to the sub panel/s shall be supervised. Failure of this protection fuse shall cause a fault signal to be emitted.

The battery circuit shall be constantly supervised for low voltage, overcharged / defective cells and battery disconnection. Reversed polarity connection and short circuits shall also be monitored. Indications for these faults shall be provided.

Detection lines shall be a closed circuit continuously monitored type and individually supervised for open and short circuit faults. Separate open and short circuit LED indications shall be provided for each individual zone at the back of the zone modules. Individual zone isolations shall be provided.

Two sets of independent sounder circuits with separate terminations shall be provided at the base control board to enable the system to remain operational should one sounder line fail. This is also to facilitate ease of installation at site. Both sounder lines shall be separately supervised for both open and short circuit faults. Specific LED indications for both types of fault conditions are to be provided for both sounder lines.

Earth fault monitoring shall be provided for the charger, detection, sounder and auxiliary supply output circuits. Specific LED indications for positive (+ve) / negative (-ve) earth fault shall be provided at the base control board.

Occurrence of any system fault shall set off an audio and visual warning. The acknowledgement of a fault signal shall cause a reminding 'beep' to be emitted and shall not cancel the indication denoting the cause of the fault. It shall also not prevent the receipt of a subsequent fault signal from any system circuit not already providing the fault.

The following features shall also be provided at the FAP :-

i. Alarm Resound Circuit

Occurrence of an alarm condition shall also sound the buzzer. Silencing of the alarm shall cause a reminding 'beep' to be emitted and shall not cancel the indication denoting the cause of the alarm and shall not prevent the receipt of any subsequent alarm signals originating from other zones.

ii. Auxiliary Outputs

The panel shall be provided with the following auxiliary outputs;

iii. With bypass facility:

Two sets of general alarm, field selectable for 24 VDC outputs or voltage free contacts.

iv. Extended Auxiliary Functions

Where required there shall be a means of incorporating additional modules into the system to enable status monitoring and sending / bypass of alarm

Fire Protection Installation

Fire Alarm System

signals to trigger auxiliary functions , such as equipment tripping and activations. Switches / relays provided for such purposes shall be made individually field selectable for voltage free or 24VDC contacts. The common buzzer silence / resound and the reminding 'beep' features shall also function with these additional modules.

v. Networking Functions

Where main and sub alarm panels are networked as a system, the main panel shall be provided with a facility to enable active monitoring of alarm and fault condition of every sub panels. Facilities shall be provided to enable a general alarm to be generated, acknowledged or reset at the main or any sub panel irrespective of the origin of the alarm signal. The system shall be networked such that the initiation of a input device from any panel will result in a general sounding of all sounders networked in the entire system. Activation of another device at sub panel level shall also result in a general alarm resound even if the main panel had not been already reset.

vi. Main / Repeater / Mimic Panels System

Outputs for individual zone alarm and common fault annunciations shall be provided to enable connections to repeater / mimic panels. Repeater panels shall be provided with standard lamp test and buzzer silence / resound features.

vii. INDICATORS

Only general fault / alarm indications that operators are required to be aware of shall be displayed at the front panel. All other specific indicators pertaining to maintenance and servicing shall be displayed behind the front panel to enhance ease of operation.

All alarm and fault indications shall be accompanied with an audio buzzer warning. Specific indicators denoting the specific type of fault shall be provided.

viii. ZONE CONTROL BOARD

1. Detection Zones

Two RED indicators built on separate independent circuits shall be provided to signify a "FIRE" condition

One AMBER indicator shall be provided to signify a "FAULT" condition

One AMBER Indicator shall be provided to signify an "ISOLATE" condition

A sounder silence control shall be provided within the Main Fire Alarm Panel to silence the sounders without cancelling the alarm indications. The principle of design shall be such that the alarm shall not be cancelled by any means during the initial three minutes alarm time. Acknowledgement shall only be able to be effected upon expiry of the initial three minutes alarm time and shall permit the receipt of

Fire Protection Installation

Fire Alarm System

subsequent alarm signals and restarting of sounders. A sounder alarm time bypass connector shall be provided for installations equipped with a voice communication system. Zone isolation shall be designed to function only prior to alarm activation and shall not serve to cut off the alarm nor the indications during the initial minutes alarm time.

A Buzzer Silence Control shall be provided to silence the fault buzzer without cancelling the fault indications and shall permit the resounding of the fault buzzer upon detection of subsequent system faults.

2. Auxiliary Isolate Control

This shall be provided to inhibit alarm signal to auxiliary connections to facilitate routine maintenance but shall not prevent the transmission of the alarm signal to the alarm monitoring station.

A Evacuate Alarm Control shall be provided to trigger a general alarm sounding to facilitate evacuation. It shall override all isolations and be immediately self cancelling when de-activated.

A Lamp Test Control button shall be provided to confirm the working condition of all system indicators.

Reset Control shall be provided to interrupt power momentarily to reset panel and shall not be operative when the sounder has not been silenced (during the initial three minute alarm time) or when normal system conditions have not been restored.

For Detection Zones indication, Two RED indicators built on separate independent circuits shall be provided to signify a "FIRE" condition:

- One AMBER indicator shall be provided to signify a "FAULT" condition
- One AMBER Indicator shall be provided to signify an "ISOLATE" condition

Power supply to the panel shall be backed by in built sealed lead acid maintenance free batteries.

The following indication shall be provided on the system control board of the FAP for power supply status :

3. "Power On" Indicator

This shall be provided to indicate that the system is energised by either the AC or standby DC source.

4. "Mains Fault" Indicator (Amber)

This shall be provided to indicate a general incoming AC power failure.

5. "Charger Fault" Indicator (Amber)

This shall be provided to indicate a mains failure or blown fuse, a

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higher or lower than normal charging condition.

6. "Battery Fault" Indicator (Amber)

This shall be provided to indicate a general battery fault caused by a battery disconnection or blown fuse, or when the battery voltage is below or above the normal level.

7. "Sounder Fault" Indicator (Amber)

This shall be provided to indicate a fault condition when any of the sounder lines is short or open circuited.

8. "Earth Fault" Indicator (Amber)

This indicator shall be provided to indicate a fault condition when any of the system lines is shorted to earth.

9. "Auxiliary Supply Fault" Indicator (Amber)

This shall be provided to indicate a fault condition when any of the auxiliary supply fuse blown to Sub Alarm Panel (SAP) and/or any ancillary equipment.

ix. CONTROLS

All control switches shall be of the push button type with built-in LEDS that serves to indicate both the working condition of the switch and the activation of its function. They shall be colour coded to enhance ease of operation. Use of the conventional rotary switches shall not be allowed. Activation of these switches shall cause the built-in LED to be lighted up. Activation of any of the zone isolate, sounder silence, buzzer silence or auxiliary isolate controls shall cause a non-silenceable reminding "beep" to be emitted at approximate intervals of 15 seconds. This reminding warning shall persist until normal system conditions have been restored and reset. This is to prevent inadvertent isolation of the system functions.

x. ZONE CONTROL BOARD

1. Zone Isolate (Green)

Zone isolation shall be designed to function only prior to an alarm activation of the respective zone and shall not serve to cut off the alarm nor the indications during the initial three minutes alarm time.

All wiring between panels and from panel to field devices shall be 4 wire Class A wiring.

2. Sub Indicator Boards

SIBs, where applicable, shall have the features above, with mimic diagrams and LED indication on zone charts.

5. FIELD DEVICES

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Fire Alarm System

Field devices refer to addressable Fire Alarm initiating devices consisting of photoelectric smoke detectors, manual breakglass call points, alarm bells, etc. complete as described in the specification or as shown on the Drawings.

a. Smoke Detectors

Smoke detectors shall be supplied and installed in areas as shown on the Drawings.

Smoke detectors shall be of the photoelectric type, UL listed, for use in conjunction with FAP proposed.

Local LED indication shall be provided at detector base to indicate normal and alarm state of detector.

The smoke detector's sensitivity shall be adjustable.

Detectors shall be installed in such a way that they can be readily withdrawn from service for testing or replacement without affecting the effectiveness of the rest of the fire alarm system.

Detectors shall be mounted on to conduit junction boxes on underside of concrete slabs, and in false ceiling areas.

Where mounted in ceiling panels, the detectors shall be fastened to the ceiling by means of stainless steel screws through escutcheon plates fixed to the detectors.

Under raised floors, the detectors shall be mounted from hot dipped galvanised steel brackets, and in any case the detector must be raised above the concrete floor.

b. Heat Detector

Heat detectors shall be listed and of electronic type for combined rate-of-rise and fixed temperature response. It shall consist of two independent thermistors, designed to automatically compensate changes in ambient condition.

All electronic circuits must be solid state and hermetically sealed to prevent the operation being impaired by dirt, dust or humidity.

Contractor shall provide built in algorithms that provide both a constant sensitivity between service intervals and eliminate spurious alarms resulting from electrical noise.

The detector shall be protected against damage by reverse of polarity or faulty wirings.

The response sensitivity of the heat detector shall be with response temperature at 58 degree C or 10 degree C per minute rise for normal application and 82 degree C or 10 degree C per minute rise for high temperature application.

All heat detectors shall be common and interchangeable to a common type of base.

The installation of heat detectors shall include all necessary conduit, wirings, detector with individual addressable electronic module. All detectors shall be

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Fire Alarm System

mounted such that the sensing element is not less than 25 mm and not more than 600 mm below the ceiling or floor slab.

The detector shall operate reliably within the following specification:

Operating temperature range:	0 to +38o C
Relative humidity:	Above 90%
Operating voltage:	24 V DC nominal
Operating current:	150 uA
Alarm current:	100 mA
Protection category IEC:	IP-43
Approval:	UL/FM/LPC

For detectors concealed within the false ceiling space, each detector shall be provided with an auxiliary response (activation) indication light (LED) mounted in a location where it is clearly visible.

c. Detector Base

All detectors shall fit into a common standard type base. Every base shall have a built-in option allowing mechanical locking of the detector head to prevent unauthorised removal or tampering.

Detector insertion and removal shall be by simple push-twist movement through the use of an extended tool by one person at the floor level with the detector mounting height up to 7 metre even with the mechanical locking device activated.

The base shall be equipped with screwless terminals capable of securely retaining wires up to 1.5 sq.mm. The base shall be suitable for use in both Class A and Class B wiring.

The electronic module shall be solid state and hermetically encapsulated to protect it against exposure to dust, dirt, humidity, etc.

The electronic module shall have a built-in red LED, which shall flash when the detector is, activated (Alarm). It shall allow connection of one additional remote LED to indicate the activation of the detector installed in concealed space or normally locked room at the remote easily accessible area.

The standard base shall consist of a sealing plate serve to prevent dirt, dust, condensation or water from the conduit reaching the terminals or detector contact points.

The standard base shall be supplied with a removable base cover to protect the contact area during installation stage and to allow checking and commissioning of the individual addressable loops before insertion of the detectors. The dust cover shall be removable by the extended tool up to 7 metres from the floor level.

Special base assemblies from the same manufacturer shall be available for special

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area or applications.

All individual addressable electronic modules shall be identical which allows interchange between bases. System which requires setting of the detector address either at the detector or the base will not be accepted.

All electronic circuitry contain in the base must be protected against usual electrical transients and electromagnetic interference. Reverse in polarity or faulty wiring shall not cause damage to the base electronic or the detector.

All detector's base mounted on false ceiling shall be provided with a hot-dipped galvanised iron 'knock-out' metal box complete with copper coupling and bush for proper securing of flexible conduit.

The base could be of an electronic module but must be interchangeable with all type of detectors.

All detector's base mounted on false ceiling shall be provided with a hot-dipped galvanised iron 'knock-out' metal box complete with copper coupling and bush for proper securing of flexible conduit.

The base could be of an electronic module but must be interchangeable with all type of detectors.

d. Multi Detector

The Private lift lobby Alarm Panel shall be independent of the building's Fire Alarm System. All detectors, wiring, panels, indicating lights and sounders, etc shall be dedicated to the private lift lobbies alarm system.

All private lift lobbies shall be installed with multi-detectors. On receipt of 1st alarm signal (either heat or smoke detected), the panel at guard house shall provide visual and audio alarm (including Decam light and buzzer).

On receipt of 2nd alarm signal from the same detector, the system shall send a signal to home the particular private lift being affected lobby to the homing floor.

e. Manual Call Points

Manual call points shall be break-glass type and take the form of a box containing spring loaded switch held in non alarm position by a glass cover.

The call points shall be factory painted signal red and shall be suitable for surface or flush mounting.

Manual call points shall also have the facility to allow alarm simulation without having to break the glass.

f. Alarm Bells

Alarm bells shall be provided above every call point location and as shown on the Drawings.

Alarm bells shall be 150mm diameter pressed steel finished in red, corrosion proof baked enamel.

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Alarm bells shall be UL listed.

Alarm bells shall sound a loud, clear, distinctive ringing tone operating on low voltage.

All alarm bells shall be supervised, and comply with CP 10.

g. DECAM/Alarm Modules

The Sub Contractor shall supply, install and commission at an approved Fire Station/Monitoring company an alarm receiver module of an approved type to the requirements of the Fire brigade and Telecoms.

The Sub Contractor shall make all necessary arrangements and applications with the relevant Authority and pay all fees and charges in connection with the installation of the alarm module which may be due during the specified Maintenance Period of this Sub Contract. (i.e. if DLP is 18 months, then the fees & charges for DECAM should cover standard period of minimum 2 years (24 months)).

6. SENSING CABLES

The Main Contractor shall supply, install and commission low voltage sensing cables between the main fire alarm control panel or FIB located at the FCC/Guard House and the control panels of M&E equipment as shown on the drawings, and as described as follows :-

- a. Fire Lift Control Panels.
- b. Passenger lift Control Panels.
- c. Smoke stop lobby/fire lift lobby fans.
- d. Staircase Pressurization fans.
- e. Basement Car Park Ventilation Fans.
- f. FCC Room Ventilation Fans
- g. Smoke Control Fans
- h. Fire shutters
- i. Automatic sliding doors /electrically locked doors.

All necessary cables, relays, contacts, etc. except final termination in the respective control panels by the respective M&E Main Contractors, shall be included in this Sub Contract.

All sensing cable shall be run in galvanised steel trunking or conduits.

These sensing cables shall be supervised.

7. BATTERY

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Fire Alarm System

A sealed lead acid maintenance free battery shall be provided within the Main Alarm Panel to provide secondary source of power supply to the Fire Alarm System.

The batteries shall provide 24 hour full load power to back-up the complete system under normal conditions and for 30 minutes during an alarm condition.

Calculations of usage and battery size are to be submitted by the Sub-Contractor for checking.

Fire Protection Installation Portable Fire Extinguishers

1. DESCRIPTION

This Section specifies the portable fire extinguishers which shall form part of the Works as shown on the Drawings.

Portable fire extinguishers shall be installed in accordance with the current "Code of Practice" issued by the Fire Safety & Shelter Department (FSSD), Singapore Standard Code of Practice.

2. STANDARDS

All equipment and accessories shall be of the highest commercial standard and shall be designed, constructed, rated and tested in accordance with the requirements of FSSD, PSB listing and other approval authorities. The current FSSD Singapore Standard Code of Practice lists the basic requirements, and B.S. 5423 : 1980 shall be complied with as far as applicable.

Materials shall comply with the various British Standards, listed elsewhere in this Section or other equivalent international standards.

3. EQUIPMENT

a. GENERAL

The portable fire extinguishers shall be provided in accordance with the Drawings and this Specification to approval of FSSD and PSB.

The Sub-Contractor shall ensure that equipment, etc., will not interfere with other piping or equipment.

b. CO2 FIRE EXTINGUISHERS

The body of carbon dioxide (CO₂) fire extinguishers shall be of light weight alloy and shall stand a hydrostatic that pressure of 183 bar min. and working pressure of 146 bar.

The CO₂ extinguisher shall operate in the upright position by simply squeezing the grip after removing the safety pin.

The extinguisher body shall be painted black with the following items marked or labelled on it:-

- i. Operating instructions in English.
- ii. Capacity (say, 4.6 kg, 2.3 kg, 9 kg).
- iii. The due date of annual inspection.
- iv. The types of fire suitable.
- v. Gross weight and net weight.
- vi. Manufacturer/Country of origin.

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Portable Fire Extinguishers

- vii. Local agent/Inspecting company.
- viii. Other information by the manufacturer.

c. 9.5 FOAM FIRE EXTINGUISHERS

The body of the foam fire extinguisher shall be of light weight alloy, or 1.60mm mild steel welded construction to B.S. 740 : Part 2; capable of standing a hydrostatic pressure of 28 bar and working pressure of 14 bar. Protective lining, in the form of polythene lining or otherwise, shall be applied to the interior surface of the extinguisher body to give complete protection against corrosion.

The foam fire extinguisher shall operate in the upright position by simply squeezing a grip or striking a knob after removing the safety pin.

A length of reinforced PVC hose complete with nozzle shall stem out from the extinguisher body for easy manipulation of foam throw.

A cartridge of CO₂ shall be fitted inside the fire extinguisher for expelling the foam out of the nozzle.

Sufficient fluoroprotein foam concentrate in a polythene bottle and sufficient water shall be stored inside the fire extinguisher and shall amount to 9 litre and shall form a well mixed low expansion foam when being discharged.

The foam fire extinguisher shall be painted cream with the following items marked or labelled on it:-

- i. Operating instructions in English.
- ii. Capacity (say, 9 litre).
- iii. The due date of annual inspection.
- iv. The types of fire suitable.
- v. Gross weight and nett weight.
- vi. Manufacturer/Country of origin.
- vii. Local agent/Inspecting company.
- viii. Other information by the manufacturer.

4. INSTALLATION

a. GENERAL

The Sub-Contractor shall install the portable fire extinguishers as indicated on the Drawings and to the requirements of this Specification and FSSD.

The locations shown on the Drawings are diagrammatic only, and the Sub-Contractor shall allow for relocation of any portable fire extinguishers as may be requested by the inspection officer of Singapore Fire Service or Registered Inspector.

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Portable Fire Extinguishers

b. FIXING OF FIRE EXTINGUISHER

Mounting brackets shall be provided, the mounting methods of fixing the mounting brackets shall be submitted to the Engineer for approval.

c. FINISHES

All equipment shall be painted as described in the "Insulation and Painting" Section of this Specification, unless otherwise dictated by FSSD.

Fire Protection Installation Electrical Installation

1. GENERAL

The electricity supply available will be provided and terminated in an isolator in the Pump rooms. The supply will be 400V, 3 Phase, 50 Hz. All conduits, trunking and cabling and the sub distribution equipment shall be provided by the Sub-Contractor. MICS cables shall be used for emergency power distribution purposes.

The Sub-Contractor shall supply and install the motor control panel for electrical supply to the pump equipment. All control panels, circuit breakers contactors, relays, busbars and associated wiring shall fully comply with this section.

2. ELECTRICAL WORKS

All cables, trunkings, conduits and conduit fittings necessary for the circuits shall be installed in accordance with CP5 : 1998 - Code of Practice for Electrical Installation.

All electrical work shall be carried out by Licensed electrical worker.

All socket outlets and isolators exposed to outdoor weather conditions shall be of the weatherproof type, complying with the appropriate Singapore or British Standard.

All exposed metalwork liable to become electrically charged shall be efficiently bonded and earthed complying with CP33 and CP5.

Each pump group shall have a guaranteed minimum power factor of not less than 0.85 (lagging) from half to full load conditions.

3. CONDUIT SYSTEMS

All conduits shall be heavy gauge hot-dipped galvanised longitudinally welded steel complying with B.S. 4568 : 1970, class 4 and of not less than 20mm diameter.

All conduit systems shall be installed fully in accordance with the requirements of CP5 : 1998

Surface mounted conduits shall be fixed with spacing saddles at intervals not exceeding 1.2m by means of screws and rawlplugs unless otherwise approved by the Engineer and total system shall be painted by the Sub-Contractor to match quality, finish and colour of the builder's paintwork in that area on to a colour code given by the Engineer. Conduit systems shall be electrically and mechanically continuous and watertight after installation but be arranged, wherever possible, to be self-draining to conduit outlet points for equipment. The system when installed, and before wiring, shall be kept plugged with wooden plugs and immediately before wiring, the complete system shall be thoroughly swabbed out until dry and clean.

All sets and bends in conduit runs shall be formed on site in bending machines. In surface mounted systems, inspection bends and tees may be permitted at columns, where large bends are to be avoided but approval from the Engineer shall be obtained prior to installation.

Runs 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

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cables. With conduits cross-expansion joints as indicated on the Sub-Contract Drawings, special arrangements shall be made to allow relative movement to occur on either side of the joint. A separate earth continuity conductor of a size given by CP5 : 1998 shall be installed between the boxes on either side of the expansion joint.

The Sub-Contractor shall make good any damages to the finish of all conduits, including threads cut on site, where two coats of good quality lead paint shall be applied.

Conduits, where surface mounted shall be true to vertical and horizontal alignment.

Special consideration shall be given for conduits and outlets fixed in areas where waterproofing to building shall not be damaged.

Flexible steel conduit and solid type adaptors shall comply with B.S. 731 : Part I with a separate earth wire exposed for earth continuity. In outdoor or moist areas, the pliable conduit shall be of the metallic watertight pattern, PVC oversheathed. All pliable conduits shall be of an approved type and shall only be used for final connections to equipment unless otherwise specified.

The Sub-Contractor shall submit all conceal/surface conduit runs for approval by the Engineer before installation.

4. CONDUIT BOXES

All conduit outlets boxes and junction boxes shall be malleable iron and of standard circular pattern with spout to B.S. 4568 : 1970.

Standard circular pattern boxes shall be used with conduits up to and including 25mm diameter. Rectangular pattern adaptable boxes shall be used for conduits of 32mm diameter and larger. For the draw-in of cables, standard pattern through boxes shall be used. All conduit boxes shall have a hot-dipped galvanized finish.

Adaptable boxes shall be of mild steel of not less than 2.50mm with galvanized finish. Boxes shall be not less than 50mm deep and of such dimensions as will enable the largest size of cable, for which the conduit run is suitable, to be drawn in without excessive bending of the cable. Covers of the same gauge as the base shall be provided and installed with brass fixing screws. All such boxes are to be drilled for holes according to the conduit entries required.

Socket outlet boxes shall be constructed of sheet steel with galvanized finish and shall comply with B.S. 3676 and 1363. Socket and switch boxes shall be recessed into wall and suitable for flush mounting accessories. For sockets and switches mounted on structural columns, surface mounting type outlet boxes shall be used of the iron clad type.

All conduit entries to adaptable boxes, outlet boxes and switchgear shall be made with coupling and hexagon male brass bush.

5. CABLE TRUNKING

Cable trunking shall be manufactured in minimum lengths of 1.8m from a minimum of 1.20mm hot dipped galvanized sheet steel finished with rust resisting primer and sprayed overall grey enamel. Covers shall be of the quick-fix pattern with centre captive screw or spring-on type. Any fixing arrangement employing self-tapping screws shall not be accepted. Trunking shall be terminated with end of flanges; which can and shall be bolted

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direct to distribution boards or other apparatus. Connecting pieces shall be used to connect together runs of trunking and shall employ special connecting pieces using cadmium plated mushroom head steel screws, nuts and shakeproof washers to give the trunking run connector rise. Each joint shall have a copper bond bolted to each adjacent trunking to ensure electrical continuity. All frayed and sharp edges shall be removed from trunking before installation and control to prevent rust forming.

Conduit entry to trunking shall be by coupling and male bush. Knockouts shall not be provided, and trunking shall be drilled on site.

In instances where the Sub-Contractor elects to use trunking to avoid a multiplicity of conduits following the same run, cables shall be installed so that a space factor of 40% is not exceeding and grouping factors as defined in CP5 : 1998.

The trunking system shall be erected complete and thoroughly cleaned out before any cables are drawn in.

Where trunking crosses expansion joints, a trunking system shall be used which will allow for expansion and maintain earth continuity. The system used shall be approved by the Engineer prior to it being used.

Where trunking is turned through on angle exceeding 45°, mitred corner pieces shall be used to form a slow bend for cables.

All cables within the trunking shall be bunched and cleated in to separate circuits and/or cables running to a common point of supply at intervals of 3m for horizontal runs and 1m for vertical runs. In addition, vertical runs of cables shall have therein weight supported by clips or cleats fixed to wooden blocks or steel pins fixed inside the trunking at intervals not greater than 3m.

All horizontal runs of trunking shall be fitted with cable retention straps to prevent cables dropping down from the trunking when additional wiring is being installed from the side or bottom of the enclosure.

6. CABLES

The Sub-Contractor shall include for the supply, installation, testing and commissioning of all cables and accessories as specified herein .

All cables shall be manufactured to the appropriate British Standards Specification.

All PVC shall be flame-retardant.

The current carrying capacity shall be in accordance with CP5 : 1998 Electrical Installation with rating adjusted to suit local conditions.

a. PVC INSULATED CABLES

All PVC insulated cables shall consist of annealed copper conductor complying with SS50 : 1981. The rated voltage of the PVC cables shall be 450/750 Volts.

Cables shall be rated in accordance with CP5 : 1998 Electrical Installation. Minimum cable size shall be 1.5mm² for small power or control circuits.

Neutral conductors shall have black insulation and live or phase conductors, red

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insulation with phase identification sleeves at each termination.

All cables shall pass SISIR type tests and batch tests or approved under SISIR quality certification scheme and have PUB's approval.

PVC insulated cores shall be sheathed with flame retardant PVC which shall serve as a bedding for galvanized single steel wire armouring. The armouring shall be covered with an outer flame retardant PVC sheath.

The Sub-Contractor shall include for provision, installation, testing and commissioning of all cables, conduits, trays, trunking and accessories specified herein.

Cables shall be enclosed in conduit or trunking in accordance with CP5 : 1998 Electrical Installation for capacities of conduits and space factor for capacities of trunking.

All wiring shall be carried out on the loop-in system and the wires drawn into the conduits after the whole of the installation has been completed.

Joints or connectors shall not be installed in wiring cables.

Exposed ends of conductors of 6mm² and above not filled with sockets shall be sweated solid for connection to clamp terminals.

b. FLEXIBLE CORDS

Flexible cords shall be multi-stranded copper conductors, high temperature, PVC insulated with flame retardant white circular PVC sheath 300V/500V grade to B.S. 6500.

Minimum size of conductor shall be 1.5mm² (30/0.25mm²)

c. PVC INSULATED ARMOURED CABLES

PVC insulated, PVC sheathed, Steel Wire armoured, PVC sheathed cables (PVC/SWA/PVC) shall be to B.S. 6346 : 1969, 600V/1000V grade with stranded, shaped, copper conductor cores of equal cross section and colour coded insulation.

d. ARMOURED CABLES

The Sub-Contractor shall provide all the necessary sleeves, glands, shrouds, end boxes, clamps, compounds specialist tools, etc., necessary to install and make off the cables in accordance with good Engineering practice and as hereunder specified.

All cables shall be provided with identification labels at each end and at all positions where cables change direction. In instances where cables are multiple at 10m intervals. Labels shall be manufactured from metal disc engraved to show the size of the cable phase and the equipment being fed.

Where multicore cables are for indication, protection and control applications, each core shall have an identification number and engraved ferrules over the cable tails.

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The ferrules shall be numbered to correspond to a wiring diagram agreed by the Engineer. All wires shall be terminated with an acceptable type of clamp connector. Pinching screw type connectors shall not be acceptable.

All cables shall be installed in accordance with the CP5 : 1998- Electrical Installation, the cables being run between their source and termination points installed on cable trays, in ducts, clipped to ceilings and wall.

Cables shall in general be supported by perforated cable trays. This tray shall be not less than 2mm mild steel, galvanized finish, and with returned edges. It shall be supported from the rib of structural slab, beams, etc, by mild steel rods, galvanized, and not less than 15mm in diameter, with underslung steel angle supports. Sample of the supporting bracket shall be submitted for comment.

The tray design and strength and/or the tray supports shall be spaced at such intervals to ensure that tray sag shall be not more than 1/500. Corrective measures shall be carried out to the Engineer's satisfaction.

Cables run horizontally, shall be properly supported on perforated cable trays and cleated at intervals of not exceeding 2m directly to the tray. Where cables are installed vertically, they shall be cleated at distances not exceeding 1m. When cables are run in other exposed areas, they shall be protected with metal trunking. The cable tray and metal trunking shall be supported with rigid metal brackets.

Where cables are clipped to wall or ceilings, they shall be secured by means of spacer saddles at centres as recommended by I.E.E. Table 11A and not exceeding the bend radii given in Table 52C. The spacer saddles shall be of the hot dip galvanized steel deep spacer type fixed to the surface by means of "rawlplugs" or other equal manner. Each cable shall be fixed by a saddle at each point and fixed to its base by two cadmium plated fixing screws.

e. M.I.C.S. CABLES

The Sub-Contractor shall be responsible for the off loading and handling of the cables on site and shall ensure that cables are delivered to site on drums and properly protected against mechanical damage.

Cables shall be installed within cable ducts and draw pit systems by means of normal hand running off the cable drum. It shall enter the draw pit protected by roller guides and be drawn through by hand. Cable winches shall not be employed.

Unless agreed by the Engineer straight through joints in cables shall not be allowed.

The minimum bending radius shall be not less than eight times the overall cables diameter or manufacturer recommendation which ever carger.

Unless otherwise specified, all cable ducts and draw pits shall be provided by the Contractor.

Mineral insulated copper sheathed cables (M.I.C.S) shall be provided with a flame retardant PVC sheath and shall be installed in accordance with the requirements of the CP5 : 1998 Electrical Installation.

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The current-carrying capacity of these cables shall be in accordance with and limited to the volt drop specified.

All M.I.C.S. cables and cable accessories, glands, etc., shall be 1000V grade to B.S. 6207 suitable for heavy duty industrial applications. All M.I.C.S. cable fittings and accessories shall be manufactured by the appropriate cable manufacturer and only make of cable shall be used.

Cables shall be sealed immediately after cutting. All cables shall give a minimum of 10 megohm when tested on a 1000V D.C. megger immediately and 48 hours after sealing. The Engineer reserves the right to test all cables during installation and up to the end of the maintenance period. Any cables not giving a satisfactory insulation level shall be resealed or if considered necessary by the Engineer, replaced by the Sub-Contractor to obtain a satisfactory test reading.

Cables terminations at distribution boards, switchgear and apparatus generally shall be made by means of cold screw-on pot type seals with ring type universal glands. Brass locknuts with serrated washers shall be used where cables terminate at apparatus not provided with screwed entry. For termination of single core cables to equipment, a piece of non-ferrous plate shall be provided. Screw on cable lugs shall be provided for the cable connections to equipment.

Through joints, if required, shall be of brass sleeve type. The sleeve shall be internally threaded at each end to receive a ring type universal gland, fitted to each of the cable ends. An ebonite spreader shall be used within the sleeve to hold the cores in position. Solder type connections shall be used on all cables up to and including 16mm². Above this size, mechanical type connections shall be used.

All joints shall be of acceptable manufacture and carried out fully in accordance with manufacturer's installation recommendations.

All terminations and seals shall be made in accordance with agreed methods, care being taken to exclude moisture and foreign matter, compound used in the making of seals shall be capable of withstanding a temperature of 1500C with plastic sleeving to copper cores.

Where M.I.C.S. cables are installed during building construction, and may be liable to mechanical damage, they shall be provided with adequate temporary protection in the form of sheet steel troughs or by other acceptable method. Damage cables not so protected shall be replaced by the Sub-Contractor at his own cost.

Where M.I.C.S. cables pass through walls, they shall be protected with a piece of conduit bushed at each end and built into the wall.

MICS cables fixed directly to the structures, shall be provided with copper spacer clips for multiple runs (up to four cables) fixed directly to the structure. Brass round head screws of minimum length of 25mm employing rawplugs shall be provided as necessary. Copper spacer clips securing single cables shall be of one fixing screw pattern. Two screw patterns shall be used for multiple cable runs. Spacing of cable fixing shall be to manufacturer's recommendations and CP5 : 1998 whichever is the smaller.

All cables shall be routed entirely separate from pipework associated with other services. Where M.I.C.S. cables pass through floors, they shall be protected for a

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distance of not less than 300mm from floor level with galvanized metal sleeves secured with clamp type saddles.

Where three phase power is run in M.I.C.S. single cores, the cables shall be installed in a manner to prevent unnecessary heating up of the sheaths which will involve an installation in trefoil formation of the three phases R.Y.B. or grouped in a double layer for a 4-wire 3 phase system and spaced from other conductors. Alternatively, they may be arranged in single layer, flat formation, touching throughout their length or if the Sub-Contractor so wishes may be ordered from the Supplier already laid up in trefoil twisted formation.

M.I.C.S. cables connecting L.V. switched inductive loads shall be protected from voltage surges by surge suppressors at the conductors terminations.

7. CABLE BUSHINGS, TRANSITS FIRE STOPPING

In certain places, where cables pass through floors, walls or other partitions, bushing of an acceptable type shall be supplied and set in position by the Sub-Contractor; where necessary, split bushings may be used for convenience in running out cables. After running and cleating the cables, the bushing must be thoroughly grouted in or otherwise securely fixed in position.

8. WIRING ACCESSORIES

Where cables pass through interior walls or floors of the building, all openings and spaces remaining after installation shall be sealed by a fire resisting and stopping system, approved by the Fire Service Bureau, which has no deleterious effect on the Cable Sheathing and which remains easy to remove after installation to allow for future alterations.

The Sub-Contractor shall supply and install the wiring accessories, including lighting switches, switches for electrical appliances, fused spur units, etc., which form part of the Works.

All wiring accessories shall fully comply with this Section.

All wiring accessories shall comply with the appropriate Singapore or British Standard.

All wiring accessories shall comply with the Singapore or British Standard 3000. Wiring Regulations, Elcom requirements and local Fire Services Department 's requirements.

Fused spur units for the control of single phase supplies to fixed equipment shall be provided with separate outlet box allowing final connection of flexible conduits.

Indicating switches shall be 20A, double pole, flush mounted, all insulated, white colour, with noon pilot lamps, confirming to B.S. 3676.

Proper words shall be engraved on the cover plate to designate the equipment served. Mounting height shall be 1350mm above finish floor level, unless otherwise specified.

9. INSTALLATION

The Sub-Contractor shall supply labour and materials to install the wiring accessories

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specified in the Technical Specification.

10. TESTING

a. Verification of Polarity:

To ensure that all fuses and single pole control devices are connected in the live" conductor only, and that wiring has been correctly connected to the socket outlet terminals.

b. Test of Continuity of Protective Conductor:-

To be tested with alternating current in accordance with Item 3 of Appendix 15 of the CP5 : 1998- Electrical Installation.

c. Tests of Effectiveness of Earthing:

To be made with loop-impedance test in accordance with Item 5 of Appendix 5 of the CP5 : 1998.

d. Insulation Resistance Test for all power and control cables :

The testing method and values shall e in accordance with Regulations 613.6L, 613.7, 613.8 of CP5 : 1998

Fire Protection Installation Sound and Vibration Control

1. GENERAL

a. DESCRIPTION

This Section specifies the supply, delivery, installation and testing of noise and vibration control equipment which shall form part of the Works as shown on the Drawings.

b. MANUFACTURE

All vibration and sound isolation equipment shall be supplied by manufacturers experienced in the design and construction of similar equipment and who have made equipment and materials for similar duties for at least five years.

All materials and equipment for the vibration isolation of any system within this project shall be wholly imported.

c. SELECTION

The Sub-Contractor shall install all mechanical plant and services in accordance with the methods of installation and precautions stated herein, and such additional precautions as may be necessary to ensure that the operation of the plant does not result in noise levels or vibration amplitudes beyond the specified limits.

The Sub-Contractor shall examine all drawings and specifications including Engineerural and structural before commencing any work on the project and shall immediately bring to the Engineer's attention any characteristics or properties of the building or any factors which in his opinion would jeopardize or nullify the attainment of the design objective.

The Sub-Contractor shall guarantee that the complete plant and installation when operated within the design criteria shall acoustically perform to the noise criteria ratings specified in this Section.

The Sub-Contractor shall be responsible for any corrective action which may be necessary either during construction or after completion of the Works to achieve all design objectives.

In selecting all anti vibration devices the Sub-Contractor must make due allowance for the static and dynamic defections which may occur in the building structure due to plant and equipment loadings.

d. STANDARDS

Materials shall comply with the appropriate British Standards. All vibration isolators shall be of the highest commercial standard and shall be rated and tested in accordance with an independent testing authority.

2. EQUIPMENT

a. SPRING ISOLATORS

The following summarizes the type and nature of the noise and vibration control techniques and equipment to be used in the isolation of various mechanical equipment.

Fire Protection Installation Sound and Vibration Control

Unless specified otherwise, spring type isolator shall be unhoused, free-standing laterally stable with levelling bolts rigidly bolted to inertia blocks/base frames. In general, diameter shall be comparable with compressed height and shall not be less than 0.75mm of compressed height at rated load, and horizontal spring stiffness shall be approximately equal to vertical stiffness.

Spring shall have a minimum additional travel to solid equal to 50% of rated deflection, and in this condition, shall not exceed elastic limit of spring.

All springs shall be mounted with adequate clearance from brackets and shall be clearly in view for critical inspection.

Where restrained mounts are specified, a housing shall be used that included vertical limit stops. A minimum clearance of 10mm shall be maintained around the restraining bolts and between the housing and spring so as not to interfere with spring action. Limit stops shall be out of contact during normal operations. Mounts used outdoors shall be of all stainless steel construction.

b. INERTIA BLOCKS

For all pumps other than pipeline mounted pumps, the Sub-Contractor shall install inertia blocks. The mechanical equipment shall be bolted directly on to the integral concrete inertia blocks.

In general, the length and width of the inertia block should be at least 50% greater than the length and width of the supporting equipment, except where otherwise specified. The depth of the inertia block shall be not less than 150mm.

The weight of the inertia block shall be as indicated in the schedule.

The base shall consist of a concrete slab cast into a welded steel base frame assembly. Frames shall be welded steel channels, of minimum 150mm thickness or the same thickness as the inertia block and shall be reinforced with weld-in 12mm steel reinforcing rods or angles at 150mm centre each way. Anchor bolts shall be fixed into position, and housed in steel bolt sleeves to allow minor bolt location adjustments, or alternatively, pockets shall be cast into inertia block to permit the later insertion of anchor bolts. A suitable base former of minimum 10mm plywood or equivalent shall be included for forming the slab. Steel channel isolator brackets shall be welded directly to channel frames, and suitably located to accommodate the height of the deflected springs and inertia block clearance with plinth.

There shall be adequate clearance (minimum 20mm) all round the springs to assure that there is no contact between any spring and any part of the mounted assembly for any possible alignment or position of the installed inertia block. The clearance between inertia blocks and floor/plinth shall be at least 75mm.

The Sub-Contractor shall ensure that all pumps are mounted at least 30mm clear of the inertia base/floor to allow the base plate to be shimmed true and level. The base shall then be grouted into position using mortar (1:2 mixed) or an epoxy grout.

The Sub-Contractor shall supply and install all welded structural steel and reinforcement required for the inertia blocks in addition to the concrete infill.

c. NEOPRENE PADS

Fire Protection Installation

Sound and Vibration Control

Ribbed or waffle pattern neoprene pads are to be used where specified. They shall be between 8mm and 9.50mm thick 40 durometer pads.

For typical applications, 40 durometer type neoprene pads should be loaded to a surface weight of approximately 35,000 kg/m².

Two layers of Neoprene pad shall be placed crossed ribbed to form an isolating barrier between the tanks and the primary and secondary support beams.

Where two or more layers of neoprene pads are used, individual layers shall be separated by 1mm of steel shim.

d. RESILIENT HANGERS

Resilient hangers are to be used for resilient suspension of pipes and ducts, where specified.

For specified deflections in excess of 12mm, springs shall be used in series with neoprene pads, and for deflections less than 12mm, neoprene shall be used in shear type hangers.

During installation, inspection shall be made to ensure that no hangers are compressed solid or bridged out, and that the stipulated minimum deflections are achieved.

Neoprene-in-shear isolators shall be of the double deflection type.

The isolators shall incorporate cast-in tapped steel loads plates to permit direct bolting to supported equipment. Cast-in drilled base plates shall also be incorporated for direct mounting to plinths.

The isolators shall be selected to achieve the minimum deflections specified, without exceeding the manufacturer's published maximum permissible loadings.

e. PUMP MOUNTS

All pumps shall be selected for the highest efficiency consistent with the specified duty and pump impeller diameter capability of the pump housing to reduce the possibility of tonal effects.

Pump impellers, shafts, and drive couplings shall be statically and dynamically balanced to B.S. 4675 : Part 1, Quality B. The peak amplitudes shall be measured on the machine structure with the pump/motors mounted on the bases as specified.

The pump and motor assembly where specified shall be mounted on concrete filled inertia blocks and completely isolated from the structure. Pump inertia blocks shall be sized to support the weight of elbows, valves and other fittings without creating undue stress on the pump assembly.

Pumps shall be connected to the pipework system using flexible connectors. These shall be double sphere neoprene flexible couplings with a minimum burst pressure rating of 57.5 bar. The flexible connectors shall be anchored on each size to secretly align pipework, connectors and pumps.

f. PIPEWORK

Fire Protection Installation

Sound and Vibration Control

The first three hangers/supports from all mechanical equipment shall be isolated using springs in series with neoprene type pads.

Each of these support shall have a minimum of 50% of the static deflection value of the set of pump spring isolators. The remaining hangers shall have a minimum of 25% the static deflection value of the set of pump spring isolators.

All pipe penetrations through wall, floors and ceiling shall be isolated from direct contact with the surface, with a fibreglass isolated sleeve caulked with a non-setting non-combustible resilient compound on both sides of the penetration.

3. INSTALLATION

a. GENERAL

The Sub-Contractor's attention is drawn to the following principal precautions which shall be taken in order to ensure that the minimum noise and vibration emanates from the plant installed under this Sub-Contract.

All rotating machinery shall be accurately balanced, statically and dynamically. Centrifugal pumps shall be mounted on vibration absorbing mountings as detailed in this Specification.

All equipment, piping, etc., shall be mounted on/or suspended from approved foundations and supports, as detailed in this Specification, or as shown on the Drawings.

All floor-mounted equipment shall be erected on 150mm high (minimum) concrete pads over the complete floor area of the equipment unless specified to the contrary.

Mounting sizes shall be determined by the mountings shall be installed in accordance with the manufacturer's instructions.

Mounting systems exposed to corrosive environments shall be protected against corrosion.

All mountings shall be accurately adjusted to ensure proper levelling.

Where vibration isolators are used for outdoor equipment, they shall be corrosion resistant and all the fixing bolts and nuts shall be stainless steel.

Painting shall be as described in the "Insulation and Painting" Section of this Specification.

b. IDENTIFICATION

All vibration isolators shall bear the manufacturer's nameplate giving manufacturer's name, serial and model number and date of manufacturer.

4. TESTING

On completion of the installation, the Sub-Contractor shall carry out sound and vibration measurement on all moving equipment and submit their results to the Engineer.

Should the tests show that noise or vibration is in excess of that specified, or that

Fire Protection Installation

Sound and Vibration Control

balancing of equipment is incorrect, or that vibration transmission through mountings, hangers, etc., is excessive, the Sub-Contractor shall correct the installation at his own cost. Further tests shall then be carried out at the Sub-Contractor's cost to show that the noise and vibration level had been reduced to the limit specified.

Sound level reading shall be taken at times when the building is unoccupied or when activities in the surrounding areas and background noise level in areas tested are at a minimum and relatively free from sudden changes. Reading shall be taken with no other equipment operating and with all plant, capable of transmitting sound to the space tested in operation.

All apparatus used for sound and vibration measurements shall be provided by the Sub-Contractor and of a type agreed with the Engineer.

Fire Protection Installation Insulation and Painting

1. GENERAL

a. DESCRIPTION

This Section specifies the thermal insulation, painting and other finishes of all plant and materials shown on the Drawings and provided as part of Works.

b. MANUFACTURE

All materials supplied of the same type shall be supplied by a single manufacturer to ensure uniformity of standards and appearance.

All materials delivered to site shall be new, and where appropriate, colour coded and labelled at the factory to identify different grades, sizes and types.

c. SELECTION

The Sub-Contractor shall select all insulating, finishing and painting materials from types suitable for the surfaces to which they are applied and for the environmental conditions in each area.

No asbestos based insulation shall be used.

d. STANDARDS

All materials and techniques used shall be of the highest commercial standard and shall comply with British Standards where applicable in particular with regard to definition, physical characteristics and tests for thickness.

All equipment and materials used shall be fire resistant and shall comply with the requirements of the Fire Safety Bureau.

Insulation shall comply with provisions of B.S. 1334 and B.S. 5422 as appropriate.

Pipework insulation shall generally comply with British Standard Code of Practice C.P. 3005 or B.S. 5970.

2. EQUIPMENT

a. INSULATION OF SUPPORTS

Drainage piping for condensing water shall be insulated free from its hangers and support.

At the point of pipework support high compressibility phenolic foam shall be employed with the vapour barrier carried over this. The use of hardwood blocks shall not be permitted.

b. LABELLING AND IDENTIFICATION

All piping, plant and equipment provided under the Sub-Contract is to be labelled in English as to duty or services. All such labelling shall correspond to schedules, diagrams, etc., as specified in the individual Sections of this Specification and on

Fire Protection Installation Insulation and Painting

the Drawings.

Labels shall be as specified in the "Miscellaneous Provisions" Section of this Specification.

All pipework (whether insulated or not) shall have identification discs/bands, generally as B.S. 1710 : 1975, Appendix D, Optional Colour Code Indications for General Building Services. These indications are generally as shown on Table 11B.5.3 together with additional services and colour codes not specifically listed in B.S. 1710 : 1975.

Table A lists the B.S. colour reference, based on B.S. 4800 for all colour codes listed.

Colour banding shall be provided at intervals not exceeding 5m and wherever necessary at bends, tees, etc., and where pipes pass from one room or zone to another. Where two or more pipes run in parallel, then the colour banding for each pipe shall be at the same locations.

Colours not covered by this Specification must be agreed with the Engineer before work commences on site.

At intervals agreed with the Engineer on straight pipes and adjacent to valves and tees, coloured arrows are to be stencilled to the pipework to indicate direction of flow. In addition, the pipe mains are to be painted using stencils to indicate the circuit system. Where the finish is unpainted, metal bands and discs are to be fitted for the colour identification specified above.

The Sub-Contractor shall supply all necessary identifying items, paint, bands, stencils, etc., to comply with this Section. The whole to be agreed with the Engineer during the progress of the Works.

c. VALVE SCHEDULES

All valves including control valves shall be equipped with labels constructed and fitted in accordance with the "Miscellaneous" Section of this Specification. These labels shall state the valve number.

A complete valve schedule shall be incorporated in the as-built drawings by the Sub-Contractor and this Schedule shall clearly indicate the valve number, duty, function, size, flow rate and any other relevant information necessary to allow the plant operators to safely operate each valve and to subsequently maintain or replace the valve as required.

The valve schedule shall clearly relate to the various system schematics to enable the entire operating sequence and circuitry to be followed.

Within each plantroom, a full systems schematic for that plant room, together with a complete valve schedule for the systems within the plant room, shall be provided and mounted on a rigid base with a glass or perspex cover.

d. EXTENT OF PAINTING

Fire Protection Installation Insulation and Painting

All plant, materials and equipment forming part of the Works are required to be painted as specified in this Section, with the sole exception of items specifically excluded in this Specification.

Items which do not require to be painted shall include:

- i. Copper pipework and fittings; (except where specifically stated).
- ii. Materials with a factory applied anodized, baked enamel or painted finish, provided that the colours are selected by the Engineer prior to application.
- iii. Insulated pipework concealed within duct shafts or false ceilings.

The requirement for painting of all pipework and ductwork is in addition to the colour coding or banding specified in this Section.

e. FACTORY PAINTING

All factory assembled plant or equipment shall be factory painted in accordance with the manufacturers' normal practice and to a standard suitable for the duty and location of the plant. The colour of the finishes shall be selected by the Engineer.

Where factory applied finishes are used, the Sub-Contractor must obtain from the plant manufacturers touch-up paint kits and detailed instructions for making good after completion any damage to finishes which may occur during transportation, storage, installation or commissioning.

f. SITE PAINTING

All plant and materials requiring to be painted on site shall generally be painted with one coat of a primer, one coat of an undercoat and two coats of an high gloss finishing coat. The paint and workmanship shall be of the highest quality and standard.

g. PAINTING

Prior to painting, all metallic surfaces except galvanized surface shall be thoroughly scraped and wire brushed as necessary to remove scale, rust and swarf. Surfaces shall then be solvent cleaned to remove all oil, grease and dirt.

When the surfaces to be painted are clean and dry, one coat of primer shall be evenly applied over the entire area. After surfaces have been primed, the Sub-Contractor shall notify the Engineers so that an inspection of the primed surfaces can be made prior to the application of the finishing coats.

When the priming coat has been applied, one coat of a flat undercoat shall be applied. Before applying the finishing coats, the Sub-Contractor shall ensure that the undercoated surface is rubbed flat and smooth. Finally, two coats of an approved high gloss finishing coat shall be applied when all dust has been removed.

Each successive coating shall be completely dry prior to the application of the next coat.

Fire Protection Installation Insulation and Painting

All surfaces shall be suitably protected during painting to prevent dust and other impurities entering the paint or adhering to the painted surface. "Wet Paint" signs shall be prominently displayed and protective barriers shall be provided where necessary.

All paints shall be prepared and applied in accordance with the manufacturers' recommendations.

All galvanized metal surfaces shall be properly etch-primed to ensure correct adhesion of the paint to the surface. Materials for etch-priming shall be as recommended by the paint manufacturers. Subsequent painting of galvanized surfaces shall comply with this Specification.

h. INSULATION

Wherever the drainage system receives condensate for the air conditioning systems e.g. all plant/AHU room floor drains, then the Contractor shall insulate the first 2 metres of the drain by means of 50mm thick 64Kg/m³ preformed fibreglass sections of K value 0.0335 W/m²K.

Fire Protection Installation Insulation and Painting

Table A	
Reference Colours for Coding Purposes (Based on B.S. 4800)	
Colour	Colour Reference
Green	12 D 45
Silver-grey	10 A 03
Brown	06 C 39
Yellow ochre	08 C 35
Violet	22 C 37
Light Blue	20 E 51
Black	Black
Orange	06 E 51
Crimson	04 D 45
Emerald green	14 C 53
Salmon Pink	04 C 43
Yellow	10 E 53
Red	04 E 53
Yellow	08 E 51
Auxiliary Blue	18 E 53

Fire Protection Installation Testing and Commissioning

1. GENERAL

In addition to all commissioning and testing called for elsewhere in this Specification, the Contractor shall carry out all necessary testing and commissioning procedures comprising tests at maker's works, site tests during construction, commissioning and acceptance tests all as specified below. Tests shall also include inspections/tests by Registered Inspectors, FSSD and BCA.

Tests shall be carried out in accordance with the Employer's Insurance Company requirements where applicable, the appropriate British Standards or B.S. Code of Practice the relevant I.E.E. Regulations for Electrical Installation, 15th Edition and in particular to FSSD's requirements.

All tests may be witnessed by the Engineer, and in the case of pressure tests at the manufacturer's works, by the insurers or other parties nominated by the Employer. Not less than fourteen days' notice shall be given by the Sub-Contractor for this purpose.

All tests shall be properly certified in a manner to be agreed with the Engineer and triplicate copies of all certificates shall be issued to the Engineer on completion.

These test records, certificates and performance data shall be supplied for all tests, whether or not they have been witnessed by the Engineer. The information given on such test certificates and services shall be sufficient to identify the material or equipment to which the certificate refers, and shall also bear the Sub-Contract reference and heading given in equipment sections.

Only when the installations have been so certified and all test figures and other relevant information has been recorded in the prescribed manner and accepted by the Engineer should the works be considered fit for handing over to the Employer.

The Sub-Contractor shall include in his tender all costs associated with the above-mentioned testing and commissioning procedures including the cost of making good any defects arising out of such tests and having the work retested. Such costs shall also include the provision of all instruments necessary for the test.

The Sub-Contractor shall provide skilled technicians/ engineers to commission the plant and associated controls to the satisfaction of the engineers. The technicians and engineers will be required to demonstrate the correct procedures in the starting, and stopping the plant, running the various items of equipment under automatic and manual control and the correct maintenance of the plant. Water flow rates of all equipment shall be adjusted to design conditions. Complete result of adjustments shall be recorded and submitted.

Three months before commissioning or testing any of the installations, the Sub-Contractor shall produce and circulate to the Engineer for comment a comprehensive commissioning procedure. This document shall outline all steps to be taken by the Sub-Contractor in testing commissioning and setting to work the installations. Details of each instrument to be employed are to be provided.

2. TESTS AT MAKER'S WORKS

Manufacturer's works test shall include all routine electrical and mechanical tests in accordance with the relevant British Standards, and in addition, any tests called for by the Engineer to ensure that the plant being supplied meets the requirements of the

Fire Protection Installation Testing and Commissioning

Specification. For plant not covered by any British Standards or specifically mentioned in this Specification, the tests shall be agreed with Engineer.

All items of equipment of each type and rating supplied under this Sub-Contract shall be subjected to type tests of electrical and mechanical performance as appropriate and as specified in the relevant British Standards or equal. In the event of the Sub-Contractor supplying certified copies of type test certificates covering equipment of similar design, rating and construction, the Engineer may waive such tests entirely. The prices given in the Form of Tender shall include for the carrying out of such tests where certificates are not already held.

3. FIRE FIGHTING SYSTEM

a. DESCRIPTION

This Section describes the tests and inspection, etc., required for the Fire Fighting System.

The Sub-Contractor shall test the system to the satisfaction of the Engineer and the FSSD and the PUB (Water Dept.) and other authorities.

b. FILLING OF INSTALLATION

All parts of the water circuit shall be filled with water before hydrostatic pressure testing, and pump running tests for verification of pressure and flow rate, are conducted.

c. HYDROSTATIC TEST

Before performing the hydrostatic test, the following system component status shall be fulfilled:-

i. Sprinkler System

1. All the main stop valves and subsidiary stop valves shall be open or closed in order to provide isolated watertight sections for hydrostatic pressure testing.
2. The pressure switches shall be isolated by the relevant valves or cocks.
3. The test and drain valves shall be closed.
4. The sprinkler inlet isolating valve shall be closed.
5. The gate valve below the 3mm orifice of the water columning prevention devices shall be closed.

ii. Hosereel System

6. All hosereel isolating gate valves shall be closed.
7. All hosereel nozzles shall be open.

Fire Protection Installation Testing and Commissioning

8. The pump isolating valves shall be open.

A hand jacking pump shall be applied to increase the system pressure to the Testing pressure as specified in the "Sprinkler System" Section for particular section of pipework and equipment which shall remain practically unchanged for six hours, as read from the gauge, without any further application of the jacking pump during this period.

The hydrostatic test shall be performed prior to the system running.

d. SYSTEM RUNNING TEST

The system shall be tested to confirm that the pressure and flow rate, and the throw of water from a standard branch pipe and 30m hose line fitted to each hosereel nozzle will conform to FSSD requirements, prior to the actual FSSD inspection.

All hosereel isolating valves and all hose nozzle on/off valves shall be lubricated.

Starting of pumps shall be loosening the glass cover rather than by breaking glass.

The hydraulically remote hosereel nozzles shall be tested for a throw of jet not less than 6m when the hose is arranged to be squeezed by the self-closing doors it has to pass through, i.e. when the doors are not kept open intentionally.

The same throw requirement shall be satisfied for the hydraulically nearest hosereel nozzles.

Pump cut-in and cut-out, pump lead-lag test, tests for water level high level, low level alarms, etc., shall be integrated into the system running test as far as possible.

Sprinkler System

The system shall be tested to confirm that the pressure and flow rate and control scheme conform to CP 52 requirements, prior to FSSD inspection.

The start and stop of each jockey pump and start of each main pump shall be tested by opening/closing of the test and drain valve stemming from the installation valve.

The water flow rate and pressure for each installation shall be tested by using the proving of water test equipment (i.e. pressure gauges and appropriate orifice plate) according to CP 52 rules. At the same time, the water motor gong shall sound properly. During the test, the main duty pump shall be in fully operation within 30 seconds, and for the standby pump, if required, within 45 seconds.

The end-of-pipe test valve at the hydraulically remotest end of the system shall be opened for testing the flow switch.

Other end-of-pipe test valve shall be selected by the Engineer at his discretion for flow switch alarm testing with the simultaneous purpose of testing the pressure switches.

Each set of pressure switches shall be tested by opening end-of-pipe test valves for starting of jockey pumps, sprinkler main pumps.

4. ELECTRICAL INSTALLATION

Fire Protection Installation Testing and Commissioning

The Sub-Contractor shall ensure that all equipment included under this Sub-Contract is thoroughly cleaned and checked for serviceability immediately before commissioning. Particular attention is drawn to the removal of building debris from plantrooms prior to carrying out any commissioning checks.

In addition to any electrical tests demanded elsewhere in this Specification, the following tests for the electrical systems shall be carried out (but not by way of limitation). The precise method of carrying out all tests shall first be agreed with the Engineer and shall include all test required by the authorities.

L.V. Installation

a. Verification of Polarity

To ensure that all fuses and single-pole control devices are connected in the "live" conductor only, and that wiring has been correctly connected to the socket-out terminals.

b. Test of Earth Continuity Conductors

c. Test of Effectiveness of Earthing

d. Insulation Resistance Tests

e. Switchboards

On site testing shall include, but not be limited to, the following :-

- i. Mechanical tests including checking of all mechanical and electrical connections, interlocks, etc..
- ii. High voltage injection and insulation tests.
- iii. Testing of protection devices by primary injection.
- iv. Functional checks of all control circuits.
- v. Calibration of metering equipment, C.T., etc..
- vi. Any other tests as recommended by manufacturer.

5. PIPEWORK

The Sub-Contractor shall ensure to the satisfaction of the Engineer that the installation complies with all requirements including the following clauses.

a. Cleaning and Flushing

The Sub-Contractor shall clean the entire installation after installation and keep them in a new condition.

All pipes, etc. shall be flushed through with water, rodded when necessary to ensure clearance of debris.

Cleaning and flushing shall be carried out in sections as the installation becomes

Fire Protection Installation Testing and Commissioning

completed.

b. Hydraulic Testing

The Sub-Contractor shall carry out hydraulic test on the complete fire protection systems to show that it is functioning satisfactorily within the requirements of this Specification and the Singapore Government Regulations (all departments).

The Sub-Contractor shall provide suitable test pumps and arrange for a supply of water required in connection with testing of pipework. The test pump shall be fitted with pressure gauges which shall be of suitable range for the pressure being applied.

Hydraulic tests shall be carried out as the pipework is installed and shall be completed before chases in walls and ducts are closed. Also test shall be carried out prior to false ceilings and other finishes are installed.

6. AUTOMATIC FIRE DETECTION AND ALARM SYSTEM

a. DESCRIPTION

This Section describes the tests and inspections, etc., required for the Fire Detection and Alarm System.

The Sub-Contractor shall in conjunction with the BAS/Fire Alarm Sub Contractor, jointly test the system to the satisfaction of the Engineer and the FSSD. Should tests and inspection be required by PUB (Electrical) or other authorities, the Sub-contractor shall make all necessary arrangements.

Tests shall comply with SS CP10 and FSSD requirements for Automatic Fire Detection and Alarm System Installation.

A 500V instrument shall be used to check the insulation resistance. The test reading shall be 1 megohm in all instances.

b. DRY RISER AND HOSEREEL SYSTEM

Pump control tests for the HR System at the pump motor control panel shall be integrated with other relevant test requirements for the HR System in this Specification, including the pedestal.

c. SPRINKLER SYSTEM

Test for operation of flow switch/pressure switch alarm of the installation valve of the sprinkler system and pump status signal, etc., shall be integrated with other test requirements in the Sprinkler System as called for in other Sections of this Specification.

d. BELLS/GONGS

Bells shall be adjusted and tested such that every corner of the building shall be suitably alarmed by the bells.

e. FAULT SIMULATION TEST

Fire Protection Installation Testing and Commissioning

As the DC circuitry is monitored, simulation tests shall be performed for all possible fault conditions.

f. **TEST FOR BATTERY CHARGER**

Battery charger tests, battery inspection, etc., shall be performed.

7. THE ENGINEERS ACCEPTANCE TEST & FSSD INSPECTION

a. **FSSD INSPECTION**

The Sub-Contractor shall allow for any test that the FSSD officer and/or Registered Inspector may require.

b. **THE ENGINEER'S ACCEPTANCE TEST**

After the final FSSD inspection for the application of the occupation permit, the Sub-Contractor shall perform the Engineer's Acceptance Test to the satisfaction of the Engineer.

This test shall cover any, or all of the test procedures undergone and any additional test arrangements upon the discretion of the Engineer if there is any defect during the FSSD inspection.

The Engineer will issue the Certificate of Completion upon his satisfaction of this test and receiving the complete set of test and inspection reports as stated in this Specification.

Fire Protection Installation Miscellaneous Provisions

1. PROVISION AND SEALING OF OPENINGS

The Sub-Contractor shall be responsible for all openings he requires for the installation of the services required under this Contract, as indicated in the Preliminaries. All sleeves and other materials required for the forming of the openings shall be provided under this Sub-Contract.

All openings formed in respect of this Contract's Services shall be sealed by the Sub-Contractor after the installation of the services. The Contractor shall provide all materials required to make the seal in accordance with Fire Safety Bureau requirements and to ensure that the integrity of the structural fire rating is not destroyed. Before the sealing of the opening, the Sub-Contractor shall provide sleeves for all cables, wall flanges for busbars and protection for trunking, or other materials.

2. FIXINGS TO STRUCTURE

Notwithstanding any form of fixing specified elsewhere in this Specification, the following shall apply wherever fixings are required into the structure for the purpose of supporting or restraining any item installed under this Contract.

Fixings into Reinforced Concrete Structure

Drilled and precast fixings into reinforced concrete will be performed at the discretion of the Engineer whose Approval shall be sought at least two months prior to commencement of any such work on site.

3. SPARE PARTS

In addition to the full sets of manufacturer's recommended spares referred to elsewhere in the Specification, the Sub-Contractor shall include in his tender price for the supply of the following items of material as spares. These spares shall be handed over to the Employer and will not be allowed to be used as replacement items during free maintenance period. However, the Employer may allow the Contractor to purchase these spares where the availability is limited.

The following spare parts shall be provided by the Sub-Contractor; in addition to the requirement on spares spelt out in CP 52 for sprinkler system.

- a. One box of mechanical seal to suit each valve size.
- b. One box of gland packing to suit each pump model.
- c. One pressure gauge of each range.
- d. Two indicating lamps of each range and colour.
- e. Two spare fuses for each range of starters.
- f. One set of spanners for pump maintenance.
- g. Regulating valve adjustment spanners.
- h. One AAV
- i. Five floor/wall escutcheon plates for each side of pipe.

Fire Protection Installation Miscellaneous Provisions

- j. Sprinkler heads as per CP 52.

All spare parts shall be presented in metal box(es) and stencilled with the words "spare parts" for Fire Protection Services Installation".

4. FLAMEPROOF MATERIALS

Unless otherwise specified, all materials used for filter media, acoustic linings, insulation and finishes shall be flameproof as defined in this Clause.

Flameproof materials shall be as tested in accordance with B.S. 3122.

No test specimen shall continue to flame for more than eight seconds after the igniting flame has been removed.

Afterglow shall not spread beyond the area of material damaged by flame.

5. IDENTIFICATION PLATES

Major plant and equipment shall be provided with an identification plate showing the equipment code number as indicated on the schematics and schedules.

The plates shall be of such a size as to be suitable for identification lettering of 50mm minimum highest.

The plates shall be colour coded according to the type of equipment and service and all plate and lettering colours shall be agreed with the Engineer prior to manufacture.

6. SPECIFICATION PLATES

Major plant and equipment shall be provided with a specification plate showing such details of the equipment duty, lubrication and maintenance requirements as may be specified or subsequently requested by the Engineer.

The plates shall be of such a size as to be suitable for lettering of 6mm minimum height.

The plates shall generally be printed black on white or white on black unless otherwise requested by the Engineer.

7. MANUFACTURERS' NAMEPLATES

Manufacturer's nameplates shall generally be provided for all plant and equipment and shall show serial and model numbers and date of manufacture.

Nameplates shall be attached at the manufacturers' work and shall generally be of the manufacturer's normal construction and material.

8. LABELS

All identification plates, specification plates, valve labels, labelling on control panels, etc., shall be made from laminated traffolyte engraved with English wording.

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

All valves shall be fitted with labels in the form of black Traffolyte discs, not less than

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50mm diameter, 1.50mm thick, with engraved numerals and/or lettering filled in with white composition.

9. SUPPORTING STEELWORK

Unless specifically shown otherwise on the Drawings, the Sub-Contractor shall supply and install all structural steelwork required for access to and support of all plant installed under this Sub-Contract, which includes the sectional tank Secondary support beam.

The form of this steelwork shall be generally as shown on the Drawings and shall include all necessary heavy weight British Standard Steel Sections, bracing steelwork, templates, checker plate flooring and access ladders, etc..

Notwithstanding the form of steelwork indicated in the Tender Documents, final responsibility for the design and performance of structural steel supports under live load conditions shall remain with the Sub-Contractor and this should be specially noted where equipment installed is other than that originally specified.

10. FIXINGS IN WATERPROOFED AREA

The Sub-Contractor shall note that where waterproofing internal linings are applied to walls, floors or roofs, under no circumstances shall this waterproofing be penetrated after its application.

All fixing necessary for the anchoring or support of pipes or equipment into the structural concrete must be made prior to application of the waterproof layer.

The following methods of fixing are advised as suitable and the Sub-Contractor must allow for the forward planning and necessary co-ordination, between services to ensure that sufficient fixings are accurately located to meet the requirements of the Contract.

Casting-in of reinforcement cages leaving sufficient exposed metal to weld-on heavy weight supports - the waterproofing layer being applied subsequently around the protruding steelwork. This method is particularly recommended where large forces must be restrained, e.g. for large pipework anchors.

Drilling and fixing of expansion bolts into the reinforced concrete structure prior to application of the waterproofing. This is only recommended for light loads and the positions of all such fixings must be approved with the Engineer prior to commencement of any such work on site.

11. FIXINGS TO REINFORCED CONCRETE

Where fixings are required to any reinforced concrete, other than in waterproofed areas, drilled in precast fixings into reinforced concrete will be permitted at the discretion of the Engineer whose approval shall be sought at least two months prior to commencement of any such work on site.

12. SUPPORTS FOR SERVICES

A uniformity of hangers, supports and brackets shall be employed between each trade of this Contract and common hanger systems shall be employed where two or more services are routed together within a proximately of 1000mm.

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All components of the support system shall be galvanized except for fixings for copper and UPVC pipework which shall be of brass.

All pipe supports shall be designed and fabricated in accordance with B.S. 3974 and generally as indicated on the Drawings.

The Sub-Contractor shall be responsible for selecting all materials and components to suit the total imposed loads on the installation and for the overall integrity of the installation. Duct and electrical supports shall be designed and fabricated to similar standard and in accordance with DW142 and the I.E.E. Regulations.

Support rods shall be threaded and complete with locknuts and washers to clamp the rod on each side of the fixings.

13. BELT GUARDS

The Sub-Contractor shall include for the supply delivery and erection of galvanized wire guards over all belt drives, flexible couplings and other exposed moving parts of the apparatus. Belt guards shall be fixed to the approval of the Engineer and in compliance with the requirements of all local authorities.

All guards shall be removable but provision shall be made so that easy access to the ends of motors and shafts is available without removal of the guards.

14. PRESSURE GAUGES

Pressure gauges and altitude gauges shall be of Bourdon type with brass syphon and cock, and piping connection to the measuring point. Size to be 100mm diameter dial.

All gauges shall have black pointer, red overrun indicators, and red mark at normal working pressure. The instruments shall be selected for the normal operating range expected and dial calibration shall not exceed twice the normal working pressure.

Pressure gauges shall be mounted on a polished wooden base board and shall be labelled as specified elsewhere.

Pressure gauges shall be installed where shown on the Drawings.