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1. AIR-CONDITIONING AND MECHANICAL VENTILATION

1.1. SCOPE

The Contractor will design and execute the works as per the Contract and the specifications below.

The work described in this specification will include but not be limited to supply, transportation, storage, installation, painting, testing and commissioning of all works for air-conditioning and mechanical ventilation including:

- Air-conditioning System
- Mechanical Ventilation System
- Control System
- Electrical System related to HVAC

Maintenance and warranty of the installation comprising of the system and equipment shall be referred to Other Contract Documents.

The works by this Contract shall comprise the following:

- Demolition and Provision of a new insulated chiller water pipework where required.
- Relocated existing FCUs to comply with new design.
- All air registers/diffusers and air distribution system accessories including manual volume control dampers, splitter damper, air outlets, access panels, etc. associated with the MVAC systems
- Complete mechanical ventilation system for toilets and plant rooms as shown on the drawings
- A condensate drain pipe system with fittings
- All thermal insulation associated with the MVAC installation
- All noise and vibration control works associated with the MVAC installation
- The sub-contractor shall include for all noise and vibration measures and acoustic treatment specified elsewhere in this specification to achieve the noise levels as specified. Detail calculation and shop drawings shall be submitted for approval. The acoustic treatment which has been specified herein is the minimum requirements and shall be provided in all cases.
- All electrical works associated with the MVAC installation (from Floor Distribution MSSB or Local MSSB to equipment. Cabling from MSB to MSSB will be provided by Electrical Sub Contractor. Refer MVAC drawings for exact limitation).

- Provision of manual override switch at Fire Services control room to switch off all fans of the MVAC system serving the building in the event of a fire alarm
- Supply and installation of control cables (fire rated type) from module controllers of Fire Alarm system to all MVAC equipments such as motorized damper...
- All painting of ductwork, pipework and equipment and the like
- Interface work with Main Contractor/Other Contractors as detailed in the following clause for 'Interface Work'
- Liaison with, and submission to, all Local Authorities to obtain all necessary certificates and approvals including the completion of all forms, preparation of all shop drawings and other document for necessary submission purpose and the payment of any fees

The submission shall include but not be limited to the following:

- Local Police Fire Services Department (FSD) for Stair Pressurisation Fans and Ventilation / Air-Conditioning Control System
- Work Completion certificate in accordance with the Local Power Company for Electrical installation associated with MVAC Installation if required
- Provision of spare parts as scheduled
- Training of Owner/Principal's staff for proper operation of the entire installed system
- Selection, installation and commissioning of plant and equipment, including appropriate isolation and acoustic treatment, to achieve the design noise levels specified elsewhere in this specification.
- All associated building work unless specifically nominated elsewhere in this specification. The work shall include the following:
 - Making good, Painting
 - Fire stopping
- Testing, commissioning, maintenance and defects liability for the MVAC work This shall include:
 - Defects liability for 52 weeks from date of Practical Completion
 - Provision of Operational Maintenance and Breakdown Services including all labour, tools, materials, spare parts and consumables during the defects liability period
- Provision of four (04) sets of Operating and Maintenance Manuals, including 'as-installed' or 'as-built' drawings and all testing and commissioning data

1.2. STANDARDS AND CODES

Unless otherwise specified, equipment, materials, fabrication and installation shall comply with all governing regulations, applicable standards and codes, and other regulations as shown in the Drawings and Specifications. In every case, the regulations, standards and codes to apply shall be the latest version.

Unless agreed otherwise, the following codes and standards will be used for the Works:

- TCVN 4088:1992 Climate standards Vietnam
- TCVN 5687:2010 Ventilation and air conditioning standards Vietnam
- QCVN 05:2008/BXD Vietnam Building Code Dwellings and Public Buildings - Occupational Health and Safety
- QCVN 02:2009/BXD Viet Nam Building code - Natural Physical & Climatic Data for Construction.
- QCVN 06:2010/BXD Vietnam Building Code on Fire Safety of Buildings
- QCVN 09:2013/BXD National technical regulation on energy efficiency buildings
- ASHRAE Ventilation for acceptable indoor air quality 62.1-2007.
- 2008 ASHRAE Handbook - Systems and Equipment.
- ARI - Air-Conditioning and Refrigeration Institute
- ASTM - American Society for Testing and Materials
- ASME - American Society of Mechanical Engineers

1.3. AIR-CONDITIONING - MATERIALS AND EQUIPMENT

1.3.1. General

This section covers the supply, delivery, installation, testing, commissioning and free maintenance and warranty of split air conditioners system complete with room wireless thermostats, refrigerant piping, wiring, drainage and control panel as shown in the drawings

Air conditioning units will be standard products of manufacturers who carry in stock locally all possible items for repair or replacement and who are reputable in providing prompt service.

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.
- All electric motors shall be of the same make and have the maximum inter-changeability of components.
- All items which are of a similar nature shall be obtained in each case from a single manufacturer.
- All items for similar duties shall be the same make and model.

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.

All items of equipment must be corrosion resistant.

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

1.3.2. Design Conditions

Outdoor design conditions:

- Geography location: 304 Kim Ma, Ha Noi, Viet Nam.
- Cooling: summer design dry / wet bulb temperature: 36,4°C / 28,3°C
- Heating: Winter design dry / wet bulb temperature: 10.2°C / 9.0°C

Indoor design conditions:

- Air temperature: 24°C for cooling, 20°C for heating
- Relative humidity: 55%

1.3.3. VARIABLE REFRIGERANT VOLUME UNIT

General

This section covers the supply, delivery, installation, testing, commissioning and free maintenance and warranty of split air cooled system complete with room thermostats, refrigerant piping, wiring, white PVC trunking, drainage and microprocessor based control panel as shown in the Drawings.

The units shall be suitable for continuous operation and shall be constructed as described below.

Each VRV air conditioning system shall comprise an outdoor air-cooled condensing unit coupled to single or multiple direct expansion fan coil units as shown in the Drawings.

The unit shall be equipped with suction, discharge and liquid shut off valves with pressure connection for servicing. Factory installed gauge package shall be provided with individual suction, discharge and oil pressure gauges for each compressor supplied with individual shut-off valves. The factory installation shall include mounting and piping to the system.

The refrigerant piping shall be extended up to 100m with 50m level difference without any oil traps.

Both indoor unit and outdoor unit be assembled, tested and charged with refrigerant R-410a.

All fan coil units within the same condensing unit shall be independent in control, and all other fan coil units shall remain operational in the event of any failure on one of its fan coil unit.

It shall be supported by hot dipped galvanised steel hangers and brackets to the building structure by means of approved metal expansion plugs. Suitable receiving holes shall be cut by approved rotary-percussion electric drills to give true and accurate drilling.

Air-Cooled Condensing Unit

The air-cooled condensing unit shall be a factory assembled unit housed in a sturdy weatherproof casing (suitable for tropical outdoor use) 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 compressors capacity.

The noise level shall not be more than 55dBA measured horizontally 1m away and 1.5m aboveground.

The unit shall be designed so that the control system and electrical circuitry can be serviced and/or checked while the system is in operation without disturbing air flow and performance.

The condensing unit shall have the following components:

a. Compressor

The compressor shall be of hermetic type having internal vibration isolation. The compressor assembly shall have low operating noise level and built-in thermal protection and current overload devices wired to stop the compressor motor in case of malfunction.

b. Condenser Assembly

The air-cooled condenser shall be constructed with copper tubes mechanically bonded to aluminium fins to form a cross fin coil. The condenser shall have a usually large face area to minimise noise and give a high EER for heat transfer.

c. Condenser Coil, Fan and Motor

Condenser coils shall be copper tubes expanded into aluminium fins. The coils shall be degreased internally and externally before being brazed with Nitrogen passing through the tubes.

The coils shall be tested in factory for leaks at 2240Kpa before assembly. They shall again be pressure tested and leak tested after assembly.

The condenser fan shall be of multi-blade low speed, low noise level type made from pressed out aluminium and dynamically and statically balanced for minimum noise and vibration. The condenser fan shall be directly coupled to a dual speed induction motor.

The axis of the fan shall be perpendicular to the face of the condenser to ensure smooth air flow. The condenser fan and motor shall be of the high efficiency type with minimum power consumption.

An ambient thermostat mounted in the inlet air stream of the condenser coil shall switch the condenser fan to low speed wherever the ambient temperature falls below 28⁰C to ensure further energy and noise level control.

The fans shall be directly connected to the splash and weatherproof, low speed motors. Both fans and motors shall be permanently lubricated, bearing design.

The condenser fans shall be centrifugal direct drive type

The fans shall be protected with heavy gauge galvanised wire guard, and painted with oven baked polyester paint. Fan Motor shall be permanent-split-capacitor type, complete with thermal protection and permanently lubricated ball bearings. All internal electrical wiring and controls within the condensing units shall be completely factory installed. Installation of Motors and wiring shall comply with their Specification.

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 400V/3 Phase/50Hz. The motor bearings shall be permanently lubricated type.

Stainless steel bolts and nuts shall be provided for the condensing units to be mounted on stainless steel brackets.

d. Refrigerant Circuit

The refrigerant circuit shall include an accumulator, liquid and gas shut off valves and necessary safety devices should be provided to ensure the safety operation of the system.

e. Protective Devices

The protective devices shall be included and not limited to the following:

- High Pressure Cut-Out
- Low Pressure Cut-Out
- Fusible Pressure Relief Plug
- Compressor Motor Solid State Protection
- Five Minute Timed Off, Anti-recycle Timer
- Separate System On-Off Switches on each Compressor

- Manual Reset Oil Pressure Protection
- Internal Compressor Relief Valve
- Internally Protected Condenser Fan Motors
- Suction Line Accumulator
- Separately Fused Condenser Fan Motor and Control Circuit

Fan Coil Unit

Each fan coil unit shall be of the ceiling mounted cassette type as shown on the drawings.

Each fan coil units shall be equipped with a self-diagnosis remote controller and having the features of setting of the room temperature (with digital indicator of room temperature), timer, air discharge direction (for cassette units), 3 fan speed selection, self-diagnosis circuit with malfunction code display. The ceiling recessed type of fan coil units must be equipped with condensate drain pumps.

The unit shall have adequate external static pressure for connection to ductwork as shown on the drawings. Each ducted type of fan-coil units shall have ducting flanges for connecting flexible ducting.

The fan coil units shall be of direct expansion type with capacities as stated in the "Schedule of Equipment".

a. Cross Fins Evaporator

The evaporator coil shall be constructed from strong clean copper tubes bonded to aluminium fins suitably spaced to ensure maximum heat transfer. The inlet of the coil shall be factory brazed to an automatic thermostatic expansion valve. The face velocity of the coil shall be low to ensure quiet operation.

The cross fin coil shall be of waffle louvre fins and inner grooved lining tube design to ensure highly efficient performance. Fin pitch shall not be less than 2.0mm.

b. Evaporator Fan

The fan shall be pressed out of aluminium or formed from high impact plastic and statically and dynamically balanced to ensure low noise and vibration free operations. It shall be directly driven by a 3 speed induction motor mounted at one end and away from the air stream.

The fan motor shall be two or three speed shaded pole type with permanent lubricated bearings, built-in inherent overload protection with automatic reset. Motor shall be suitable for 230V/1 Phase/50Hz electric supply. Motor bearings shall be of the permanent lubricated type. A factory furnished junction box shall be provided.

c. 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 medium speed selection shall not exceed 40dBA measured from a position of 1.5 metres from the fan coil unit.

d. Filters

Air filters shall be non-combustible and of the permanent washable type. The air filter shall have a minimum effective life of 2500 hours.

1.3.4. Refrigerant Pipes

The refrigerant piping shall be assembled from dehydrated copper piping and fittings shall conform to ASTM B280 and the nominal wall thickness as follows:

Outside Diameter (mm)	Wall thickness (mm)
Ø41.30	1.52 straight
Ø34.92	1.40 straight
Ø28.60	1.27 straight
Ø22.22	1.14 straight
Ø19.10	1.07 straight
Ø15.88	1.02 straight
Ø12.70	0.813 soft coiled
Ø9.52	0.813 soft coiled
Ø6.35	0.762 soft coiled

Refrigerant pipes will be sized to ensure that pressure drop does not exceed 2 PSIG (0,15bar).

Piping will be copper pipes of refrigeration quality, internally degreased and cleaned. Refrigerant pipes will be tested for leakage at 20 bars (300psig) and dehydrated.

The refrigerant pipes and the drain points will be located at suitable location to ensure easy installation and maintenance.

Pipe jointing shall be welding with silver base alloy. All pipes shall be new and in one continual length without any intermediate joint. Pipes of short length joint together will not be acceptable.

1.3.5. Condensate Drain Pipe

All condensate drain line shall be heavy duty uPVC. The condensate drain line shall be terminated to the nearest connection point as indicated in the Drawing. All piping shall be supported to prevent buckling at interval not exceeding 2.0 m.

1.3.6. Pipes Insulation

Insulation material shall be closed cell elastometric tube class 'I' or better.

a. Specifications

Thermal Conductivity: 0.032 w/mK @ 23°C (ASTM C518)

Thickness:	Refrigerant Pipe	Condensate Pipe
	19 mm	13 mm
	9 mm (embedded in wall & slab or screeding)	

Moisture absorption: Non-hygroscopic.

Water vapour permeability: ≤ 0.065 ng/Pa.m.s.

Spread of flame index: 0.

Smoke developed index: 3(maximum)

Adhesive: Use only adhesive supplied by the insulation manufacturer.

b. Protection

Insulation exposed to sunlight and mechanical damage: Provide 0.6 mm zinc anneal or 0.8 mm aluminium sheathing or run pipes in 0.8 mm metal trunking.

Insulation exposed to sunlight but not the risk of mechanical damage: Provide metal sheathing or trunking, or apply 2 coats of UV resistant paint supplied or recommended by the insulation manufacturer.

c. Installation

Insulate all refrigerant piping that may sweat. Apply insulation un-slit where possible. If slit, re-fix slit faces with adhesive applied to full area.

Timing: Leak test piping before insulating joints, fittings and valves.

1.3.7. Drain Pan

The pan shall be un-rusted material construction with nonferrous connections and fully insulated.

Condensate drain pan shall be adequately insulated to prevent condensation. Drain pipe connection shall be provided at both ends of the pan with provision to plug off the connection not in use.

Condensate drain pan shall be provided with factory assembled and wired condensate pump of a non-ferrous construction with all necessary controls.

1.3.8. Controls

Computerised control shall be used to maintain a correct room temperature with minimum power consumption. Unit shall be equipped with 3 speed fan controller, timer on/off control, temperature setting as well as actual room temperature display in LED indicators.

Wireless remote controller shall be provided for each fan coil unit.

The network controller will be connectable to operate and control all the fan coil units according to designed address of the fan coil units. The network controller shall be interfaced to the existing building management system (BMS). Compatibility to the existing BMS communication protocol shall be verified by the contractor.

1.3.9. Cable Conduits

All power and control cables shall be run in PVC conduits along side with refrigerant pipes and terminals in KO boxes with cover for future connection between the fan coil unit and condensing unit.

1.4. MECHANICAL VENTILATION - MATERIALS AND EQUIPMENT

1.4.1. Fans - General

This section covers the supply, delivery, installation, painting, testing and commissioning and free maintenance and warranty of all mechanical ventilation fans and associated controls and accessories.

All fans shall be carefully selected and be entirely suitable for their particular service, position of fittings and chosen with respect of corrosion, in flammability or other hazardous application.

The fans shall be capable of handling the air quantity necessary for the specified system performance against the resistance of the system. The resistance shown on the Schedules are for tendering purposes only and the Contractor shall be held responsible for checking the final system resistance before ordering the equipment.

Fans shall be balanced and free from vibration. All fans shall have complete impeller assemblies including drive components, and be statically and dynamically balanced.

Performance test of up to 110% normal running speed shall be conducted. The rotor and pulley shall be further balanced on site to the approval of the Client's Representative; the rotors shall be selected for quiet operation in accordance with the relevant British Standard Code. Performance shall be rated in accordance with the ACMA Standard.

Unless specified, fans shall be designed and constructed for continuous operation.

All fans shall be fitted with engraved identification and directional labels giving full details of speed, H.P, pulley and belt sizes and type of grease required, and mechanically fixed where they can be easily seen and not subject to potential damage.

All fans including motors, electrical wiring, control panels, etc. within the air-stream of Smoke Control, pressurization shall be able to withstand up to 250°C to comply with the requirements of the Local Authorities (TCVN-5687 : 2010).

1.4.2. Axial fans

Axial, fans shall be supplied and fitted, generally as shown on the Tender Drawings. The fans shall be selected with direct driven motors giving non-loading characteristics. Motor speeds shall not exceed 1500 rpm or as noted on the Tender Drawings.

Fans shall be balanced and free from vibration and the blades of adjustable type. The blades shall be counterbalanced and mounted on a thrust bearing.

Casings shall be of standard length designed to protect both the motor and impeller, continuously welded throughout and hot-dipped galvanised after manufacture. Inspection doors to enable direction of rotation to be checked shall be provided.

For fans of 1200mm diameter and above, impeller hubs may be cast spheroidal graphite cast iron type 500/7 to B.S. 2789. The fan blades may be cast in aluminum to B.S. 1490. Cast components shall be X-rayed before machining.

Terminal boxes welded to the casing shall be provided for electrical connection to fan motor.

Lubrication of bearing shall be possible from outside the fan casing.

Impellers may be of glass reinforced polyester resin or die cast aluminium.

1.4.3. Centrifugal fans

Fans shall be constructed of heavy gauge, hot dip galvanized steel. The forwardly curved centrifugal fan shall be statically and dynamically balanced. Fan housings shall have curved inlet rings for efficient air entry.

A 2.5mm hot dip galvanised wire grille type fan guard shall be provided over each fan cylinder. Fan guards shall be designed in compliance with OSHA safety standards or equivalent.

Fan casings shall be of heavy galvanized sheet construction adequately stiffened and braced and shall be entirely free from vibration or drumming during normal operation. All surface of fan casings shall be galvanized after manufacture.

Impellers shall be hot dipped galvanised after fabrication.

Impellers shall be rigidly fixed to solid bright stainless steel shafts adequately sized and proportioned to ensure that the maximum operating speed is not more than 60% of the first critical speed.

The shafts shall be carried in ring lubricated self-aligning sleeve bearings for shafts of 150mm diameter and larger. Each bearing having large oil capacity to ensure efficient lubrication. On shafts of sizes smaller than 150mm diameter, grease lubricated self-aligning ball bearings resiliently mounted to reduce noise transmission shall be used.

Bearings shall be ball type selected with a nominal life factor of 300,000 hours and shall be grease lubricated and equipped with grease escape valve to permit replacement of lubricant without dismantling the bearing Housing.

All surfaces of fan casings shall be galvanised after manufacture and all fans with an inlet eye diameter exceeding 300mm or with a scroll 450mm or more in width shall have a bolted access door on the scroll for access purposes. The doors shall be located near the scroll bottom and of the pan type set in a raised frame so that the inner surface is flush with the scroll. The doors and frames shall be arranged for insulation if applicable. The doors shall be secured to the frames by hand-grip bolts and shall be provided with lift handles.

Nominal motor nameplate ratings shall be at least 15% higher than the motor operating input at design conditions.

1.4.4. Propeller Fans

Propeller-type ventilation fans manufactured from plastic or other similar approved materials designed for commercial or domestic uses shall be supplied and fitted, generally as shown on the Tender Drawings. Fans shall be window-mounted or wall-mounted to suit the particular installation. Wall-mounted fans shall be supplied with wall boxes and wall plates suitable for removal for cleaning, or built-in walls where shown on the Tender Drawings.

Motors shall be totally enclosed (I.P.44) with permanently lubricated bearings.

The fans shall be complete with weatherproof flush fitting exterior grilles, draught-preventing insect or similar shutters linked to the fan switches and flush fitting interior grilles.

1.4.5. In-Line Centrifugal Fans

In-line fans shall be of mixed flow type. Casings shall be of fabricated from galvanised steel. Impellers shall be of aluminium with integral inlets. Motors shall be of external rotor motors designed to IP44 protection using class B insulation. Fans shall be anti-vibration mounted.

1.4.6. Air filters

Filters will be provided as indicated in the contract documents.

Maximum air velocity through the filters will not exceed 2.5 m/s or the figure recommended by the manufacturer whichever is the lower.

Filter housings will be provided; having airtight access panels for filter replacement complete with corrosion-resistant filter frames and clamps, gasket and rubber sealed to prevent air by-pass.

In general all filters should be mildew proof resin Net (dust density 0.15mg/m³) 50% (gravity method) and fully washable.

1.4.7. Air ducts

Unless otherwise specified, the supply, return and fresh air ducts will be galvanized steel duct. They will be mounted with great care to ensure complete air tightness until the diffuser. All joints shall be tight to prevent air leak noise. As a general guide, the air flow velocities should exceed the following:

- Main supply air duct: 6m/s - 10m/s.
- Branch supply air duct: 4m/s - 6m/s.
- Outlet air duct: 3m/s

Galvanized steel ducts will comply with the following specifications:

Galvanized steel ductwork will be fabricated from new, best quality, full sized galvanized flat steel sheets. They will be rectangular type unless otherwise specified.

All flanges and steel works for jointing and supporting will be galvanized.

Jointing for flanged cross joints will be sealed with an approved non-flammable rubber gasket of thickness not less than 4 mm.

Access panels will be provided at every point where access for checking, servicing and cleaning of equipment is required.

The Contractor will provide and install hand operated galvanized steel dampers for the proper regulation of the ventilating and air conditioning systems.

All ductwork installation will be leakage tested in accordance with ductwork leakage testing of ASHRAE standard.

1.4.8. Flexible Joints

Materials and installation methods for all flexible connections between ductwork systems and equipment shall comply with the requirements of DW/142.

Flexible connections shall be provided at the suction and delivery connections of all fans and air handling units and elsewhere as shown on the Drawings or as may be required to eliminate vibration.

All fans which are connected to ductwork systems shall be connected by means of flexible connections at both suction and discharge ends.

Flexible connections shall be lead impregnated vinyl and shall generally be of materials approved by the Fire Services Bureau and installed to allow replacement without the need to dismantle ductwork.

The flexible material shall be fixed to the fan outlet and ductwork so that no air leakage occurs.

Where flexible connections are used to connect fans to insulated ductworks, then flexible fibreglass of 12.50mm thickness shall be fitted over the cloth and enclosed in an aluminum foil vapour barrier.

Where silencers are fitted to fans on the suction and discharge side then flexible connections shall be of lead impregnated vinyl or other suitable barrier mat providing an acoustic barrier and approved by the local Authorities.

1.4.9. Volume Dampers

The Sub-Contractor shall provide and install hand operated dampers where required for the proper regulation of the ventilating and air conditioning systems whether shown on the Drawings or not.

All volume dampers shall comply with DW/142 and shall be provided in separate purpose-made flanged casings of rigid construction conforming to the DW/142 Standards of air-tightness.

The damper spindles shall be provided with suitable seals when passing through the casing and penetrations shall be limited by the use of internal gears.

In high velocity ductwork (as defined in DW/142), dampers shall be situated in areas of relatively low velocity, and shall also be of the aerofoil type to prevent undue disturbance of the air flow.

All regulating dampers shall be proprietary products with aerofoil blades for a low pressure drop characteristic unless otherwise stated. The dampers shall be capable of being securely locked in the set position and all blades of the dampers shall be driven through an interlocking geared mechanism.

1.4.10. Sleeves

Where pipe pass through walls, floors, etc., the Sub-Contractor shall supply and install pipe sleeves.

Where pipes pass through walls, floors or ceilings rendered liquid-tight puddle flanges shall be supplied by the Sub-contractor and fixed by the Main 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

The Sub-Contractor shall set all sleeves in the shuttering of walls, floors, etc., before concrete is poured and in compliance with the Main Contractor 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 samples of such plates are to be submitted to the Engineer for checking.

1.4.11. Fire Rated Duct

The air ducts 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.

Ductwork shall be formed from minimum 1.2 mm thick galvanised sheet metal, with all seams welded and all connection fully complete with gasket. 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. The fire rated duct construction shall also be to the approval of the relevant authorities.

Each fire damper shall be provided with a proprietary access door, pre-insulated as required, of no less than 300x300mm. All doors shall be hinged type with a locking handle. Special branch sections shall be included on circular and flat oval ductwork to accommodate the access doors.

Fire dampers shall be Authorities Approved and rated equivalent to the wall in which they are installed.

The gap between the fire damper housing and the wall shall be closely packed with a fire proof material capable of withstanding a temperature of up to 1100 Degree C. Fibreglass shall not be allowed.

Duct connections to the damper shall be arranged so that expansion of the ductwork in a fire cannot impair the operation of the damper by protruding into the damper housing.

1.4.12. Grilles and diffusers

All air supply, return and exhaust fittings shall be provided of the types and duties shown on the Sub-Contract Drawings.

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

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

All supply air fittings shall have the facility for adjustment of the air flow direction.

The Square air diffusers shall be of steel construction spray painted or electro coated to a finish and colour chosen by the Engineer. The interior surfaces shall be painted matt black.

The diffusers shall have a deflection plate and deflection vanes to suit the selected horizontal air patterns or shall be vertical supply on return air patterns, as shown on the Sub-Contract Drawings.

All air fittings shall have concealed fixing systems. Exposed screw fixings will not be accepted.

All supply and return air linear diffusers and registers shall be of extruded aluminium with finish to a colour to be decided by the Engineer.

Wire mesh grilles where indicated on the Sub-Contractor Drawings shall be made of 13 x 13mm, 1.60mm diameter galvanized steel wire mounted on a substantial galvanized steel frame.

Return air grilles for exposed fan coil units shall generally be arranged such that the central core of the grilles is demountable for access to the filter for cleaning. Mounting frames for these grilles shall include provisions for fixing the filters in position.

All grilles, diffusers, etc., shall be erected square and level and accurately set out as to spacing. All fittings shall be mounted on substantial frames and shall be provided with 7mm thick soft rubber or felt joining ring inserted under the frame, or as the case may be, so as to obviate air leaks and prevent the formation of condensation on the fittings.

1.5. VIBRATION AND NOISE CONTROL

1.5.1. General

This section covers the general requirements that constitute the attainment of an acoustic 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.

It is the intent of this Specification that noise levels due to mechanical equipment and related services will be controlled to the Design Objectives stated herein, in all occupied areas.

The requirements specified are considered to be the minimum precautions necessary to achieve these objectives. The entire installation shall operate without objectionable noise and vibration as determined by the Engineer.

The subcontractor shall employ an acoustic specialist to engineer his design and installation with due considerations to vibration, vibration-induced noise, airborne noise via ductwork and all air supply and return paths, including the control of all noise breakout via ducts and associated fittings.

The subcontractor should bring to the Engineer attention should any of the requirements, in his opinion, is not attainable. Otherwise the subcontractor shall guarantee that the equipment will operate within the criteria, or bear all costs of remedial work to achieve the Design Objectives.

Machinery and equipment shall be installed so as to ensure that the transmission of tactile and audible vibration to the building due to the operation of that machinery and equipment and/or its connection to pipework, ductwork or conduits, is reduced to the practical minimum.

All rotating parts shall be balanced statically and dynamically to recognised standards.

All rotating parts, or machinery which contains rotating parts, shall be isolated from the building structure via anti-vibration isolators.

Inertia bases shall be provided for machines with large, out-of-balance forces, such as internal combustion engines, air compressors, reciprocating refrigeration compressors, pumps and high pressure fans.

Reinforced concrete pads, at least 100mm thick, shall be provided below all major mechanical and electrical equipment which is floor supported.

Installation of vibration and noise control equipment, including spring hangers, shall not obstruct proper equipment access for maintenance.

1.5.2. Design Objectives

Maximum noise levels in office spaces shall not exceed data in table below.

Office Area	NC Level	Sound Level <i>dB_A</i>
Conference rooms	25-30	35-40
Private	30-35	40-45
Open-plan areas	35-40	45-50

1.5.3. Products

Sound Attenuators

- (a) Factory pre-fabricated.
- (b) Shell:
 - i. Galvanized steel not less than 1mm thick.
 - ii. Leak proof at pressure differential of 2000 Pa.
- (c) Fire Properties of Media:
 - i. Fire properties shall be complied with local Fire Services Department's requirements.
 - ii. Flame spread Classification: Not greater than 20, when tested in accordance with ASTM E84, NFPA Standard 255, or UL No. 723, or Class 1 in accordance with BS476 Part 7, or equivalent international standards.
 - iii. Fire Propagation: in accordance with BS476 Part 6, the index of overall performance (AI) not exceeding 12, and sub-index (Ai₁) not exceeding 6, or equivalent international standards.
 - iv. Ignitability: in accordance with BS476 Part 5, Class P, not easily ignitable, or equivalent international standards.
 - v. Fuel contributed and smoke developed: Not greater than 20, when tested in accordance with ASTM E84, NFPA Standard 255, UL No. 723 or equivalent international standards.
- (d) Media
 - i. Minimum 48 kg per cubic meter density glass fiber or minimum 80kg per cubic meter density mineral fiber, packed under minimum 5 percent compression.
 - ii. Filler to be inert, vermin proof, and moisture proof.
 - iii. Where sound attenuators are selected for outdoor operation, they shall be completely weather-proofed and treated against corrosion.

(e) Internal Construction:

- i. Galvanized perforated steel baffles: Minimum 0.7 mm thick.

(f) Net Insertion Loss Ratings and Pressure Drop:

- i. Determined by duct-to-reverberant room test method at design airflow. The calculation for selection of sound attenuator shall be provided by the Contractor in accordance with the requirement of the particular specification.
- ii. The maximum pressure drop across the selected attenuator shall be 50Pa, unless otherwise specified.

(g) Certified Tests:

- i. Submit certified test data from approved laboratory for pressure drop and insertion loss ratings.
 - For square or rectangular attenuators: 600mm x 600mm.
 - For cylindrical attenuators: 600mm diameter.
 - For cone diffuser/silencers: Sizes indicated on drawings.
 - Certification data for pressure drop and net insertion loss: based on tests of same attenuator.
 - Attenuators and test reports: subject to inspection upon request of Architect.

(h) Acoustical Lining

- i. Internal acoustical ductwork lining shall be fibrous glass
 - ii. Facing for low velocity duct liner (max. 12 meters/sec).
 - Finish: Neoprene coated
 - Stenciled NFPA 90
 - iii. Facing for circular ducts and medium/high velocity ductwork (over 12 meters/sec), or where indicated on drawings.
 - Finish: Perforated, minimum 28 percent open area, minimum 0.7mm thick galvanized steel.
 - iv. Minimum Thickness
 - In ductwork: 25 mm, unless otherwise noted on drawings.
 - In plenums: 100 mm.
 - In linear slot diffuser plenums: 13 mm.
 - v. Minimum Density
 - In ductwork: 32 kg per cubic meter.
 - In plenums: 48 kg per cubic meter.
 - In linear slot diffuser plenums: 32 kg per cubic meter.
 - vi. Fire properties: Same as in clause no. 2A(c).
-

- vii. Suitable for duct velocity of 30 meters per second, without erosion damage.
- viii. Dynamic loss coefficient: maximum 1.2.
- ix. Maximum thermal conductivity: 0.035 Watt/meter K, for 25mm thickness.
- x. Noise reduction coefficient (NRC) for 25mm thick lining: minimum 0.75.

(i) Material

The panels shall be constructed of galvanized steel of normally 1.6 mm thickness solid outside and 1.0 mm thickness perforated inside. Hole size shall not exceed 2.5 mm in diameter and account for 11 to 23% of the total surface area. Modules shall be welded, free draining, and free of cavities in which water may collect. Acoustic infill shall be 100 mm thick of density 48 kg/m³ fiberglass (See below Table 1 and Table 2). Modules shall be coated with a powder coating applied through the use of an electrostatic charge and thermally bonded to the surface of the steel sheets if necessary.

The enclosure can also be constructed from single layer of 15mm thick gypsum board on both sides of 50mm metal stud with infill of 50mm thick fiberglass of density 48 kg/m³.

Acoustic infill material shall be of fiber acoustic material, non-corrosive, resistant to attack by fungus, fire-resistant, vermin proof, and non-hydroscopic. Fill material shall be free draining, self-supporting and shall retain physical and sound absorptive characteristics after long term polymer sheeting. The acoustic infill shall be packed by a sound transparent water proof layer if necessary for outdoor application.

(j) Acoustic Performance

Sound Absorption Coefficient Tests shall be performed in accordance with ASTM C 423, Type A mounting or with BS 3638: 1963.

Transmission Loss Tests shall be performed in accordance with ASTM E 90 and ASTM E 413 or with BS 2750 Part 3: 1980.

Table 1. Sound Transmission Loss Data – STC 40

Octave Band Centre Frequency, Hz	125	250	500	1K	2K	4K
Sound Transmission Loss Data, dB	21	29	39	50	56	56

Table 2. Sound Absorption Loss Coefficients

Octave Band Centre Frequency, Hz	125	250	500	1K	2K	4K
Sound Absorption Loss Coefficients	0.60	0.80	0.90	0.90	0.90	0.80

(k) Access Doors

Hinged doors openings shall be provided at suitable locations in the enclosure for access to the equipment for future maintenance. The construction of the door shall be similar as above and shall not jeopardize the acoustic characteristics of the entire enclosure. Door gasket shall be provided at door periphery to prevent any leakage.

(l) Durability / Maintenance & Weathering Characteristics

All panel configurations shall be tested for corrosion resistance in accordance with ASTM B 117 in a NVLAP - certified or other equivalent international standards certified

independent test laboratory accredited under the Accreditation Criteria Guide 25:1990 (E).

(m) Fire Resistance

Tests shall be performed on nonmetallic materials in accordance with ASTM E 84. All materials shall have a Class A fire rating with flame spread not greater than 15 and comply the local code requirement.

(n) Method of Construction for Acoustic Enclosures

The acoustic enclosure shall be assembled by lowering consecutive panels between flanged steel beam posts with sound absorptive facing the noise source. Consecutive panels shall rest in one another in such a manner as to preclude line-of-sight gaps or openings through the panel.

Individual acoustic panels shall be removable and replaceable. (It shall be shown that, should safety or other considerations mandate the use of mechanical equipment to raise and / or lower individual enclosures into position, the lift capacity of the equipment need not exceed 91kg).

Enclosure shall be installed such that enclosure surfaces facing both the noise source and the sensitive receiver are plumbed in accordance with accepted engineering specifications and to the satisfaction of the Architect.

(o) Structural Capacity

The acoustic panels shall withstand wind loads to conform to the Local Construction Regulations and Code of Practices for wind load calculations. Prior to fabrication, details structural calculations shall be submitted to the satisfaction of Engineer, verify that enclosure enclosures and structural support posts meet the wind load specifications in accordance with accepted engineering specification.

Adhesive and Sealer

- (a) Fire Properties: To comply with local Fire Services Department's requirements.
- (b) In conformance with NFPA 90A, or equivalent international standards.
- (c) In conformance with BS476 Part 7 Class 1, or equivalent international standards.

Non-Hardening Caulking

- (a) Guaranteed to be permanently elastic.
- (b) The caulking shall comply with the local Fire Services Department's requirements.
- (c) In conformance with BS476 Part 7 Class 1, or equivalent international standards.

Flexible Duct

- (a) The flexible ductwork shall be tested and installed in accordance with the Air Diffusion Council (ADC) "Flexible Duct Performance & Installation Standards." such as but not limited to, installed fully extended with radius elbows. All testing shall be in accordance with ASTM E-477 and/or ADC Test Code FD-72R1.
- (b) Flexible duct shall be sized for project friction loss design criteria, but not more than 2.5 m/s air velocity. The length of flexible duct connection shall be minimum 1.5 m.
- (c) Acoustical performance of the flexible duct shall be as follows:

Flexible Ductwork Acoustical Performance
 in Accordance with ADC Test Code FD 72-R1
 Attenuation - Insertion Loss (dBre:20Pa) for Straight 2 m length
 Zero Flow

Octave Band Center Freq. (Hz)	125	250	500	1K	2K	4K
200 mm diameter	6	11	17	19	19	12
300 mm diameter	5	10	15	17	16	9

Duct Enclosure

- Duct Enclosure as specified shall be double layers of 15 mm gypsum board support on separated framework without any contact with the duct work. Air spacing of 100 mm between ductwork surface and gypsum board shall be maintained and internally packed 50 mm thick insulation 64 kg/cum rockwool. All exterior duct enclosure outside the concerned space shall have protective surface and suitable for outdoor application. Detail shall be submitted for Architect's approval, weatherability, and color stability shall be compatible with the finish on the surfaces.
- The duct enclosure shall withstand wind loads to conform to the Local Construction Regulations and Code of Practices for wind load calculations. Prior to fabrication, details structural calculations shall be submitted to the satisfaction of Architect, verify that enclosure and structural support posts meet the wind load specifications in accordance with accepted engineering specification.
- The duct enclosure shall offer a minimum noise reduction as follows:

Octave Band Centre Frequency, Hz	125	250	500	1K	2K	4K
Noise Reduction in dB	15	20	20	25	25	25

1.5.4. Execution

Sound Attenuators

- All attenuators shall be fitted with end plates and packed in SEALED bags at factory prior to shipment.
- Install in accordance with Manufacturer's Recommendations to obtain published performance.
- Maximum Static Pressure Loss:
 - After installation: measure total system pressure before and after attenuators.
 - If pressure loss exceeds maximum static pressure loss schedules on drawings: at no charge, replace attenuators and/or modify entrance and/or discharge aerodynamic flow to obtain specified performance.

Acoustical Lining

- Adhere with 150 mm wide strips of adhesive.

- i. 300 mm on centers.
- ii. At joints in lining.
- (b) In addition, secure with weld pins and 50 mm diameter washers on 400 mm centers.
- (c) Coat edges with sealer.
- (d) Provide continuous sheet metal edge protectors at entering and leaving edges of lined duct sections, and all joints.
- (e) Dimensions of lined ductwork are clear inside dimensions after lining has been installed.
- (f) Extent of ductwork sound linings:
 - i. Discharge plenum of AHUs as indicated on schedule or as required, lining shall be 100 mm thick, 48 kg/cum density. Provide lining for all plenum surfaces including walls, ceiling and sheet metal floors.
 - ii. All AHU supply and return ducts : 50 mm thick
 - iii. All Fan Coil Units for NC 40 or below spaces : 25 mm thick
- (g) Where ductwork velocities exceed 12 meters per second, use of internal lining shall be reviewed by the Architect in fulfilling the above requirements. If internal lining is deemed unsatisfactory for the particular application, provide perforated metal facing over internal lining, or sound traps as directed.

Sound Proof Construction for Duct Penetrations

- (a) Required for openings between ductwork and following construction:
 - i. Equipment room walls.
 - ii. Floors, except in shafts.
- (b) Sound proofing
 - i. Fill openings with fibrous glass blanket or board for full depth of penetration.
 - ii. Caulk each side of opening with non-hardening, non-aging caulking compound.
- (c) Shop Drawings
 - i. Sound Attenuators, including certified test data.
 - ii. Acoustical lining.
 - iii. Certification that sound lining meets erosion test method described in UL Publication No. 181.
- (d) Silencer Performance
 - i. Sound attenuators performance indicated below are guidelines only to meet NC requirements. The Contractor shall employ their own acoustic specialist manufacturer to review the actual sound data of the proposed equipment and define the sound attenuators performance to achieve the target NC levels.

Acoustic calculations to predict the final NC levels shall be submitted to the Project Engineer for approval.

Pipes and Conduits

Pipework connected to rotating machinery shall incorporate resilient supports, sized to meet the static deflections of the isolators designated for the associated machine for the length within the Plant Room.

Ensure that there is no rigid connection between pipes and the Plant Room wall. A clear opening of 25mm shall be left around all pipes penetrating Plant Room walls, packed with hardness 30 rubber foam sleeves ends with silicone sealant.

Electrical cables carrying power supplies to rotating machinery shall be in a looped form, and not connected via rigid conduits which may short-circuit vibration isolators.

1.6. ELECTRICAL WORKS

1.6.1. General

This section of the subcontract includes the supply, installation, painting, wiring, termination, testing and commissioning of all electrical equipment and controls necessary for the proper functioning of the works of this subcontract, and in particular the following:

- (a) All switchboards, remote control panels, sub-boards, etc., and all wiring from these boards to equipment.
- (b) Wiring from distribution boards or local isolators provided by the electrical services subcontractor to equipment.
- (c) Earthing

The subcontractor shall supply, install and connect all earth continuity wiring for effective earthings of the whole electrical installation under this scope in accordance with the requirement of the Australian Standard and to the requirements of the Local Authorities.

All final circuit protective conductors shall terminate at their respective board's earthing bar.

- (d) All electrical controls including sensors, relays, contactors, protection gear and associated control wiring.

Refer to the drawings and the rest of the specifications for interfaces between this subcontract and other subcontracts.

The subcontractor shall allow fully in his Tender Price for attendance during the commissioning of all equipment involved with the electrical and control installation to ensure optimum performance of the overall system, and for attendance on other parties involved the control and electrical system.

1.6.2. Mechanical Services Switchboards (MSSB)

Mechanical Services Switchboard will be provided by the Electrical Sub Contractor. The MVAC sub contractor shall ensure the below specified items are provided to complete the operational and functional mechanical services switchboard.

- (a) General

Mechanical services switchboard shall be provided in each plantroom or where indicated on the drawings or directed on site.

All switchboards shall be Form 1.

The fault level RMS for the switchboards shall be obtained from the Electrical Sub Contractor.

All electrical central panels shall be a dead front, totally enclosed, front connected cubicle constructed to conform with the requirements of AS1136.

Each panel shall be sized to suit its purpose and location.

Adequate space in accordance with AS3000 shall be provided for all specified equipment, incoming and outgoing cables and their terminations and access for installation and future maintenance.

Equipment shall be mounted in the panel in such a way that any item can be removed without disturbing any other item.

Equipment which must be accessible for operating the mechanical services such as selector switches and indicator lights shall be mounted on a hinged front panel of the cubicle.

Indication and control items to be provided on each switchboard includes, run and fault lights for each drive, voltmeter and selector switch, timeclock override switches, lamp test switch.

Access to the remaining equipment within the cubicle shall be by hinged doors.

(b) Construction

Cubicles shall be welded construction, fabricated from sheet steel not less than 1.6mm thick, with sheets bent to minimise the number of welded joints and provide sufficient rigidity with or without the doors fitted.

Doors shall be fabricated from sheet steel not less than 1.6mm thick, folded and braced for sufficient rigidity to prevent excessive warping and flexing.

Doors shall be straight and flat without distortion. Edges shall be rounded with no sharp or irregular projection.

Doors shall be hung to the cubicle by chrome plated lift off hinges.

Doors shall be fitted with lockable chrome plated handles or other approved means of fastening.

Doors with diagonal dimension greater than 1000mm shall also be fitted with locking bars and guides.

The edges of doors shall be fitted with compression gaskets. Doors shall be capable of being removed individually without disturbing other doors.

Earth continuity shall be provided throughout the cubicle including covers and doors by use of serrated star washers under nuts and bolt heads or other approved means.

(c) Finish

Unless otherwise specified the requirements for cubicle finish apply to exterior and interior surfaces.

After construction of the switchboard cubicles, covers and doors all welds shall be ground smooth and the whole switchboard shall be cleaned of slag, rust and grease prior to etch priming.

One coat of each primer having a suitable corrosion inhibiting compound shall be applied.

An undercoat shall be applied as a base for final coats unless otherwise recommended by the paint manufacturer.

At least two final full gloss coats of baked enamel, or paint of equal finish and hardness, shall be applied.

(d) Busbars And Connections

Within the cubicle busbars shall be the preferred method of connection on the line side of the protective devices for each circuit. Multipole proprietary busbar assemblies shall be used where possible.

Busbars shall be rated to carry the maximum loads of all equipment served with a maximum temperature rise in accordance with AS1136.

Busbars and busbar supports shall be designed to withstand the forces generated by the specified prospective fault currents.

Busbars shall be identified by coloured sleeving or by 25mm wide colour bands at 500mm centres with at least one colour band for each busbar section. The colours shall indicate the phases, neutral and earth.

Cable connections may be used within the control panel.

Cables shall comply with AS3147 and shall be sized to limit maximum temperature, when all equipment is at full load, to the rating of the cable insulation.

Cables shall be rated and fixed to withstand the prospective fault level without damage.

Neutral and earth busbars or links shall be provided with sufficient separate ways for connection of all incoming and outgoing neutral and earth conductors.

(e) Cable Terminations

The cubicle shall be provided with adequate cable entry facilities comprising entry slots fitted with removable cover plates, conduit knockouts or glands.

Brass gland plates shall be provided for termination of M.I.M.S. cable.

Suitable supports such as ducts, trays or support straps shall be provided within the control panel for all incoming and outgoing cables.

Incoming and outgoing cables, whether power or control, shall be terminated in the fixed portions of the control panel, not on hinged panels.

Power cables may be terminated directly on the terminals of switchgear and starters.

Control wiring shall be terminated on a numbered terminal strip. Internal connections shall be provided between the terminal strip and equipment.

(f) Control Wiring

Control wiring shall comply with the requirements of AS3147. The conductors size shall be minimum 7/0.5mm or 30/0.24mm. Conductors shall be insulated with minimum 250 Volt, V75 grade PVC. Conductors which are run unprotected in busbar chambers shall be double insulated.

The insulation and/or sheath of control wires shall be of one colour through the control panel and the colour shall be distinct from that of any power wiring.

Control wires shall be identified by means of moulded ferrules or sleeves at both ends. The ferrules or sleeves shall be of insulating materials which, except where otherwise specified, are to be white with black lettering and are to have a glossy finish.

Control wiring shall be run separately from power circuit wiring. Wires shall not be jointed or tee'd between terminals.

Each wire shall be separately terminated with tinned (but not soldered) crimped lugs of approved type suitable for the terminals and wire used.

Conductor terminations need not be provided where insertion or tunnel type terminals are used. Terminal studs or blocks shall be adequately rated for the duty. Terminal blocks of the insertion or tunnel type shall incorporate captive pinching screws and serrated clamping plates with an inherent locking feature.

Screws shall not bear on wires. Terminals shall be identified using an approved marking and numbering system.

An allowance shall be made on the length of each wire at the point of connection to a terminal for the remaking of the termination at least once without the need to disturb the main run of the wire.

Unless otherwise approved only one wire shall be connected to each terminal of insertion or tunnel type blocks.

Control wiring shall be laced and formed into looms supported on approved wiring cleats. Alternatively wiring may be run in insulated ducts.

1.6.3. Components

(a) General

Components of the one type, e.g. contactors, shall be of the same manufacture throughout the installation.

(b) Isolating Switches

Isolating switches including control panel main isolators shall comply with AS1775 and be suitable for fault making/load breaking duty.

Utilisation category shall be AC-23.

(c) Circuit Breakers

Circuit breakers shall be of the moulded case type complying with AS3111 or AS2184 depending on load and fault current rating.

The trip current rating shall be clearly marked on the circuit breakers and be clearly visible when the circuit breakers are installed in the control panel.

Identification of the contact positions shall be clearly marked on circuit breakers in a contrasting colour.

(d) Fuses

Fuses shall be H.R.C. cartridge type complying with AS2005.

Fuses shall be mounted in moulded carriers with shrouded controls similar to G.E.C. Red Spot.

Fuses shall not require a special tool for withdrawal or insertion.

(e) Indicator Lights

Indicator lights shall be of the oil tight type with heat resistant plastic or glass lens, minimum 22 mm diameter.

Lamps shall be incandescent type, maximum 24 Volts, rated between 2 and 6 Watts.

Lamps shall be capable of being changed from the front of the control panel and the lampholder shall remain rigidly fixed to the panel during lamp changing.

(f) Labelling

Every control panel and every item of equipment on or in the control panel shall be clearly and accurately labelled for identification and in the case of switches, pushbuttons, etc. to indicate the function, direction of operation, etc. as appropriate.

Minimum size of lettering shall be 3 mm; larger sizes shall be used where appropriate. Lettering shall be of a contrasting colour to its background.

Engraved lettering shall be black on white except in the case of main switch labels which shall have red lettering on white background.

1.6.4. Electrical Installation

(a) General

Unless specified otherwise wiring shall generally be run in PVC/PVC cables concealed wherever possible in ceiling spaces, wall and partition cavities, etc. Certain wiring is required to be in MIMS in accordance with AS1668.

When wiring is unavoidably exposed in occupied areas, wherever it is required to have mechanical protection and where it is chased into masonry, it shall be run in conduit.

Wiring associated with the mechanical services shall not be grouped together with nor run in the same duct, tray or loom with other electrical and communication wiring in the premises.

(b) Conduits, Ducts And Cable Trays

Conduits shall be Class B rigid PVC to AS2053 or screwed galvanised steel to AS2052.

Conduits shall generally be run wherever possible by casting into slabs, columns, etc. by running in wall cavities, ceiling spaces etc. or by chasing into masonry and in accordance with any details shown on the drawings.

Where conduits and ducts are run on the surface, they shall be neatly run parallel or perpendicular to building elements and where more than one conduits follows approximately the same route they shall be grouped together.

Where conduit runs exceed 12 m draw-in boxes shall be provided at intervals not greater than 12m.

All conduits and ducts must be in position and securely installed before any wiring is drawn-in.

Exposed conduits shall be fixed at not greater than 600 mm centres. Flexible conduits shall be used for final connections to motors and appliances.

Where cable trays and ducts are suspended below a roof, slab or ceiling single sided brackets shall be used to facilitate installation and removal of cables.

Generally trays, ducts, brackets, bracket spacing and method of fixing shall be such as to give adequate strength and rigidity.

Fixings for ducts, hangers or brackets shall be approved metal expansions devices, installed in strict accordance with the manufacturer's recommendation.

Wooden, fibre or plastic plugs will not be permitted. Explosive type fixings of the powder-powered type will not be permitted.

(c) Wiring Materials

Wires and cables shall be of specified manufacture as indicated the Schedule of Technical Data, type V75 PVC insulated, 660 Volt grade with copper conductors complying with AS3147.

Wires and cables shall be new and delivered to site in their original packages.

Where double insulation is required wires shall be PVC insulated and PVC sheathed.

Minimum size conductor shall be 2.5mm² for all cables.

Flexible conductors shall be not less than 24/0.2mm.

(d) Wiring Installation

Where large numbers of wires are running together, as where wiring emerges from a control panel they shall be run in duct or on cable tray.

All wiring shall be withdrawable. Therefore wires shall not be cast direct into concrete, cement render, plastic or the like.

The whole of the wiring shall be carried out on the loop-in system.

Above accessible and removable tile type ceilings TPS wiring shall be fixed at not less than 1200mm intervals to the slab or roof structure above. Alternatively, it

may be suspended on a catenary system. In either case no wiring shall be permitted to lie on top of ceiling tiles, luminaires and other items in ceiling.

1.7. TESTING, BALANCING & COMMISSIONING

1.7.1. General

Prior to delivery from the factory and shipment to site, the sub-contractor shall submit test certificates issued by the manufacturer for the MVAC equipment to be used for this project (including type test certificates). On completion of the works, the sub-contractor shall commission the MVAC installation and put them into operation in accordance with the Specification.

After commissioning and prior to Practical Completion, the sub-contractor shall provide all necessary facilities and instruments to carry out all tests as defined within the Specification to satisfy the Consultant that the installation meets the requirements of the Specification.

The sub-contractor shall ensure that there are sufficient facilities included in the air and water distribution systems to carry out an effective and comprehensive testing and commissioning exercise.

During the Defects Liability Period, the sub contractor shall carry out a regular comprehensive preventive maintenance service as well as breakdown service as specified later in this section of the Specification.

In addition, the sub contractor shall liaise with the other Contractors for the installation work and to carry out all adjustment necessary for the safe, reliable and satisfactory operation of all the equipment supplied under this Contract. Such adjustment shall be carried out after all control systems have been installed and tested.

The sub contractor's commissioning personnel must be experienced and trained. Qualifications of the commissioning personnel shall be submitted to the Consultant for approval.

1.7.2. Manufacturer's Supervision

The VRV system shall be tested and commissioned in the presence of Commissioning Engineers from the manufacturers.

1.7.3. Acceptance

The sub contractor shall appoint Commissioning Engineer, who shall co-ordinate all testing, inspections and final works to the approval of the Consultant. The sub contractor shall also submit in writing all the testing and commissioning procedures for the Consultant's approval. Testing shall be executed according to requirements stipulated in other sections of this Specification.

Unless otherwise approved in writing by the Consultant, a period not exceeding two weeks shall be allowed for all commissioning adjustments which must be completed prior to the Date of Completion of the Contract works.

The sub contractor shall within one month after the Date of Completion of the Contract works, carry out all outstanding items and rectify minor defects as instructed by the Consultant.

1.7.4. Equipment for Testing and Commissioning

All equipment required for the commissioning and testing of the Works shall be provided by the sub contractor.

These equipment shall include:

- Octave band sound meter
- Vibration meter
- Sling psychrometer
- Mercury in glass thermometers
- Pitot tube and inclined gauge manometer
- Electronic rotating vane anemometer
- Insulation megger
- Ammeter
- Voltmeter
- Cable test kit
- A discharge funnel or hood for measurement of air flow for light troffer or linear diffusers

All instruments shall have been recalibrated within six months of the start of commissioning or testing.

Calibration of all instruments shall be certified by the instrument manufacturer or a calibration agency approved by the Consultant. Refrigerant piping circuit shall be pressure tested to 4000 kPa for 24 hours, using dry nitrogen or anhydrous carbon dioxide.

1.7.5. Testing During Installation

Pressure test shall be carried out with compressors discharge and suction services valves closed. The pressure test shall be immediately followed by evacuation simultaneously from both sides of the systems to an absolute pressure of 3mm of mercury (i.e. the boiling point of water in the system is below 0°C) with compressors service valves open and vacuum pump running. The compressor service valves shall then be closed, and the vacuum pump isolated from the system. The evacuation test shall be deemed satisfactory if the absolute pressure rise over twelve hours does not exceed 4mm of mercury electronic vacuum indicator.

1.7.6. On-site Testing and Commissioning

The sub-contractor shall submit for the Consultant's approval a detailed programme for conducting on-site acceptance tests and commissioning.

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 when commissioning is complete, however, the sub contractor shall be required to carry out Performance Tests during the first years operation as maximum load conditions prevail.

The sub contractor shall start up, operate, test and adjust the systems in accordance with the agreed programme. The setting up shall be supervised by the manufacturer's representative, who shall remain on site until the equipment is operating satisfactorily and accepted by the Consultant. The sub contractor shall advise and co-ordinate with the manufacturer's representatives so that all testing is carried out according to the agreed programme.

The whole systems shall be flushed through prior to any testing commissioning is carried out as detailed in each relevant section of the Specification.

The whole installation shall be given the following tests to bring the plant into running order. The Consultant shall be given reasonable notice together with a copy of recorded test results, generally not less than seven days, regarding the nature of tests, the time and location. Acceptance tests will only be witnessed by the Consultant when the submitted test results are found satisfactory.

All instruments, tools, materials and labour required to perform these tests shall be provided by the sub contractor.

If the test results show that the plant and equipment is not functioning in a satisfactory manner or satisfying the requirements of this Specification, the Consultant shall decide whether this is due to incorrectness of faulty work by the sub contractor and if this be the case, the sub-contractor shall, when called upon, carry out at his own expense such alterations, replacements and adjustments as may be required, to the Consultant's decision as to what constitutes a satisfactory test shall be final.

1.7.7. Training

After handover of the plant, the sub contractor shall provide training to the facility management personnel in the safe and proper operation, care and maintenance of the system and shall demonstrate the operation of any special purpose plant requiring a skilled or certificated operator.

All instructions and demonstrations shall be carried out by way of special visits by competent and experienced technicians at a date to be notified by the Consultant.

1.7.8. Maintenance

The sub contractor shall carry out regular inspections at periods not greater than one calendar month, and shall fully service and maintain all plant included in this Contract for the term of the Maintenance and Defects Liability period.

The work required is:

- (a) Attend the site regularly to perform maintenance required by the equipment manufacturers and as detailed in the Operation and Maintenance Manuals.
- (b) Attend the site at any time during the specified Contract maintenance period, on request by the Consultant or Owner, and carry out remedial work necessary to keep the plant in good operating condition.
- (c) Make good any defects at the time of practical completion and all other defects which become apparent during the contract maintenance period.

1.7.9. Operation and Maintenance Manual

On completion of satisfactory Performance Tests and prior to Practical Completion, supply to the Consultant one copy of the Operating and Maintenance Manual for review and approval.

Once reviewed and approved, the 04 copies of the approved manual shall be provided.

The Manual shall include a full description of the installation and function of the various systems involved, together with instructions to cover every action necessary for the efficient operation and maintenance of the installation(s).

The Manual shall be neatly prepared and bound in a vinyl hard-back multiple ring (minimum 3 rings) folder with embossed lettering on the front in the format approved by the Consultant.

