

PART IV

GENERAL TECHNICAL SPECIFICATION

FOR

AIR CONDITIONING INSTALLATIONS

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4.1 **SCOPE**

- 4.1.1 This General Specification describes the usual material required for Air Conditioning installations and the general methods of constructing and installing the various components and equipment associated therewith.
- 4.1.2 This General Specification forms a supplement to the drawings and specifications for a particular subcontract. Where the detailed Specification of Part V and/or the drawings differ from this General Specification, the Detailed Specification and Drawings shall take precedence.

4.2 **GENERAL**

- 4.2.1 All workmanship and materials used in the installation shall be of the highest quality and, where not fully covered by this Specification, shall conform with best modern practice, as determined by the Engineer.
- 4.2.2 The entire installation shall comply fully with all relevant requirements of governmental and local authorities and the equipment provided for the installation shall comply in all respects with the Occupational Health and Safety Act of 1993 as amended.
- 4.2.3 All electrical work associated with the installation shall comply with the requirements of the Municipal Authorities and shall be carried out in accordance with the latest edition of the "Standard Regulations for the Wiring of Premises".
- 4.2.4 Alternative equipment, materials or apparatus from those that are noted or required on the drawings and/or in the Specifications, may only be offered and supplied on the written approval of such equipment, material or apparatus by the Engineer.
- 4.2.5 All things being equal, preference will be given to South African manufactured equipment, material or apparatus. In cases where all the necessary information is not supplied by the tenderer, then the Engineer's decision shall be final.

4.3 CHILLED WATER GENERATORS

4.3.1 DESIGN, MATERIALS AND FINISH

- 4.3.1.1 Chillers shall be of standard, factory assembled packaged type and the design, material and finish shall be equivalent to a well-known make approved by the Engineer.
- 4.3.1.2 The refrigerant to be used shall be R134a unless otherwise specified in Part V.

4.3.2 CAPACITY

- 4.3.2.1 The cooling capacity as specified in Part V shall be delivered in accordance with the relevant ARI specification.
- 4.3.2.2 The fouling factors used when selecting chillers shall not be less than the following:
- | | | |
|-----------------|---|---------------------------|
| Condenser tubes | : | 0,088 m ² K/kW |
| Chiller tubes | : | 0,044 m ² K/kW |
- 4.3.2.3 The maximum permissible saturated condensing temperature is 40,6°C.
- 4.3.2.4 The minimum permissible saturated suction temperature is 1°C.
- 4.3.2.5 The minimum permissible sub-cooling of the refrigerant is 6°C at full load.

4.3.3 COMPONENTS

The chiller shall comprise the following:

- ☐ One or more reciprocating or screw compressor;
- ☐ One or more evaporator;
- ☐ One or more water cooled condenser;
- ☐ All necessary refrigeration pipework;
- ☐ Accessories as listed;
- ☐ Control equipment as listed;
- ☐ Frame; and
- ☐ Compressor motor drive

4.3.4 COMPRESSOR(S)

The compressor(s) shall be of the screw type or of the open or semi-hermetic reciprocating type with built-in cylinder head by-pass controlled by either suction pressure or external signal in a number of steps as specified in Part V. The compressor shall be fitted with suction and discharge valves and crankcase heater. The compressor shall be direct driven at a speed not exceeding that of a four pole motor. A sight glass for checking oil level shall be fitted in the crankcase.

4.3.5 WATER COOLED CONDENSER

- 4.3.5.1 The condenser(s) shall be of the multi-pass shell and tube type constructed in accordance with the relevant ASME code. The condenser(s) shall be equipped with a pressure relief device and liquid line isolating valve.
- 4.3.5.2 The condenser(s) shall be circuited to give the sub-cooling specified and shall be fitted with a

device with which the liquid level within the condenser can be readily and reliably checked whilst the machine is on load.

4.3.5.3 The condenser shell shall be fitted with either a marine type water box or shall be connected to external piping in such a way that the water box covers can be easily removed.

4.3.5.4 The maximum permissible velocity of water in the tubes is 3 m/s.

4.3.6 EVAPORATOR

The evaporator shall be of direct expansion type with refrigerant flowing in the tubes and water in the shell. The shell shall be lagged with a minimum of 25mm non-combustible insulation, vapour sealed and finished with a durable outer protection.

4.3.7 REFRIGERANT CIRCUIT(S)

Each circuit shall include the following components:

- ☐ Refrigeration pipework in accordance with Part IV Clause 7.
- ☐ Expansion Valve
- ☐ Liquid line solenoid valve
- ☐ Filter driers with replaceable core.
- ☐ Sight glass situated above the operating level of the liquid in the condenser.
- ☐ Liquid line shut-off valve.
- ☐ Hot gas muffler.

4.3.8 INSTRUMENTATION

The unit shall be fitted with gauges to indicate suction pressure, discharge pressure and oil pressure for each compressor.

4.3.9 CONTROL AND ACCESSORIES

The unit shall be wired with all necessary controls in a separate enclosure. The following components shall be included:-

- 4.3.9.1 Crankcase heater control to operate when compressor stops.
- 4.3.9.2 Non-recycling pump down relay.
- 4.3.9.3 Timer to prevent compressor cycling in less than five minutes. (Units above 40kW refrigeration capacity only).
- 4.3.9.4 Transformer if controls are to operate at less than mains voltage.
- 4.3.9.5 High and low pressure cut out, the former with manual reset.
- 4.3.9.6 Oil pressure cut out with manual reset.
- 4.3.9.7 Unloaders to bypass cylinder heads on start up.
- 4.3.9.8 Low water temperature safety protection.
- 4.3.9.9 Chilled water leaving temperature control set to operate with a minimum of four steps in units above 200 kW refrigeration capacity, and in two steps in units above 100 kW refrigeration capacity.

4.3.10 MOTOR

The compressor(s) shall be driven by a three phase squirrel cage induction motor(s). The motor(s) shall have sufficient power and torque for all operating conditions on the compressor(s).

The motor(s) shall have four or six poles. Where open compressor(s) are used, standard protected drip proof or totally enclosed fan cooled motor(s) shall be fitted.

4.3.11 DRIVE

Where open compressor(s) are used the motor(s) shall be direct coupled to the compressor(s) by a flexible drive. A protective coupling guard shall be fitted to each drive.

4.3.12 FRAME

Components shall be mounted on a rigid frame such that any major component can be readily removed without removing other components. The base holding the motor-compressor shall be sufficiently rigid to prevent any torsional or lateral vibration or misalignment between the motor and compressor shafts.

Anti-vibration mounting shall be in compliance with Part IV Clause 35.

4.4 PACKAGED AIR CONDITIONING UNITS - AIR COOLED AND EVAPORATIVE CONDENSER COOLED

4.4.1 The packaged air conditioning units shall be suitable in all respects for outdoor location and shall be equal to **GÜNTNER** Roof Mounted Packaged Air Conditioners.

4.4.2 Units shall comprise the following components all housed within, or forming part of, their cabinet:

- Refrigeration Compressors
- Air Cooled Condensing coils
- Condenser Fans and Motors
- Refrigeration pipework and controls
- Refrigerant gas charge
- Direct Expansion Cooling coils
- Centrifugal Supply Air Fans with Motor and Belt Drive
- Electric Heater Elements
- Cleanable air filters
- Mixing plenum with Economy Cycle Dampers
- Electric Switchpanel
- Internal electrical wiring.

4.4.3 Unit casings shall be constructed of not less than 1,2mm thick mild steel panels suitably braced and framed so as to prevent drumming, whilst at the same time being arranged in easily removable panels to facilitate access to any portion of the internal components. Casing panels shall be attached to a sub-frame of welded mild steel sections, which framework shall also hold all internal equipment in position. The casing panels shall be internally lined with "sonic liner" or equivalent non-combustible material, such insulation being adequately secured to the internal surfaces with non-combustible adhesive and mechanical fasteners. All mild steel casing panels and framework shall be thoroughly degreased and then painted with a suitable rustproofing primer prior to the application of two finishing coats of good quality enamel or lacquer in the standard colour of the manufacturer.

4.4.4 Tenderers are to note that the unit casing specification above is the minimum required, and that preference will be given to units having double skin panel construction. Further, preference will be given to units having an outer skin of anodised aluminium, or fibreglass construction.

4.4.5 Units shall contain a minimum of two refrigeration compressors. These shall be of the hermetic or the accessible hermetic type, direct driven by integral suction gas cooled squirrel cage motors, at a rotational speed not exceeding 1500 r.p.m. The compressor shall be complete with positive displacement reversible force-feed lubrication systems, and shall have low oil pressure protection, and shall contain crankcase oil heaters to ensure boil-off of dissolved refrigerant from lubricating oil when the compressors are stationary. Each compressor shall have at least one stage of capacity modulation other than full load and shall be arranged to start unloaded.

Each compressor shall have at least one stage of capacity modulation other than full load and shall be arranged to start unloaded.

4.4.6 Condenser coils shall consist of copper tubes with mechanically bonded aluminium plate fins, all housed in a robust galvanised steel frame and protected with a suitable galvanised wire mesh screen. Suitable space shall be provided at the coil ends in order that tube bends are easily accessible in the event of possible refrigerant leaks.

4.4.7 Condenser fans shall be of the slow-running propeller type, direct driven by squirrel cage electric motors. The units shall be provided with a minimum of two propeller fans, which shall be arranged, preferably for vertical discharge through suitable weatherproofed protective wire guards. The fan and motor bearings shall be of the permanently lubricated sealed type, and the motor shall be resiliently mounted so as not to transmit vibration to the unit casing.

4.4.8 Condenser air intake and discharge arrangements shall be such that no short-circuited discharge air can be drawn back into the air intake.

- 4.4.9 Refrigeration pipework shall be carried out in seamless, refrigeration quality copper tubing, suitable provision being made to ensure that the piping is not subjected to any stresses from vibration of the compressors. The refrigeration system shall be split into at least two stages on the liquid side for adequate capacity control. Refrigerant circuits shall incorporate replaceable core type filter-driers, sight glasses, thermostatic expansion valves and vapour proof insulation on the suction lines. The systems shall be factory charged with Refrigerant 22.
- 4.4.10 Automatic safety controls within the unit shall include a dual pressure switch with manual reset on the high pressure side, and an oil pressure switch with manual reset. Provision shall be made for pressure relief of the high side refrigerant piping in accordance with government regulations. Provision shall also be made for cycling the condenser fans so that the units may be capable of operating down to an ambient temperature of 10°C db .
- 4.4.11 Direct expansion cooling coils shall consist of at least two separate refrigerant circuits and shall comprise of copper tubes with mechanically bonded aluminium fins. The coils shall be encased in a heavy gauge grade 304 stainless steel casing fitted with a 1,2mm thick grade 304 stainless steel condensate pan so sized and located as to prevent entrainment of moisture into the air stream, whilst also ensuring positive drainage of condensate.
- Cooling coil sizes shall be selected so that the face velocity does not exceed 2.5 m/s.
- 4.4.12 Supply air fans shall be of the double inlet, forward curved centrifugal type with impellers running in sealed, permanently lubricated ball-bearings incorporating pillow blocks located in the suction eye on both sides of each fan. Fan impellers shall be statically and dynamically balanced, and shall run well below critical speed. Fan assemblies shall be so mounted within the packaged air conditioning unit that they do not transmit any vibration. Where units having more than one fan are offered, these shall all be driven by a common motor.
- 4.4.13 Tenderers are to note that the supply air fan specification above is the minimum required and that preference will be given to units having a single, backward curved centrifugal fan mounted on anti-vibration mounts, and complete with a ventilated removable guard on the V-belt drive.
- 4.4.14 Supply air fan motors shall be three phase squirrel cage type, rated not less than 25% above the power input absorbed by the fans, and shall run at a rotational speed not exceeding 1500 r.p.m. The motor shall drive the fans by means of a V-belt drive having not less than two V-belts.
- 4.4.15 Heater elements shall be of the factory-bent, incoloy type, rated for still air, and fitted into the unit in such a manner as to ensure full air flow over each element.
- The heater elements shall be fitted into a withdrawable fabricated galvanised channel frame. The side on which the terminals are located shall be fitted with a terminal base of sufficient size to contain all necessary electrical wiring. The terminal box shall be fitted with a removable weather proofed cover so fastened that no screw shall project into the actual terminal box. The electrical wiring within the terminal box shall be effected in insulated wiring capable of withstanding the temperatures encountered without breakdown of the insulation.
- 4.4.16 Air filters shall be equal to **FIBATRON WP77**, minimum 50mm thick, high performance washable, pleated panel type, housed in adequate holding frames, and fitted with gaskets to ensure a positive airtight seal around them.
- 4.4.17 The return air and fresh air mixing plenum shall be factory installed and shall be of similar construction to the rest of the cabinet. The mixing plenum shall be complete with return air and maximum fresh air volume control dampers equal to those specified later herein.
- 4.4.18 Because of the use of an economy cycle, and the resultant possible low "on coil" dry bulb temperature in the intermediate season, the compressors shall be protected by low limit thermostats positioned in the mixing plenum, and set to prevent the compressors from operating at a mixed temperature below 18°C.

- 4.4.19 A weatherproof electrical switchpanel shall be incorporated to form part of the unit, and shall house all the necessary switchgear and controls required to operate the various components within the units. The switch panel shall comply with best modern practice, and shall incorporate all necessary protection against overload or short-circuit. The switchpanel shall be fitted with a suitably sized main isolator backed up by High Rupturing Capacity fuses with a minimum capacity to suit the system fault level. In addition phase failure relays shall be incorporated to protect against low voltage or phase failure. The switchgear shall be fully interlocked so that cooling and heating cannot operate simultaneously, and so that the compressors cannot operate unless the condenser fans and supply air fans are operational. A run down timer shall be incorporated so that the supply air fans shall continue to run for three minutes after the unit is switched off. The switchpanels shall be fully labelled with engraved black ivorine labels having 6mm high white lettering. The labels shall be rivetted to chassis plates to identify all switchgear, relays, instruments and controls inside the switchpanel.
- 4.4.20 Wiring within the switchpanel and the unit shall comply with wiring regulations as relevant, and shall be neatly grouped in horizontal and vertical runs in P.V.C. trunking. All wiring shall be colour - coded in the colours red, yellow and blue for the relevant phases, and black for neutral, the busbars being similarly marked. Busbars shall be copper of adequate cross sectional area, suitably spaced and mounted on stand-off type porcelain insulators. All exposed current carrying parts must be fully insulated with P.V.C. tape of the colours mentioned above. Every wire inside, and outside the switchpanel, shall be fitted with ferrules and shall be labelled with identical numbers at both ends. All outgoing leads shall be connected to a clearly marked terminal strip.
- 4.4.21 All equipment stored or installed on site shall be adequately protected at all times, until the final overall acceptance of the entire installation by the engineer.

4.5 AIR HANDLING UNITS

- 4.5.1 Units shall comprise the following components all housed within, or forming part of, their steel cabinets:-

Direct Expansion Cooling Coil
Refrigeration or Chilled Water Pipework and Controls
Centrifugal Supply Air Fans with Motor and Belt Drive
Cleanable Air Filters
Internal Electrical Wiring

- 4.5.2 Unit Casings shall be constructed of not less than 1,2mm thick mild steel panels suitably braced and framed so as to prevent drumming, while at the same time being arranged in easily removable panels to facilitate access to any portion of the internal components. Casing panels shall be attached to a sub-frame of welded mild steel sections, which framework shall also hold all internal equipment in position. The casing panels shall be internally lined with "sonic liner" or equivalent non-combustible material, such insulation being adequately secured to the internal surfaces with non-combustible adhesive and mechanical fasteners. All mild steel casing panels and framework shall be thoroughly degreased and then painted with a suitable rustproofing primer prior to the application of two finishing coats of good quality enamel or lacquer in the standard colour of the manufacturer.

Coastal unit casings shall be of galvanised construction throughout and generally in accordance with the above.

- 4.5.3 Tenderers are to note that the unit casing specification above is the minimum required, and that preference will be given to units having double skin panel construction.

- 4.5.4 Direct expansion cooling coils shall consist of at least two separate refrigerant circuits.

Cooling coils shall comprise copper tubes with mechanically bonded aluminium fins. The coils shall be encased in a heavy gauge grade 304 stainless steel casing fitted with a 1,2 mm thick grade 304 stainless steel condensate pan, so sized and located to prevent entrainment of moisture into the air stream, whilst also ensuring positive drainage of condensate.

Cooling coil sizes shall be selected so that the face velocity does not exceed 2,5 m/s.

The chilled water flow through the cooling coil shall be counter flow to the airflow across the cooling coil. The chilled water connections shall be supply at the bottom, and return at the top.

- 4.5.5 Refrigeration pipework shall be carried out in seamless refrigeration quality copper tubing. The refrigeration system shall be split into at least two stages on the liquid side for adequate capacity control. Refrigerant circuits shall incorporate replaceable core type filter-driers, sight glasses, thermostatic expansion valves and vapour proof insulation on the suction lines.

- 4.5.6 Supply air fans shall be of the double inlet, forward curved centrifugal type, with impellers running in sealed, permanently lubricated ball-bearings incorporating pillow blocks located in the suction eye on both sides of each fan.

Fan impellers shall be statically and dynamically balanced and run well below critical speed. Fan assemblies shall be so mounted within the air handling unit that they do not transmit any vibration. Where units having more than one fan are offered, these shall all be driven by a common motor.

- 4.5.7 Supply air fan motors shall be three phase, squirrel cage type, rated not less than 25% above the power input absorbed by the fans, and run at a rotational speed not exceeding 1500 r.p.m. The motor shall drive the fans by means of a V-belt drive having not less than two V-belts.

- 4.5.8 Air filters shall be equal to **FIBATRON WP77**, minimum 50mm thick, high performance washable, pleated panel type, housed in adequate holding frames, and fitted with gaskets to ensure a positive airtight seal around them.

- 4.5.9 Internal electrical wiring shall comply fully with wiring regulations as relevant, and shall be adequately secured. Adequate earthing shall be allowed.
- 4.5.10 Air handling units shall be equivalent to the make specified on the layout drawings or in Part V.
- 4.5.11 All equipment stored or installed on site shall be adequately protected at all times, until the final overall acceptance of the entire installation by the engineer.

4.6 REFRIGERATION CONDENSING UNITS - AIR COOLED

4.6.1 Air cooled refrigeration condensing units shall be suitable in all respects for outdoor location and shall comprise the following components housed within, or forming part of, its cabinet:-

- ☐ Refrigeration Compressors
- ☐ Air Cooled Condensing Coils
- ☐ Condenser Fans and Motors
- ☐ Refrigeration pipework and controls
- ☐ Refrigerant gas charge
- ☐ Electric switchpanel
- ☐ Internal electrical wiring.

4.6.2 Unit casing shall be constructed of not less than 1,2 mm thick mild steel panels suitably braced and framed so as to prevent drumming, whilst at the same time being arranged in easily removable panels to facilitate access to any portion of the internal components. Casing panels shall be attached to a sub-frame of welded mild steel sections, which framework shall also hold all internal equipment in position. All mild steel casing panels and framework shall be thoroughly degreased and then painted with a suitable rustproofing primer prior to the application of two finishing coats of good quality enamel or lacquer in the standard colour of the manufacturer.

Coastal unit casings shall be of galvanised construction throughout and generally in accordance with the above.

4.6.3 Units shall contain a minimum of two refrigeration compressors. These shall be of the hermetic or the accessible hermetic type, direct driven by integral suction gas cooled squirrel cage type motors, at a rotational speed not exceeding 1500 r.p.m. The compressors shall be complete with positive displacement reversible force-feed lubrication systems, and shall have low oil pressure protection, and contain crankcase oil heaters to ensure boil-off of dissolved refrigerant from lubricating oil when the compressors are stationary.

Each compressor shall have at least one stage of capacity modulation other than full load and shall be arranged to start unloaded.

4.6.4 Condenser coils shall consist of copper tubes with mechanically bonded aluminium plate fins, all housed in a robust galvanised steel frame and protected with a suitable galvanised wire mesh screen. Suitable space shall be provided at the coil ends in order that tube bends are easily accessible in the event of possible refrigerant leaks.

Condenser coils installed under coastal conditions shall consist of copper tubes with mechanically bonded copper plate fins, all housed in a robust stainless steel frame and protected with a suitable stainless steel wire mesh screen. Condensers to be Blygold treated.

4.6.5 Condenser fans shall be of the slow-running propeller type, direct driven by squirrel cage electric motors. The units shall be provided with a minimum of two propeller fans, which shall be arranged preferably for vertical discharge through suitable weatherproofed protective wire guards. The fan and motor bearings shall be of the permanently lubricated sealed type, and the motor shall be resiliently mounted so as not to transmit vibration to the unit casing.

4.6.6 Condenser air intake and discharge arrangements shall be such that no short-circuited discharge air can be drawn back into the air intake.

- 4.6.7 Refrigeration pipework shall be carried out in seamless, refrigeration quality copper tubing, suitable provision being made to ensure that the piping is not subjected to any stresses from vibration of the compressors. The refrigeration system shall be split into at least two stages on the liquid side for adequate capacity control. Refrigerant circuits shall incorporate replaceable core type filter-driers, sight glasses, thermostatic expansion valves and vapour proof insulation on the suction lines.
- 4.6.8 Automatic safety controls within the unit shall include a dual pressure switch with manual reset on the high pressure side, and an oil pressure switch with manual reset. Provision shall be made for pressure relief on the high side refrigerant piping in accordance with government regulations. Provision shall also be made for cycling the condenser fans so that the unit may be capable of operating down to an ambient temperature of 10EC db.
- 4.6.9 A weatherproof electrical switchpanel shall be incorporated to form part of the unit and shall house all the necessary switchgear and controls required to operate the various components within the unit. The switchpanel shall comply with best modern practice, and shall incorporate all necessary protection against overload or short-circuit. The switchpanel shall be fitted with a suitably sized main isolator backed up by High Rupturing Capacity fuses with a minimum capacity to suit the system fault level. In addition phase failure relays shall be incorporated to protect against low voltage or phase failure. The switchgear shall be interlocked so that the compressors cannot operate unless the condenser fans are operational. The switchpanel shall be fully labelled with engraved black ivory labels having 6mm high white lettering. The labels shall be rivetted to chassis plates to identify all switchgear, relays, instruments and controls inside the switchpanel.
- 4.6.10 Wiring within the switchpanel and the unit shall comply with wiring regulations as relevant, and shall be neatly grouped in horizontal and vertical runs in P.V.C. trunking. All wiring shall be colour-coded in the colours red, yellow and blue for the relevant phases and black for neutral, the busbars being similarly marked. Busbars shall be copper of adequate cross sectional area, suitably spaced and mounted on stand-off type black porcelain insulators. All exposed current carrying parts must be fully insulated with P.V.C. tape of the colours mentioned above. Every wire inside and outside the switchpanel, shall be fitted with ferrules and shall be labelled with identical numbers at both ends. All outgoing leads shall be connected to a clearly marked terminal strip.
- 4.6.11 Air cooled refrigeration condensing units shall be selected to match the associated air handling unit, and shall be equivalent to the make specified on the layout drawings or in Part V.
- 4.6.12 All equipment stored or installed on site shall be adequately protected at all times, until the final overall acceptance of the entire installation by the engineer.

4.7 REFRIGERATION PIPEWORK

- 4.7.1 Refrigeration piping shall be carried out in seamless, bright, clean refrigeration quality copper tubing and recessed solder joint fittings. Fittings shall be wrought copper or tinned cast brass. Soft annealed tubing shall be used on all pipe sizes below 19mm O.D. ,whilst hard drawn tubing shall be utilised on all larger sizes. All pipe cuts shall be neatly reamed and cleaned prior to making joints. Silver solder shall be used and tubing shall be protected against oxidation during silver soldering by the use of dry nitrogen flowing through the tubing.
- 4.7.2 Liquid refrigerant lines shall incorporate the following components:-
- ☐ Bypass flow replaceable type filter driers, of angle type and rated for the full refrigeration duty of the system.
 - ☐ Y - type full flow strainers.
 - ☐ Isolating valves of the diaphragm type.
 - ☐ Moisture indicating type liquid sight glasses.
 - ☐ Angle type, backseating, capped liquid charging valves with flare charging connections fitted with flare-fitting cap nuts.
 - ☐ Liquid line solenoid valves.
 - ☐ Thermostatic expansions valves of the external Equaliser type.
- 4.7.3 Suction lines shall be vapour proof insulated with 25mm thick, preformed "**ARMAFLEX**" or equal insulation. The "**ARMAFLEX**" insulation lengths shall be applied to the piping as and when the joints are being soldered in order to reduce the joints in the insulation to a minimum. Once the piping has been tested for leaks the insulation joints shall be glued and taped.
- All visible refrigeration piping and/or piping exposed to the weather shall be housed within galvanised, or ultra violet resistant P.V.C. trunking.
- 4.7.4 Refrigeration pipework shall be supported at centres not exceeding 2,4mm. Pipes shall be securely clamped to points of support using suitable holderbats. Insulated piping shall have moulded cork inserts of 25mm thickness and 50mm width in place of normal insulation where supports occur, vapour proofing at such points being carefully executed. Vibration eliminators of "**ANACONDA**" or equal make shall be installed where indicated on the drawings and the piping shall be supported immediately after such vibration eliminator.
- 4.7.5 All refrigeration pipework passing through walls and concrete floor slabs shall have P.V.C. sleeves within minimum 3mm thickness for the full depth of the wall and/or floor.
- 4.7.6 The sensing bulb of the thermostatic expansion valve shall be securely fastened to the suction line using a copper strip and brass screws.
- 4.7.7 Care shall be taken to ensure that pipework is neatly run in straight lines, this applying especially to soft copper tubing. Pipes shall pitch 25mm in 6m in the direction of flow to ensure oil return.

4.8 REFRIGERANT CHARGE

- 4.8.1 Refrigerant pipework systems shall be charged with refrigerant after evacuation and testing for leaks as outlined below:-
- 4.8.2 Complete refrigeration circuits shall be tested by means of dry Nitrogen to a pressure of at least 50% above working pressure. With the system under the pressure of the Nitrogen, all possible points of leakage shall be brushed with a solution of soap and water to which a few drops of Glycerine have been added. All soldered joints shall be tapped with a hammer to break possible flux seals. Any leaks which may be found by bubbling of the soapy water should be made good after the Nitrogen has first been released. When a leaking joint is detected, the fitting shall be taken out, cleaned and resoldered into the pipework again.
- 4.8.3 Systems should next be charged with Refrigerant to a minimum pressure of 200 kPa and then brought to a pressure of at least 50% above working pressure with dry Nitrogen. A "**HALIDE**" or Electronic leak detector shall at this stage be used to detect any further leaks.
- 4.8.4 Systems found to be free of leaks shall remain under pressure for a 24 hour period. If no pressure drop is observed after this period, taking into account ambient air temperatures, the Nitrogen mixture shall be discharged to atmosphere.
- 4.8.5 The system shall then be evacuated by means of a suitable vacuum pump to a vacuum of 2,5mm of Mercury, allowed to stand for 12 hours, and, if no pressure rise has occurred, shall be charged with refrigerant via the charging valve.

4.9. PACKAGED AIR CONDITIONING UNITS - WATER COOLED

4.9.1 The water cooled packaged air conditioning units shall comprise the following components all housed within, or forming part of, their steel cabinet-

- ☐ Refrigeration Compressors
- ☐ Water Cooled Condenser
- ☐ Refrigeration pipework and Controls
- ☐ Refrigerant Gas Charge
- ☐ Direct Expansion Cooling Coil
- ☐ Centrifugal supply air fans with Motor and Belt Drive
- ☐ Cleanable Air Filters
- ☐ Electrical Switchpanels
- ☐ Internal Electrical Wiring

4.9.2 Unit casings shall be constructed of not less than 1,2mm thick mild steel panels suitable braced and framed so as to prevent drumming, while at the same time being arranged in easily removable panels to facilitate access to any portion of the internal components. Casing panels shall be attached to a sub-frame of welded mild steel sections, which framework shall also hold all internal equipment in position. The casing panels shall be internally lined with "sonic liner" or equivalent non-combustible material, such insulation being adequately secured to the internal surfaces with non-combustible adhesive and mechanical fasteners. All mild steel casing panels and frame work shall be thoroughly degreased and then painted with a suitable rustproofing primer prior to the application of two finishing coats of good quality enamel or lacquer in the standard colour of the manufacturer.

Coastal unit casings shall be of galvanised construction throughout and generally in accordance with the above.

4.9.3 Tenderers are to note that the unit casing specification above is the minimum required, and that preference will be given to units having double skin panel construction.

4.9.4 Units shall contain a minimum of two refrigeration compressors. These shall be of the hermetic or the accessible hermetic type, direct driven by integral suction gas cooled squirrel cage motors, at a rotational speed not exceeding 1500 r.p.m. The compressors shall be complete with positive displacement reversible force-feed lubrication systems, and shall have low oil pressure protection, and shall contain crankcase oil heaters to ensure boil-off of dissolved refrigerant from lubricating oil when the compressors are stationary. Each compressor shall have at least one stage of capacity modulation other than full load and shall be arranged to start unloaded.

4.9.5 Each compressor shall be provided with its own tube in tube, shell and coil, or shell and tube water-cooled condenser, and shall incorporate a pressure relief device to comply with Government Regulations. All tubing within the condensers shall be of copper.

4.9.6 Refrigeration pipework shall be carried out in seamless, refrigeration quality copper tubing, suitable provision being made to ensure that the piping is not subjected to any stresses from vibration of the compressors. The refrigeration system shall be split into at least two stages on the liquid side for adequate capacity control. Refrigerant circuits shall incorporate replaceable core type filter-driers, sight glasses, thermostatic expansion valves and vapour proof insulation on the suction lines. The systems shall be factory charged with Refrigerant 22.

- 4.9.7 Automatic safety controls within the unit shall include a dual pressure switch with manual reset on the high pressure side, and an oil pressure switch with manual reset. Units shall incorporate timing devices to delay starting of compressors in order that refrigerant pressures may first balance between starting and stopping of the compressors.
- 4.9.8 Direct expansion cooling coils shall consist of at least two separate refrigerant circuits and shall comprise copper tubes with mechanically bonded aluminium fins. The coils shall be encased in a heavy gauge galvanised steel casing, fitted with a 1,2mm thick stainless steel condensate pan so sized and located to prevent entrainment of moisture into the air stream, whilst also ensuring positive drainage of condensate.
- Cooling coil sizes shall be selected so that the face velocity does not exceed 2,5 m/s.
- 4.9.9 Supply air fans shall be of the double inlet, forward curved centrifugal type, with impellers running in sealed, permanently lubricated ball-bearings incorporating pillow blocks located in the suction eye of both sides of each fan. Fan impellers shall be statically and dynamically balanced, and shall run well below critical speed. Fan assemblies shall be so mounted within the packaged air conditioning unit that they do not transmit any vibration. Where units having more than one fan are offered, these shall all be driven by a common motor.
- 4.9.10 Supply air fan motors shall be three phase squirrel cage type rated not less than 25% above the power input absorbed by the fans, and shall run at a rotational speed not exceeding 1500 r.p.m. The motor shall drive the fans by means of a V-belt drive having not less than two V-belts.
- 4.9.11 Air filters shall be equal to **FIBATRON WP77**, minimum 50mm thick, high performance washable, pleated panel type housed in adequate holding frames, and fitted with gaskets to ensure a positive airtight seal around them.
- 4.9.12 An electrical switchpanel shall be incorporated to form part of the unit, and shall house all the necessary switchgear and controls required to operate the various components within the unit. The switchpanel shall comply with the best modern practice and shall incorporate all necessary protection against overload or short-circuit. The switchpanel shall be fitted with a suitably sized main isolator backed up by High Rupturing Capacity fuses with a minimum capacity to suit the system fault level. In addition, phase failure relays shall be incorporated to protect against low voltage or phase failure. The switchgear shall be fully interlocked so that cooling and heating cannot operate simultaneously, or so that the compressors cannot operate unless the condenser water pump and the supply air fans are operational. A run down timer shall be incorporated so that the supply air fans shall continue to run for three minutes after the unit is switched off. The switchpanels shall be fully labelled with engraved black ivory labels having 6mm high white lettering. The labels shall be rivetted to chassis plates to identify all switchgear, relays, instruments and controls inside the switchpanel.
- 4.9.13 Wiring within the switchpanel and the unit shall comply with wiring regulations as relevant, and shall be neatly grouped in horizontal and vertical runs in P.V.C. trunking. All wiring shall be colour-coded in the colours red, yellow and blue for the relevant phases and black for neutral, the busbars being similarly marked. Busbars shall be copper of adequate cross sectional area, suitably spaced and mounted on stand-off type porcelain insulators. All exposed current carrying parts must be fully insulated with P.V.C. tape of the colours mentioned above. Every wire inside, and outside the switchpanel, shall be fitted with ferrules and shall be labelled with identical numbers at both ends. All outgoing leads shall be connected to a clearly marked terminal strip.
- 4.9.14 Water-Cooled Packaged Units shall be equivalent to the make specified on the layout drawings or in Part V.
- 4.9.15 All equipment stored or installed on site shall be adequately protected at all times, until the final overall acceptance of the entire installation by the engineer.

4.10. COOLING TOWERS

- 4.10.1 Cooling towers shall be of sufficient capacity to match the heat rejection requirements of the Water Cooled packaged air conditioners or chillers, whilst being selected in accordance with the air entering wet bulb temperature given in Part V of the Specification.
- 4.10.2 Cooling towers shall be of forced draft type, rectangular in shape, of sectional steel construction, and shall be equal to **EVAPCO** model **LST, or BAC**, Cooling Towers.
- 4.10.3 The Cooling Tower sump and main supports shall be constructed of hot-dip galvanised steel with a minimum thickness of 2mm. Reinforcing angles and channels shall be 4mm thick hot-dip galvanised steel. Standard sump accessories shall include access doors, stainless steel strainers, and brass make-up valve with unsinkable, foam filled, plastic float.
- 4.10.4 Fans shall be of the forward curved centrifugal type, statically and dynamically balanced. The fans shall be mounted on either a solid steel shaft or a hollow steel shaft with forged bearing journals. Shafts with welded journal construction or centre bearings shall not be permitted. The fan shaft shall be supported at each end by heavy duty, regreasable, self-aligning ball bearings in cast iron housings.
- 4.10.5 Driving motors serving the cooling tower fans shall be of the drip proof, squirrel cage type, and shall run at a rotational speed not exceeding 1500 r.p.m. The motor shall be mounted on an adjustable base external to the unit for ease of service and maintenance. The V-belt drive shall be designed for not less than 150% of the motor nameplate power rating. The motor and drive shall be installed with a protective canopy.
- 4.10.6 The cooling tower fill shall be of a fill type with a serpentine arrangement, with built in water distributors and air turbulators. It shall be constructed of self-extinguishing, polyvinyl chloride with a minimum thickness of 0,5mm, and shall be resistant to rot, decay and biological attack.
- 4.10.7 The spray header and branches shall be constructed of Schedule-40, polyvinyl chloride pipe for corrosion resistance, and shall have a steel connection for attachment of the external piping. The branches shall have removable plugs in the ends for cleaning purposes. The water shall be distributed over the fill by precision moulded spray nozzles with large, 9,5mm by 25,4mm, orifice openings to eliminate clogging.
- 4.10.8 Eliminators shall be constructed entirely of inert polyvinyl chloride in easily handled sections. The eliminator blades shall be spaced at 25,4mm centres, and shall incorporate three changes in air direction to ensure complete removal of all entrained moisture from the discharge air stream. They shall have a hooked leaving edge to direct the discharge air away from the fan's intake to minimise recirculation.
- 4.10.9 Cooling towers installed at the coast shall be coated with Power Bond II finish (cold tar epoxy coating) or equivalent, for maximum protection against corrosion. All paintwork shall be made good as required once the cooling tower has been installed. Alternatively a casing constructed from fibreglass will be acceptable.
- 4.10.10 Where cooling towers located in plantrooms under conditions where papers and plastic bags are likely to be drawn into the cooling tower fans, these towers are to be fitted with suitable weld mesh screens across the entire air intake section.

4.11 CLOSED CIRCUIT COOLERS

- 4.11.1 Closed Circuit Coolers shall be of sufficient capacity to match the heat rejection requirements of the Water Cooled packaged air conditioners or chillers, whilst being selected in accordance with the air entering wet bulb temperature given in Part V of the Specification.
- 4.11.2 Closed Circuit Coolers shall be of the induced or forced draft type, rectangular in shape, of galvanised sectional steel construction and shall be equal to **EVAPCO** model **ATW** or **LSW**, or **BAC**, Closed Circuit Coolers.
- 4.11.3 The Closed Circuit Cooler sump and main supports shall be constructed of hot-dip galvanised steel with a minimum thickness of 1.8mm. Reinforcing angles and channels shall be 4mm thick hot-dip galvanised steel. Standard sump accessories shall include access doors, stainless steel strainers, and brass make-up valve with unsinkable, foam filled, plastic float.
- 4.11.4 Fans shall be of the forward curved centrifugal type, statically and dynamically balanced. The fans shall be mounted on either side of a solid steel shaft with forged bearing journals. Shafts with welded journal construction or centre bearings shall not be permitted. The fan shaft shall be supported at each end by heavy duty, regreasable, self-aligning ball bearings in cast iron housings.
- 4.11.5 Driving motors serving the closed circuit coolers fans shall be of the drip proof ,squirrel cage type, and shall run at a rotational speed not exceeding 1500 r.p.m. The motor shall be mounted on an adjustable base external to the unit for ease of service and maintenance. The V-belt drive shall be designed for not less than 150% of the motor nameplate power rating. The motor and drive shall be installed with a protective canopy.
- 4.11.6 The cooling coil shall comprise steel tubing circuits supported by a heavy steel frame. The assembled coil shall be tested at 2400 kPa air pressure under water to ensure that it is leak free. The airflow through the coil shall be counterflow to the water flow, and the tubes of the coil shall be staggered in the direction of the flow to obtain a high film co-efficient. To protect the coil against corrosion the entire tubing and frame assembly shall be hot-dip galvanised.
- 4.11.7 The spray header and branches shall be constructed of Schedule-40, polyvinyl chloride pipe for corrosion resistance. The branches shall have removable plugs in the ends for cleaning purposes. The water shall be distributed over the coil by precision moulded spray nozzles with large, 9,5mm by 25,4mm, orifice openings to eliminate clogging.
- 4.11.8 Eliminators shall be constructed entirely of inert polyvinyl chloride in easily handled sections. The eliminator blades shall be spaced at 25,4mm centres, and shall incorporate three changes in air direction to ensure complete removal of all entrained moisture from the discharge air stream. They shall have a hooked leaving edge to direct the discharge air away from the fans air intake to minimise recirculation.
- 4.11.9 Closed circuit coolers installed at the coast shall be coated with Power Bond II finish (cold tar epoxy coating) or equivalent, for maximum protection against corrosion. All paintwork shall be made good as required once the closed circuit cooler has been installed. Alternatively a casing constructed from fibreglass will be acceptable.
- 4.11.10 Where closed circuit coolers and/or evaporative condensers located in plantrooms under conditions where papers and plastic bags are likely to be drawn into the closed circuit cooler/evaporative condenser fans, these closed circuit coolers/evaporative condensers are to be fitted with suitable weld mesh screens across the entire air intake section.

4.12 WATER TREATMENT

4.12.1 GENERAL

The Equipment and Chemical program are to be supplied by specialists in this field. The chemicals are to be compatible with all metals and materials that may be found in the system to be treated.

Chemicals utilised are to comply with the regulations of the local Authorities.

The Water Management Specialist / Chemical Supplier should ensure that his Program includes the optimisation of all the resources involved. Thus chemical usage, water and energy consumption will be taken into consideration.

Chemicals and services must be provided for the 12-month maintenance period. The Supplier will do at least a monthly service where water analysis tests are performed and a written report provided.

Corrosion racks must be installed and a quarterly report on the corrosion rates being experienced must be provided.

The chemical supplier must take safety and aesthetics into account and provide suitable holdings tanks from which the chemicals can be dosed.

Chemical Programs

The following systems shall be chemically treated:

- ☐ open condenser water systems
- ☐ closed hot and/or chilled water systems

4.12.2 PRETREATMENT

The Open and Closed systems must be flushed out and pretreated using a suitable chemical designed for this purpose.

The pre-treatment chemical and the procedure followed, must clean the systems, minimise flash corrosion and prepare them for the ongoing maintenance program.

4.12.3 WATER TREATMENT CONTROL EQUIPMENT

The water treatment unit shall be installed in the make-up line prior to the Closed Circuit Coolers or Cooling Towers. The unit shall be fitted in a horizontal straight pipe section.

Automatic control of the water stabilisation chemicals and bleed control is required.

The stabilization chemical for the open system should be dosed using a proportional feeding system.

This is to be achieved by the installation of a suitable water meter in the make-up line to the cooling towers. This water meter will send an activating pulse to the dosing pump.

A water meter and Y-tape strainer shall also be installed in the make-up line before the water treatment unit in order to record the make-up flow rate, and to collect all direct within the municipal mains water feed pipeline.

The water meter is to be installed with a by-pass to allow for maintenance without having to shut down the entire system.

The microbiological control chemical should be dosed using a pump that is timer controlled. It must be possible to set the frequency and length of time of dosing accurately.

The bleed off must be controlled by a conductivity sensor that is installed in a by-pass line between the supply and return lines from the cooling towers. A solenoid valve, that is normally closed, is to be activated via the sensor once a preset conductivity is reached. It must be possible to test the bleed unit manually, if so desired.

The chemical feed system and the bleed control system is to be two separate systems.

All of the above equipment is to be housed in suitable enclosures and must comply with all safety regulations including the Occupation Health and Safety Act.

4.12.4 OPEN COOLING SYSTEMS

The open condenser water treatment should achieve:

- ☐ water stabilization
- ☐ microbiological control

Stabilization of the condenser water will be such that neither scale forming nor corrosion will be allowed to take place in an uncontrolled manner.

Microbiological control will be the treatment of the water so that slime, bacteria (including disease-carrying bacteria such as Legionella) and algae are kept in check.

4.12.5 CLOSED SYSTEMS

The closed system hot and/or chilled water systems shall be treated such that the design heat transfer efficiency is maintained. This is to be achieved by keeping the system free of corrosive attack, deposit formation and any microbiological growth.

The chemical program for the closed systems must cater for and be compatible with all metals and materials that may be encountered.

4.13 WATER PUMPS

- 4.13.1 Water Pumps shall be sized by the Air Conditioning Contractor to handle the required water quantity against the calculated total head pressure, while operating at an efficiency of not less than 55%.
- 4.13.2 Water Pumps shall be of the non-overloading, centrifugal, volute type. They shall be of the vertically split, single suction type having the casing secured directly to the bedplate and operating at a rotational speed not exceeding 1500 r.p.m.
- 4.13.3 Water Pumps having discharge connections not exceeding 75mm may be of the close coupled type in which the impeller is overhung on the motor shaft, or, of the bracket-mounted type in which the casing is overhung from the bearing bracket. Pumps of either type shall operate at a rotational speed not exceeding 1500 r.p.m., except that where the total dynamic head exceeds 20m, rotational speeds not exceeding 3000 r.p.m. may be permitted.
- 4.13.4 Casings shall be designed for a working pressure of 5 bar or 1.5 times the actual discharge pressure, whichever is greater. Pressure classification of flange connections shall correspond to casing working pressures.
- 4.13.5 High points of pump casings shall be provided with air vent cocks. Low points of casings shall be provided with valved drains, and inlet and outlet connections shall be provided with properly located gauge tappings. Casing brackets of vertically split pumps equipped with stuffing boxes shall be arranged to form drip pockets. A drip pipe shall be run from each drip pocket and shall terminate over the nearest drip funnel or floor drain.
- 4.13.6 Impellers shall be bronze and shall be dynamically balanced. Impellers of pumps having 40mm and larger discharge connections shall be fully enclosed and hydraulically balanced.
- 4.13.7 Shafts for pumps with mechanical seals shall be stainless steel, monel metal, or shall be carbon steel with sleeves of bronze, chrome iron or nickel iron, extending through the mechanical seals. Shafts shall be provided with water slingers where mechanical seals are used.
- 4.13.8 Bearings for close coupled pumps shall be of the ball or roller type. Bearings for all other pumps shall be either ball or roller type, or ring oiled, or wool packed sleeve bearings with ample oil reservoirs. Thrust bearings shall be of either the ball or Kingsbury type. Bearings shall be effectively sealed to prevent loss of oil, and entrance of dirt or water.
- 4.13.9 Stuffing boxes will not be accepted by the Engineer.
- 4.13.10 All pumps, other than close coupled pumps, shall be provided with suitable flexible couplings with earthing straps. Couplings shall impose no restriction on normal end play or expansion.
- 4.13.11 Pumps shall be factory-assembled by their suppliers, together with their driving motors, on a common welded steel bedplate fabricated from mild steel channel sections. Bedplates shall be robustly constructed and free from distortion. Machine spacer plates or shimstock shall be used to align the pump and motor. Drives and associated guards shall comply with the relevant sections of the specifications, drives being works-aligned, and alignment rechecked after installation of the pumps on site, immediately prior to setting into operation.
- 4.13.12 Water Pumps shall be supplied as complete sets by their suppliers, incorporating pumps, bronze impellers, motors, drives, bedplates, stainless steel drip trays etc., factory assembled and despatched to the project complete in all respects.

4.14 WATER PIPEWORK

- 4.14.1 Water piping systems shall follow the routes indicated on the relevant Drawings. Piping shall be arranged to maintain sufficient headroom, keep access ways unobstructed and not interfere with maintenance and adjustment of valves and equipment.
- 4.14.2 Where pipe sizes are not indicated on the Drawings, pipes shall be sized for a maximum water velocity of 2,5 m/s within the Plant Rooms, and a maximum of 2 m/s for piping extending between the Plant Rooms and the Closed Circuit Coolers or Cooling Towers.
- 4.14.3 Steel piping shall have a minimum thickness equal to medium grade to SABS: 62.1971. Piping for closed circuit condenser water systems shall be of black medium type with welded joints. Galvanised medium piping shall be used on all open vented systems, such as cooling water type condenser water systems, drainage and mains water supply pipework. It shall not be permissible to weld or burn with a cutting torch any galvanised piping without having it regalvanised by an electroplating process
- 4.14.4 Long radius bends shall be used wherever possible, elbows only being permissible where limited space dictates their use. Reductions in pipe sizes shall be effected with reducing sockets, bushing reducers not being permissible. Threaded fittings shall be malleable iron to B.S.S. 143 or SABS 509:1955, or wrought steel to B.S.S. 1740:1971, as relevant. Welded fittings shall be genuine butt-weld fittings, to ASTM A234 GR.WPB-Dimensions to BS1640 or ASA B16.9. Welding of threaded fittings is not permitted.

4.14.5 VALVE SCHEDULE

All globe and gate valves (except screwed gate), shall incorporate back seating on spindles to facilitate repacking of gland under pressure.

All valves installed shall be of a high standard of manufacture and well known brand.

Types of valves shall be of the same manufacture.

Screwed valves shall be to BS.21 taper.

Flanged valves shall be BS4504 standards with connecting flanges to match.

ASA Standards will be accepted on steam installations (1050 kPa and over).

Screwed valves to be used up to and including 50mm, 65mm and over to be flanged valves.

Valves will be selected to conform to the pressure\temperature rating and duties applicable to the particular system, or application where being installed.

All valves shall conform to the following material specifications:

Bronze BS1400 LG 2-C\ASTM B62
Cast Iron BS 1452 GR 14\ASTM 126 Class B
Malleable ASTM A-47 GRD 32 510
Ductile BS 2789 (1961) ASTM or A 395
Cast Steel ASTM A 216 GRD W C B

Strainers shall be of the "Y" pattern, bronze screwed, with stainless steel screen equal to TOA fig. "Y" or cast iron body flanged, bolted cover with blow down plug and stainless steel screen to be fitted with extraction handle for easy removal, to SHOWA fig. 33 or equal.

Screen perforations as follows:

up to and including 50	1,2mm dia
mm 65mm to 150mm	2,0mm dia
200mm and over	3,5mm dia

Gate Valves shall be SABS 776-1975, Class B screwed, or equal, or cast iron body flanged with bronze rising spindle, and trim, outside screw and yoke, solid wedge disc, to BS 5150 J Fig. KF 502 or equal.

Globe Valves shall be bronze body screwed, internal screwed bonnet, rising spindle bronze to bronze tapered seats to Conti Fig. 70400 or equal, or cast iron body flanged with bronze rising spindle, and trim, outside screw and yoke to BS 5152 J Fig. KF 501 or equal.

Check Valves shall be bronze screwed, swing check type, bronze seats to Conti Fig. 77104 or equal, or cast iron body flanged solid, cast iron flap with bronze trim and bolted cover to BS 5153 J Fig. KF 601 or equal.

Alternative Wafer type, non-slam check valves, central pivoted butterfly flaps with bronze on BUNAN seats to DIN 3202, or API 594 J, Fig. KF 301 or equal.

Balancing Valves shall be Crane, Tour or Anderson or equal, shut-off/balancing valve with pressure sensing points over the valve for determining water flow rates. All valves to have calibration markings and 65mm and over, flanged cast iron Epoxy coated.

4.14.6 At all high points of the water systems fit PURG-O-Mat Fig. KS 69, or equal, automatic air vents with integral check valves. Each air vent shall be preceded by a gate valve to allow maintenance of the air vents. Automatic air vents shall ensure positive removal of all air from water piping systems. At all low points of the systems fit 15mm diameter drain cocks with hose unions, these valves so located that the entire piping system can be completely drained. Fit such drain valves at equipment if necessary to allow complete drainage.

4.14.7 Closed circuit condenser water and chilled water systems shall be connected to an expansion tank. The tank shall be of adequate size to suit the system, and shall be manufactured from 2mm galvanised sheet steel. The minimum water level in the tank shall be kept at approximately 300mm from the bottom by means of a 20mm nominal size ball valve. The tank shall be provided with a separate quick filling connection, overflow, and a lid with an air vent.

4.14.8 At all equipment connections to vibrating equipment fit flexible connectors equal to Fig. KF 401, as supplied by Kerr Valves. All flexible connectors shall have flanged joints and be capable of a 16 bar, or 1,5 times the system working pressure, whichever is the higher value.

4.14.9 Copper earthing straps shall be fitted over all flexible connections and shall be carried out in accordance with the standard wiring regulations (see Clause 31.1 - Page 50).

4.14.10 Pipe joints shall be neatly made, all pipe cuts properly cleaned and reamed. At all connections to equipment use flanged joints to conical face unions for smaller pipe sizes up to 40mm nominal bore. Incorporate sufficient flanged joints or unions to allow dismantling of sections of pipework to facilitate access to plant items for maintenance purposes. Use screwed joints on galvanised pipework up to, and including, 100mm nominal size, and on black piping up to, and including, 50mm nominal size. Where galvanised piping is called for above 100mm diameter, use black piping with welded joints, all hot-dip galvanised after welding.

Black piping all sizes over 25mm diameter may be welded. Screwed joints on piping up to 25mm diameter shall utilise P.T.F.E. jointing tape equal to 3-M manufacture. For larger joints use Hemp and Stag, or equivalent jointing compound. Flanged joints shall include Klingerite gaskets or equivalent. Caulking of joints will not be permitted.

4.14.11 Plug open ends of pipings, drains, fittings and equipment connections during installation to keep systems free of rubble, dirt and other foreign matter.

4.14.12 Maximum support spacing for pipework shall be:-

50mm diameter and smaller	3 m
65 to 100mm diameter	4,5 m
above 100mm diameter	6 m

4.14.13 All piping systems shall be flushed out properly to ensure cleansing, prior to the operation of the plant.

4.14.14 Piping systems shall be tested by means of an hydraulic pump to twice the operating pressure of the system, or, where it is not permissible due to the maximum allowable piping working pressure, the piping shall be tested to the limit set by such maximum allowable working pressure.

4.14.15 PRESSURE INDICATION

All dial pressure gauges shall be snubbed or glycerine filled to prevent pointer vibration. Gauges shall have an accuracy of 2%. The range shall extend to 150% of the maximum operating pressure.

All inclined manometer differential pressure gauges shall have an accuracy of 2%. The range shall extend to 150% of the maximum operating pressure, with graduation being in steps of 10 kPa.

All differential dial pressure gauges shall have an accuracy of 2%, and shall not be less than 100mm diameter. Zero pressure reading shall be in the centre, and the range of scale on either side shall extend to 150% of the maximum operating pressure, with provision being made for individual pressure reading.

4.14.16 TEMPERATURE INDICATION

All direct reading thermometers and temperature reading devices shall have an accuracy of 0,5°C, and a range of -10°C to 10°C, unless otherwise specified, with graduation being in steps of 1°C.

Stem thermometers shall be approximately 100mm long, and dial type thermometers approximately 80mm diameter.

Wells shall be set vertical or at an angle to retain oil. Pipes smaller than 80mm bore shall be enlarged at points where wells are installed as per following table:

Pipe bore (mm)	15	20	25	32	40	50	65
Size of enlargement (mm)	32	40	50	50	50	65	80

The sensor element shall be at the centre of the pipe.

4.15 **CHILLED WATER PIPEWORK INSULATION**

Chilled water piping shall be insulated, using rigid preformed sections having a bore to suit the pipe.

The insulation shall be externally covered. The covering to the insulation shall form a complete vapour barrier as specified below.

Insulation in plantrooms and enclosures, insulation which is visible, and insulation exposed to the weather, shall be finished with two coats of polyester resin reinforced with 300g fibreglass Chopstrand. This shall be sanded smooth followed by finishing tissue and coated with a resin rich topcoat pigmented to the colour codes in Clause 36.6 of this section. The finish on insulation exposed to the weather shall be white in colour.

Factory made, fibreglass coated (as above), preformed saddle sections of pipe shall be placed at all hanging support points. The pipe supports shall be placed over these saddle sections, allowing for a continuous vapour seal across the pipe insulation.

The densities of the insulation at hanging/support points shall be as follows:

15 mm to 100 mm diameter	-	60 kg/m ³
Above 150 mm diameter	-	80 kg/m ³

Rigid preformed piping insulation shall be applied, wherever possible, for the insulation of bends, tees, elbows, flanges and valves. Where pre-formed pipe insulation is not possible to use, blocks or batts shall be securely wired or banded in position and all joints and voids shall be filled with mineral wool.

Where practically possible, piping shall be supported OUTSIDE the insulation on cradles. Where the load on the insulation exceeds the strength thereof, a suitable part of the insulation shall be replaced by material having higher crushing strength.

Where insulation is specified for piping, the same shall apply to all fittings and pipe connections within the system.

The Sub-contractor shall base his main offer on the following specification: -

INSULATION		POLYISOCYANURATE (PIC) 35 kg/m ³ ;
PRIMER	Make	Bitumen Emulsion, First Coat Pipe\section seal PEKAY BE2 BITUMEN EMULSION
JOINT SEAL	Make	PEKAY MASTIC 220
BINDING TAPE	Make	Vinyl Buff Tape 24mm wide 3M
VAPOUR SEAL (All Piping)		TWO COATS POLYESTER RESIN
MEMBRANE (All Piping)		300g FIBREGLASS CHOPSTRAND

FINISH VAPOUR SEAL
(Concealed Piping)

HIGH GLOSS ENAMEL

FINISH VAPOUR SEAL
(All other Piping)

PIGMENTED RESIN RICH TOPCOAT

INSULATION THICKNESS

CONCEALED PIPING AND EXPOSED PIPING INSIDE BUILDING

15mm diameter to 80mm diameter -
Above 100mm diameter -

25mm thick
50mm thick

EXPOSED PIPING TO THE WEATHER

15mm diameter to 65mm diameter -
Above 80mm diameter -

25mm thick
50mm thick

4.16. **DUCTWORK**

4.16.1 Ductwork shall be carried out in accordance with the details shown on the Drawings, and shall be fabricated from prime quality galvanised sheet steel. All duct sizes indicated on the drawings are metal sizes, and include the necessary allowances for any internal insulation which may be specified.

4.16.2 Ductwork shall be fabricated and installed in accordance with the following specification, which shall be read in conjunction with the standards set by the South African Bureau of Standards (SABS) Standard Specification for Air Conditioning Ductwork, SABS 1238-1979, which shall be adhered to in detail except only as hereinafter specified.

4.16.3 Rectangular ductwork sheet steel thickness and cross breaking length shall be as follows:-

Duct Size long side mm	Semi Perimeter	Duct Joint	Sheet Steel thickness mm	Cross Breaking length mm
Up to 750	<1150	Slip & Drive	0,6	2400
Up to 750	>1150	Mez	0,6	2400
760 to 1350		Mez	0,8	1500
Above 1350		Mez	1,0	1500

4.16.4 Longitudinal seams shall be Pittsburgh lock on all duct sizes. Cross joints on concealed ductwork having a semi-perimeter not exceeding 1150mm shall be as follows:-

Duct Size long side mm	Long Side	Short Side
Up to 750	'S= slip	Drive Slip

Cross joints on concealed ductwork having a semi-perimeter in excess of 1150mm shall be of Mez or equal flange type, installed in accordance with the manufacturer's recommendations. As an alternative to the Mez or equal flange joints, 40mm x 3mm angle flange joints may be used.

Cross joints on all exposed ductwork shall be of Mez or equal flange type.

4.16.5 Ductwork supports shall be of rod and angle type, sheet metal straps not being permitted. The size and spacing of these supports shall be as follows:-

Duct Size long side mm	Semi Perimeter	Angles mm	Rods dia mm	Spacing Max - mm
Up to 750	<1150	40 x 2	6	2400
Up to 750	>1150	40 x 2	6	2400
760 to 1350		40 x 3	8	2400
Above 1350		40 x 6	8	3000

Rods shall be cut back so as not to protrude beyond the angle bracket.

4.16.6 Rectangular ductwork shall be regarded as low velocity, low pressure ductwork, suitable for pressures up to 500 Pa and velocities up to 10 m/s. It shall accordingly be fabricated and installed to comply with the above requirements, and SABS 1238-1979.

4.16.7 All cross joints in ductwork shall be sealed with a liberal coating of 3M or equal Duct Sealer. Longitudinal joints/seams exposed to the weather shall be made waterproof.

- 4.16.8 All duct connections to vibrating equipment shall consist of a flanged joint, followed by a flexible connector, consisting of a neoprene covered, fibreglass cloth, fixed on either side of the joint in a double lock seam, to form an airtight flexible joint with a minimum of 50mm separation between metal edges. Ducting at flexible joints shall be so supported that the ductwork is held square with the adjoining ducting and no stress is imposed upon the flexible joint. Copper earthing straps shall be fitted over all flexible duct connections and be carried out in accordance with the standard wiring regulations.

The flexible connections exposed to the weather shall be covered with a sheetmetal strip, to protect the flexible material from direct sunlight.

- 4.16.9 Flexible ducts shall be **EUROPAIR INSULATED ISODEC – TYPE 25A**, or approved equal. They shall comprise aluminium innercore, shielding the fibreglass insulation from the airstream. The outerjacket / vapour barrier shall be of a very tough spirally reinforced multiple layer aluminium laminated construction. Where flexible ducts connect to normal sheet metal ductwork or other equipment, a liberal coating of 3M or equal Duct Sealer shall be used, the joint then sealed with **DURO – DYNE**, or equal, 75mm wide duct tape, and finished with an approved clamp or metal strap to ensure an airtight joint.

- 4.16.10 Circular flexible ducting connected to supply air diffusers shall not exceed 1,5 metres in length.

- 4.16.11 All supply air ducting shall be pressure tested with a maximum permissible leakage of 5% at a test pressure of twice the working pressure.

- 4.16.12 The maximum permissible leakage rate for return and ventilation air systems shall not exceed 5%.

Kitchen canopy and fume extract air ducting systems shall be made 100% airtight.

- 4.16.13 All insulated ducting in storage, or in position, shall be adequately protected at all times.

- 4.16.14 All ducting joints exposed to weather shall be waterproof and corrosion free.

- 4.16.15 All ducting exposed to the weather shall be painted as per Clause 4.36.2 of this section. Colour coding shall be as per Clause 4.36.6 of this section.

4.17 DUCTWORK INSULATION

- 4.17.1 Ductwork shall be insulated according to the requirements noted on the Drawings and in accordance with the following specifications.
- 4.17.2 Where noted on the Drawings, the supply air ducting shall be internally insulated with 25mm thick "sonic liner" or equal, glued to the inside surface of the ducting with a fire retardant adhesive. In addition the insulation shall be further mechanically secured with Grip Nails, or 'Spotter Pins', at 450mm centres, and not more than 75mm from the edges of each panel. The insulation ends shall be covered with 0,8mm thick galvanised metal strips rivetted to the duct panels to prevent erosion of particles of the insulation into the air stream.
- 4.17.3 External supply and return air ducting shall be internally insulated with 50mm thick "sonic liner" or equal, glued to the inside surface of the ducting and mechanically secured as specified in clause 17.2 above.
- 4.17.4 Ducting installed in open roof spaces above insulated ceilings shall, in addition to being insulated internally with 25mm thick "sonic liner" or equal in accordance with clause 17.2, be wrapped externally with 50mm thick "foil faced" or equal fibreglass insulation, unless otherwise noted on the drawings. This external insulation shall be strapped around the ducting with strapping bands fixed at 1200mm centres, and joints sealed with foil duct tape.
- 4.17.5 All supply and return air ducting installed in open plantrooms and exposed to the weather shall be insulated with 40mm thick polyisocyanurate (PIC) foam insulation (35 kg/m³) glued onto the ducting. All joints in the ducting are to be sealed before application of the insulation. The insulation shall be covered with 300 g fibreglass chopstrand. The chopstrand shall be covered with two coats polyester resin. This shall be sanded smooth and coated with a resin rich topcoat pigmented in white colour.
- 4.17.6 Ventilation ducting only installed above ceilings and below concrete slabs shall be uninsulated, unless otherwise noted on the Drawings.

4.18 DIFFUSERS. GRILLES AND LOUVRES

4.18.1 Air distribution shall be effected by means of ceiling diffusers or grilles of the sizes, types and having the discharge patterns as indicated on the Drawings.

4.18.2 Ceiling Diffusers and grilles shall be fixed to spigots extending not less than 100mm from the ducting, unless otherwise indicated on the Drawings, and shall be securely fixed so that no screws or other fixing devices are visible.

4.18.3 Supply air diffusers shall be of steel construction, and shall consist of an inner core which shall be easily removable from the outer section to facilitate access to the volume control damper located behind the diffuser. The inner core shall consist of concentric rectangular collars and the outer section shall consist of a single rectangular or bevel collar provided with a concealed spigot for attaching the diffuser to the supply ductwork.

The rear backing including the disc of all supply air diffusers for coastal projects, shall be lagged with a minimum 3mm thick life care - fire and heat resistant foam.

Supply air diffusers shall be equal to **RICKARD** model CCD or VCD, complete with dampers, and shall be finished in an epoxy powder coating in a colour to suit the Architects requirements. Alternatively fibreglass or aluminium diffuser casings will be acceptable.

4.18.4 Supply air grilles shall be of the double deflection type, consisting of two rows of individually adjustable aerofoil section vanes, the front vanes being horizontal and the rear vanes vertical. The vanes shall be housed in a surrounding fixing flange with neat mitred joints at the comers. The entire grille assembly shall be of extruded aluminium construction and shall be finished in plain anodised aluminium unless otherwise noted on the Drawings.

Supply air grilles shall be equal to **EUROPAIR OR TROX** complete with factory fitted opposed blade dampers.

4.18.5 The multivane opposed blade dampers provided with supply air diffusers and grilles shall be finished in matt black lacquer. The dampers shall be attached to the rear of the grilles and fitted into the spigot connections or the diffusers and shall be adjustable, by means of a key or a lever, from the front of the installed diffusers and grilles.

4.18.6 Return air grilles shall consist of aluminium grid core housed in an extruded aluminium fixing flange with neat mitred comers and finished in plain anodised aluminium, unless other noted on the Drawings.

Return air grilles shall be equal to **EUROPAIR OR TROX** with a 12mm grid core.

4.18.7 Door grilles shall be of extruded aluminium construction, equal to **EUROPAIR OR TROX** suitable for fitting into doors of varying thickness, and shall be finished in a colour to suit the Architects requirements. Door grilles shall be fixed to doors by means of countersunk screws with a colour to match the door grille.

4.18.8 Outside air intake weather louvres shall be of the extruded aluminium, fixed vane type, fitted with a metal vermin proof screen on the rear side, as well as an opposed blade damper.

Dampers shall be provided with a locking device so that once they have been set for the correct air flow they can be permanently locked in position. Louvres shall be finished in plain anodised aluminium.

Where indicated on the Drawings the outside air intake louvre assembly shall be fitted with filter holding frames, with firmly fixed foam rubber gaskets and spring clips, for the attachment of the fresh air filters, as later specified herein. The frames shall be fixed to the weather louvre so as to prevent any air by-passing the filters.

4.18.9 Rubber gaskets shall be glued to the rear of the fixing flanges of all diffusers, grilles and louvres, to ensure airtight seals and prevent smudging.

4.19 DAMPERS

4.19.1 Dampers shall be provided where shown on the Drawings for shut-off, bypass or volume control purposes, or where required to comply with local fire codes.

4.19.2 Volume control dampers shall consist of multiple blades acting in opposed blade manner, the blades being robustly linked together to operate in complete unison. Individual blades shall be hooked-edge construction, so bent for rigidity. The blades shall have steel trunnions mounted in bronze sleeve bearings or ball bearings. Permanently set dampers shall be provided with suitable devices to facilitate locking them in position, with 'Open' and 'Shut' position indicated.

Motorised dampers shall include suitable fastenings and supports for motor actuators.

Damper hardware shall be the product of an accredited manufacturer of such items, equal to **DURO-DYNE**. Damper sections shall be housed in flanged steel metal casings of 1,6mm thick galvanised steel. Damper blades shall not exceed 200mm in width and 1000mm in length. Dampers over 1000mm in length shall be sectionalised into separate cells, each with its own shaft and bearings, to ensure that the blade length of each section does not exceed 1000mm.

4.19.3 Fire dampers shall be equal to **BLENDAIR** or **TROX**, and manufactured to a recognised fire code with a two-hour fire rating. Damper casings shall have flanged ends and damper blades shall not exceed 300mm in width. The fire dampers shall comply in all respects with the requirements of the local municipal fire authorities in the area where they are to be installed.

Damper blades shall be closed by the operation of approved fusible links, located where they would be immediately affected by an abnormal rise in temperature of the air stream. When called for on the Drawings, the blades shall also be actuated by solenoid operators which shall be provided by the damper manufacturer. When closed the blades shall be held by a catch arrangement so as to provide a positive seal against the air stream.

4.19.4 Duct mounted air volume control dampers and fire dampers installed in ducts shall be provided with a minimum 300 x 300mm inspection opening, so that the dampers may be checked, maintained and reset when required. These inspection openings shall be covered with suitably sealed access panels.

4.20 SOUND ATTENUATORS

4.20.1 Sound Attenuators shall be provided and installed in the positions indicated on the Drawings, and shall be selected to provide the Noise Criteria levels specified in Part V hereof. Sound Attenuators shall be of factory fabricated type equal to those manufactured by **SOUND ATTENUATORS LIMITED**.

4.20.2 The sound absorbing lining material shall impart no odour to the air, shall not delaminate readily, and shall have no loose material or any exposed surface that may be detached by the air stream either during installation, or under regular operating conditions. The material shall also be non-combustible.

4.20.3 All lining material shall be in good condition at the time of final inspection. Material that has been damaged in shipment by rough handling, vibration or exposure, shall be rejected. Material that has been damaged prior to final inspection shall be replaced or coated to prevent detachment of loose material as directed by the Engineer.

4.20.4 Sound absorbing lining material generally shall have a density of not less than 16kg per m³, a thickness of not less than 25mm, and sound absorbing efficiency at each frequency of not less than the following:-

Frequency cycles per second	250	500	1000	2000
Percent absorption	45	65	65	80

4.20.5 The factory fabricated sound attenuators shall be complete units consisting of an outer casing, sound absorbing material and internal baffles and supports. Casings shall be made of zinc-coated steel, not lighter than that specified herein for ducts of the same outside dimensions.

4.20.6 Sound attenuators installed in any extract system from a kitchen canopy shall be Melinex lined.

4.20.7 Sound attenuators that form part of a system that operates under smoke/fire conditions shall have their lining covered with perforated plate.

4.21 AIR FILTERS

- 4.21.1 Air filters shall be installed before the coils in the packaged air conditioning units and the air handling units, and shall be equal to **FIBATRON WP77**, minimum 50mm thick, high performance, washable, pleated panel filters.
- 4.21.2 Long life air filters installed in independent air filter banks in Plantrooms, or before the coils in packaged air conditioning units and air handling units, where indicated on the Drawings, shall be equal to **BRANDT EXPO 3000** extended surface air filters with **VILEDON** type PSB 290 filter media having an arrestance of 90% (ASHRAE). Each filter cell shall be suitable for the manufacturer's recommended air flow of 0,833 m³/s at an initial resistance of 20Pa. Manometers to be used in conjunction with these filters shall be set for a final resistance of 150 Pa.
- 4.21.3 Fresh air filters shall be of the same make, type and size as the return air filters fitted in the units, and shall be fitted into the holding frames installed on the rear of the outside air intake weather louvre, so as to be easily removable from inside the plant room area or building.
- 4.21.4 Air filters shall be fitted into holding frames which shall be so designed to allow a negligible quantity of air to bypass the filters.
- 4.21.5 All filter banks shall be mounted in easily accessible positions and shall be reachable with a normal 1.8m long ladder.

4.22 PROPELLER FANS

- 4.22.1 Propeller fans shall be of the size and type as indicated on the Drawings, and shall be capable of the duties specified in Part V hereof.
- 4.22.2 Propeller fans shall be of the direct connected, motor-driven type equal to **DONKIN, WOODS, LUFT** or **ZIEHL** manufacture. Wheels shall have steel or aluminium blades with heavy hubs. The fans shall be quiet in operation and shall be dynamically balanced.
- 4.22.3 Mounting rings or plates shall be cast, or die formed, to smooth curves where the air enters the wheels. Mounting plates shall be heavy enough to prevent distortion and shall be turned up at all edges or braced with steel angles.
- 4.22.4 Propeller fans mounted below the ceiling shall be provided with wire mesh guards.
- 4.22.5 Where indicated on the Drawings, propellers fans shall be mounted within correctly proportioned fan chambers suitable for connecting to ducting. The fan chambers shall be designed to allow the required space for radial air flow into, and from the impeller tips, and shall be fitted with diaphragm plates for mounting the fans, suitable fixing flanges at both ends, external terminal boxes and an access door for inspection and maintenance of the fan motors. The fan chamber casing shall be manufactured of 1,2mm thick galvanised sheet steel.
- 4.22.6 Exhaust fans to be installed through walls shall be equal to **WOODS XPELAIR** type WX, built-in wall fans, having an ivory coloured finish and complete with a back-draught shutter to open and close as the fan is switched on and off.
- 4.22.7 Exhaust fans to be installed through windows shall be equal to **WOODS XPELAIR** type GX, having an ivory coloured finish, and shall be complete with automatic shutters which shall close off the fan openings when the fans are not in operation. The fans shall be fitted through the windows in circular openings in the glazing, to be provided by the Principal Contractor.
- 4.22.8 Single phase fans shall be wired in neatly affixed, suitably rated, three core white cabtyre flex to white plugtops, to be plugged into adjacent switch plugs to be provided by others, in the positions indicated on the Drawings.
- 4.22.9 All ferrous parts of fan components shall be corrosion free.

4.23 AXIAL FLOW FANS

- 4.23.1 Axial flow fans shall be of aerofoil type equal to **DONKIN, WOODS, LUFT or ZIEHL** manufacture. They shall be of the size and type as indicated on the Drawings, and shall be capable of the duties specified in Part V hereof.
- 4.23.2 Fan impellers and hubs shall be of die-cast aluminium alloy and shall be accurately balanced to ensure vibrationless running.
- 4.23.3 The fan casing shall be fabricated from heavy mild steel plate, suitably reinforced and fitted at each end with a flange drilled for fixing. An inspection door of ample size shall be provided in the casing.
- 4.23.4 The fan motor, with frame diameter matching the impeller hub size, shall form an integral part of the fan. The motor shall be of the totally enclosed, squirrel cage type, suitable for the supply voltage specified. Motor connections shall be brought out to terminals located in a weatherproof, external terminal box which shall be an integral part of the fan casing.
- 4.23.5 Fans shall be resiliently mounted on, or suspended from, strong angle iron brackets by means of suitable anti-vibration mountings.
- 4.23.6 Fan speeds shall not exceed the maximum values specified in Part V hereof.
- 4.23.7 All ferrous parts of fan components shall be corrosion free.

4.24 CENTRIFUGAL FANS

- 4.24.1 Centrifugal fans shall be equal to **DONKIN, WOODS, LUFT or ZIEHL** manufacture, having capacities as called for in Part V hereof, and shall be installed in the positions as indicated on the drawings.
- 4.24.2 Centrifugal fans shall be of the multi-vane type with forward or backward curved vanes, and shall be of single or double inlet as specified in Part V hereof, or as indicated on the drawings.
- 4.24.3 The fan casing shall be fabricated from heavy sheet steel, reinforced and rigidly supported by means of a steel angle superstructure, and shall be corrosion free.
- 4.24.4 Bearings shall be of the sleeve, ball or roller type in accordance with the fan manufacturer's standard practice. They shall however be selected and fitted for quiet operation in accordance with the bearing manufacturer's recommendations. Where bearings are located in the air stream, precautions shall be taken to prevent the loss of lubricant. The runners of single inlet fans shall be overhung from outboard bearings.
- 4.24.5 The fan wheel and shaft shall be statically and dynamically balanced and designed to prevent vibration at the required operating speed. This operating speed shall be well below the first critical speed.
- 4.24.6 Fan drives shall be by means of V-belts and grooved pulleys. Fan motors mounted on the fan housings are not acceptable.
- 4.24.7 Large fan housings shall be made up in sections to permit installation through available openings in the building.
- 4.24.8 Fan shafts shall be of steel, and shall be properly protected against corrosion by means of suitable wrappings, and protective grease coatings.
- 4.24.9 All ferrous parts of fan components shall be corrosion free.
- 4.24.10 All fan casings shall be fitted with removable airtight access panels, to ensure maintenance inspections of fan internal casings.

4.25 ELECTRIC MOTORS

4.25.1 All electric motors on the installation shall be of one make unless forming an integral part of the equipment served, and shall not operate in excess of 1500 r.p.m., unless approved by the Engineers for specific applications.

4.25.2 Motors shall be 380 volt, three phase, 50 Hertz for all sizes from 0,4 kW upwards. Smaller motors may be 220 volts, single phase, 50 Hertz.

4.25.3 All motors shall be of the totally enclosed, fan cooled type, and shall have metric frame dimensions. Motors shall be quiet in operation and corrosion free to the full acceptance of the Engineers.

All electric motors for outdoor condensing units shall be of the weatherproof type, and all motor components shall be corrosion free.

4.25.4 Three phase motors shall all be squirrel cage, induction type, with special high torque motors being used on high inertia loads such as large centrifugal fans.

4.25.5 Starting methods for three phase motors shall be in accordance with local regulations. In the event that these regulations are not available at the time of tender, the following starting methods shall be allowed for:-

Motors up to	4 kW	direct-on-line
Motors above	7 kW	Star-delta (where the site is not serviced by its own transformer)
Motors above	22,5kW	Auto transformer started in three steps

4.25.6 Single phase motors shall be of the capacitor run or start type, protected by a manual reset overload.

4.25.7 The nameplate rating of electric motors shall be at least 15% greater than required, on motors below 15kW. On larger motors a 10% margin shall be allowed.

4.26 **MACHINERY DRIVES**

- 4.26.1 Direct drive couplings shall be of the non-lubricated type, rated at least 125% of driving motor horsepower, and flexible to allow minor misalignment. "Pin-and-push" type couplings shall not be used, all direct drive couplings being of **FENAFLEX** type FX, as manufactured by Fenner or approved equal. Direct drives shall be accurately aligned using the appropriate instruments to within 0,25mm.
- 4.26.2 V-belt drives shall in no case consist of less than two belts, and shall be selected in accordance with manufacturer's rating, plus one additional belt per drive. Sheaves shall be machine cast iron with Taperlock shaft bushes, all equal to Fenner. Aluminium pulleys will not be permitted. All drives on the installation shall be of the same make, and of modern high-capacity belt section, such as Fenner **ALPHA, BETA**, etc. V-belts shall be fitted in matched sets only.
- 4.26.3 All drives shall be fitted with adequate drive guards complying with the relevant Government regulations, which guards shall be readily removable for access to the drives. Guards fitted to the belt drives shall have an expanded metal face to enable visual inspection of the drive without the need to remove the guard.

4.27 ELECTRIC HEATER BATTERIES

- 4.27.1 Electric heater elements shall be of the factory-bent type, so arranged that all connections are on the same side. They shall be black heat, rated for still air operation by their manufacturer's, but operated at a minimum air velocity of 5 m/s. Elements shall be rated for 250 volt site electricity supply, with consequent lower wattage heat output and lower sheath temperature. Arrangement for heater elements within the heater batteries shall be such that they are uniformly spaced across the width of the duct to present equal air flow over each element. When necessary they shall be arranged in staggered rows to ensure the best distribution of air flow over individual elements.
- 4.27.2 Heater elements shall be fitted into a frame attached to a terminal box, the frame fitted into a rectangular opening on one side of the duct. The frame shall be constructed of 1,6mm bent-up galvanised sheet steel channel, and the terminal box, frame and heaters assembly shall be readily withdrawable from the heater casing.
- 4.27.3 Terminal boxes shall be fabricated from 1,2mm galvanised sheet, and fitted with a hinged cover fabricated from 15% free area flattened expanded mesh to allow adequate ventilation. No screws, fixings or sharp edges shall project into the terminal box. The hinged terminal box shall be carried out with silicone insulated heat resistant cable wired to a porcelain terminal strip, to which incoming P.V.C. insulated cables are also to be connected. Connections for looping wiring within the terminal box shall be executed with porcelain connectors.
- 4.27.4 Ductwork attached to heater batteries shall be insulated internally with 6mm MB700 glassfibre millboard for 500mm on air inlet side, and 1000mm on air leaving side, if space permits.
- 4.27.5 Heater batteries shall be protected against overheating with fire safety thermostats of the manual reset, rigid tailstock type, sensing temperature in ductwork on the leaving side of the battery. Thermostat locations shall be such that their operation is unaffected by radiation from the heater elements, and their temperature setpoint shall be 55°C. Thermostats shall have single pole, double throw contact arrangement to enable trip condition to be indicated by means of pilot lamps on the relevant electrical switch panels.
- 4.27.6 All air handling plants fitted with electric heater batteries shall be so automatically controlled that when the plants are shut down, the operation of heater elements is stopped, but fans shall continue to operate for 3 minutes before shutting down, all to cool off heater elements for prolonged life, as well as to prevent false tripping of fire protection thermostats.

4.28 ELECTRODE HUMIDIFIERS

- 4.28.1 Electrode type, steam generating humidifiers shall have the capacities as called for in Part V of the Specification.
- 4.28.2 Humidifiers shall be installed in full accordance with their manufacturer's instructions, with their steam injection nozzles fitted in the positions indicated on the Drawings.
- 4.28.3 Humidifiers shall be piped to suitably selected steam injection nozzles, each being of sufficient length so as to extend over the full length of the coils or the ducts, or be the maximum standard length available for the manufacturer's of the humidifiers, and positioned for optimum mixing of the steam discharge with the air, without condensate forming on any adjacent casings or inside the supply air ducts. Should steam distribution hosing runs, because of their length, cause excessive steam temperature drop and a consequent high rate of condensate within them, then the hoses shall be insulated with suitably sized light density, performed fibreglass sectional lagging, covered with P.V.C. plastic sheeting, overlapped over each section, and fixed with approved adhesive.

Each humidifier shall be supplied with two sets of spare replaceable electrode elements.

- 4.28.4 Water connections to, and drain connections from, the humidifiers shall be carried out in water quality tubing using **SECUREX**, or equivalent compression type fittings. The mains water serving the humidifiers must NOT BE TREATED, and shall be taken from the mains water supply connections to be provided by others, in each plant room, in the positions indicated on the drawings.

4.29 AUTOMATIC CONTROLS

4.29.1 Provide, install and set into operation all the automatic control devices shown on the relevant Diagrams, and interlock same as required to perform their function correctly. The sub-Contractor shall note that the various controls shown on the drawings, and as mentioned herein, indicate the basic control elements and functions required only. They shall additionally furnish all ancillaries necessary to fulfil the desired plant operation.

4.29.2 All control equipment shall comply with the following:

4.29.2.1 Valve and damper operators shall be quiet in operation. In the event of power failure, operators shall be provided with spring return so that they will "fail safe" in either the normally open, or normally closed position as required.

Operators operating in sequence with other operators shall have adjustable operating ranges and starting points, to permit adjustment of the control sequence as required by the operating characteristics of the system.

4.29.2.2 Temperature and Humidity controllers shall be of the type specified in Part V of the Specifications, and as indicated on the Wiring diagrams.

Thermostats shall have bimetal, vapour pressure, liquid filled, or resistance type sensitive elements, and humidistats shall have sensitive elements of human hair, or other suitable material of approximately equal sensitivity, or of the hygroscopic resistance type.

Room thermostats, electronic sensors and room humidistats shall be securely attached to suitable bases mounted on the walls or other building surfaces. Each thermostat, electronic sensor or humidistat shall be located where shown, or, if not shown, where it will respond to average temperature or humidity in the area controlled.

Thermostats, sensors and humidistats generally shall be mounted 1,8m above the floor, unless otherwise indicated on the drawings, and shall not be mounted on outside walls or partitions if other locations are possible.

Thermostats mounted on outside walls shall be provided with insulating bases.

Room thermostats and room humidistats in which the adjusting mechanism is integral with the sensing element shall have locked, or concealed adjusting devices, by means of which the operating points can be adjusted through a range of not less than 5 degrees and 10 per cent, respectively, above and below the operating points specified.

4.29.2.3 Electric temperature control systems operating at less than the normal lighting circuit voltage shall be provided with transformers to supply power for the equipment.

Transformers and line voltage controllers serving individual ventilation or air conditioning units may not be fed from the fan motor leads.

Transformers other than transformers in bridge circuits shall have primaries wound for the correct control circuit voltage. Each transformer shall have adequate capacity to operate simultaneously all apparatus connected to it, and shall be capable of carrying a 25 per cent overload for one hour. Each transformer shall be enclosed in a steel cabinet with conduit connections, and shall have a fused disconnect switch on the primary side, and a fuse cut-out, or thermal cut-out, on the secondary side, if the output exceeds 50 volt amperes. One leg of the secondary winding of every transformer shall be properly earthed.

4.29.3 AIR CONDITIONING, VENTILATING, HEATING AND EXHAUST PLANTS

4.29.3.1 Plants shall be switched ON and OFF automatically, by means of an electrically operated time switch, driven by a totally electronic unit to allow the switch to continue operating, without interruption to its programme, during power failure of up to eight (8) hours.

Time switches shall incorporate a weekend cut-out feature, and shall be set to operate the plant during the hours listed in Part V hereof.

Time switches shall be installed within the electrical switchpanel, and shall be interlocked with a rotary type MANUAL\OFF\AUTO over-riding control switch, so that the plant may be operated manually, or switched off on Public Holidays, without interruption of the programme of the time switch.

MANUAL\OFF\AUTO switches shall be mounted in the positions indicated on the Drawings.

Where applicable, as indicated on the wiring diagrams, the time switch shall be replaced with an optimised start control system equal to **LANDIS & GYR, STAEFA, SATCHWELL** or equal, which shall automatically start and stop the plant. The control shall include an outdoor and indoor thermostat which shall influence the plant starting time, to ensure the desired indoor temperature at the beginning of the occupied period.

- 4.29.3.2 Where applicable, as indicated on the relevant Diagrams, plants shall be protected against low voltage or single phasing by an electronic single phase/low voltage monitoring device, pre-set to trip the entire plant should the line voltage drop by more than 10%, or the loss of one or more phases. The device shall be set to reinstate the operation of the plant five minutes after the voltage has returned to normal.
- 4.29.3.3 Fire safety thermostats of the rigid tailstock type shall be mounted in the return air stream to each unit, or behind the common return air opening to the plant room, as applicable, and if indicated on the drawings, to sense the return air temperature and shut-down the entire system should the return air temperature exceed $\pm 40^{\circ}\text{C}$. These safety thermostats shall be of the manual reset type.
- 4.29.3.4 Plants shall be started in sequence by means of time delay relays. The timing between switching stages shall be set at not less than 20 seconds.
- 4.29.3.5 Where applicable, the temperature control circuit of each compressor unit shall be interlocked with the condenser fan switch so that the compressors will not operate unless the fan switch contacts are closed.
- 4.29.3.6 Cooling and heating thermostats, or temperature sensors, shall be installed in the positions indicated on the Drawings to control cooling and heating through the number of stages as called for in Part V of the Specification.
- 4.29.3.7 Thermostats or temperature sensors positioned within the conditioned space shall be mounted on neat, recessed wall boxes of sufficient size, so as to project at least 25mm on all sides of the controller.
- 4.29.3.8 Each refrigerant circuit within the packaged air conditioning units shall include a dual pressure switch with manual reset on the high pressure side, and an oil pressure switch, with manual reset feature, to stop the compressor if the oil pressure drops below a preset minimum, all as previously specified herein.
- 4.29.3.9 Ventilation fans shall be interlocked with the air conditioning plant as called for on the relevant Drawings.

Fresh air intake fans shall be interlocked to operate only when the plant is switched on.

An additional manual override facility shall be provided to operate fresh air fans, for service inspection purposes.

Exhaust fans will be switched on and off at their relevant control points.

4.30 SWITCHPANELS AND CONTROL BOARDS

- 4.30.1 Provide and install, in the positions indicated on the Drawings, switchpanels and control boards complying in operating principals with the automatic control sequence as described before.

- 30.2 Before commencing with the manufacture and wiring of the switchpanels and control boards, the Sub-contractor shall submit three copies of up-to-date Wiring Diagrams, schematic ladder type Diagrams of the control systems, and dimensioned panel layout Drawings to the Engineer for approval. All Drawings shall show the correct terminal numbers and wire identification numbers to be used.

The Engineer shall be informed of all modifications to the wiring made until the end of the guarantee period, and updated drawings shall be submitted immediately after each modification is made.

- 4.30.3 The complete electrical installation, and all electrical equipment and material covered under the Sub-contract shall comply with the latest edition of the S.A.B.S. Code of Practice. The workmanship and installation shall comply with the S.A.B.S. Code of Practice for the wiring of premises, the Factories, Machinery and Occupational Safety Act of 1984, Local Municipal Regulations and Bye Laws.

All components of a similar nature shall be of one make with corresponding parts being interchangeable. All equipment shall be of robust construction and have ample ratings for the duties imposed.

- 4.30.4 The System Fault Levels for which the switchpanel components shall be designed and selected shall be 10KA, or as otherwise noted in Part V of these Specifications, for each switchpanel and control centre.

All equipment in the switchpanels such as fused switches and moulded case circuit breakers, for controlling outgoing circuits, shall be rated accordingly.

- 4.30.5 Switchpanels and control boards shall be of the floor mounted type for panels having a total face area in excess of 1,2 m², and wall mounted if less than 1,2 m². Where switchpanels exceed 1,2 meters in length they shall be divided into multi-sections.

Switchpanels shall be arranged for front access only, and bottom cable entry with the main incoming isolators positioned on the extreme left hand side of each switchpanel. All switchpanels shall be arranged for top exit via cable ducts.

When starting equipment creates higher than normal ambient temperatures, the switchpanels shall be adequately ventilated by means of splash-proof, top ventilation openings provided with vermin proof screens.

Switchpanels and control boards shall be the products of specialist manufacturer's of this class of equipment, as approved by the Engineer, and shall be purpose made to contain all switchgear, controls, instruments and indicating equipment, and shall be complete with all internal wiring, all conforming with the following requirements.

- 4.30.6 Switchpanel and control board casings shall be fabricated from 2,0mm thick mild steel suitably stiffened with mild steel sections and fitted with removable, hinged doors, with flush-mounted locks each provided with triplicate keys, as well as removable panels secured with chromium plated dome nuts.

Wall mounting panels shall be of the surface type with removable inner mounting chassis.

Floor standing switchpanels and control centres shall be mounted on channel section, mild steel bases.

Door widths shall not exceed 900mm for all switchpanels. All doors, removable covers, door pillars, mullions, etc., shall be dust resistant and provided with oil resistant, closed-cell composition, synthetic rubber or similar gaskets. Gasketed surfaces shall be so constructed that gasketing material is retained by metal channels, and does not depend entirely on an adhesive holding the gasket on a flat metal surface.

All fixing screws shall enter holes tapped into an adequate thickness of metal, or nuts welded to the back surface of the metal plates. Self-tapping screws will not be accepted.

Switchpanels shall be so designed that no circuit breaker toggles shall protrude through the doors. All switches, the main circuit breakers, on/off handles, instruments and indicating equipment, reset buttons and pilot lamps only shall, however, be fully exposed and operable, as relevant, without the need to open the doors to the switchpanels, this equipment being flush mounted on the door of the switchpanel or on a fixed panel section on one side, or on top of the switchpanel.

Adequate barriers shall be provided in the switchpanels to segregate load circuit compartments from the busbar chamber, in such a way that transmission of flame from one compartment to another is minimized.

The electrical equipment within the panels shall be mounted on a steel chassis. The chassis shall also be used for the mounting of the relevant busbars.

Finish of the panels shall be in enamel. Orange on the outside and White inside. Boards shall be given three coats of paint after an initial coating of zinc-rich primer, to give a high-class gloss finish. Colour samples of the Orange enamel paint shall be approved by the Engineer prior to the switchpanels being painted. All switchpanels and control boards shall be fitted with earthing straps, in accordance with the standard wiring regulations.

4.30.7 Busbars shall be provided in hard drawn annealed copper, loaded to not more than 1,55 Amps per mm² of copper, on a $\pm 50^{\circ}\text{C}$ rise, and shall be enclosed in a top horizontal and accessible compartment, with steel casing separating the busbars from other equipment. Busbars shall be mounted on porcelain or epoxy resin type busbar insulators mechanically braced to withstand 40 kA through fault current. The clearance between busbars shall not be less than 40mm between phases, and 25mm to earth, and they shall be secured by bolts having a diameter of not less than the thickness of the busbars, with a minimum diameter of 8mm. Machined bolts and nuts with washers and spring washers shall be used, and busbar supports shall have a maximum pitch of 900mm. Connections shall be made by means of copper, preferably double indent, compression lugs. All busbar joints shall be silver or tin plated, and connected with high tensile steel cadmium plated bolts and lock washers. Busbars shall be taped after all connections are made. Busbar droppers to circuit breakers shall be of minimum section 10 mm², single copper conductor.

4.30.8 Neutral bars are to be not less than half the cross-sectional area of the phase busbars, but not less than 25mm x 6mm, and are to be mounted on porcelain or epoxy resin type insulators, where heaters or other phase to neutral loads are used.

Where neutral bars are purely on the control side, 15mm square brass bars with 2 tapped holes per way may be used, mounted on bakelite or equal insulators.

4.30.9 Earthing straps of not less than 25mm x 6mm copper shall run the full length of the complete floor standing panels, either at the top or bottom of the panels, where it must be securely bolted to the switchpanel framework to ensure good continuity.

Wall mounted switchpanels shall be provided with an earthing brass bolt of not less than 10mm diameter, securely fixed to the panel chassis.

4.30.10 All wiring within the panels shall be neatly grouped in horizontal and vertically run, approved fire resistant P.V.C. trunking, with dip-on removable covers. All wiring shall also be colour-coded in the colours red, white and blue for the relevant phases, and black for neutral, the busbars being similarly marked.

Power wiring shall be of 2,5 mm², minimum section P.V.C. covered, stranded wire, rated for 600 volts.

Control wiring from the secondary side of control transformers shall be minimum 1,5mm², P.V.C. covered, stranded, 250 volt grade wire with bared ends soldered. All switchpanels shall be carefully designed and sized to ensure ample space for wiring and making-off incoming cables.

- 4.30.11 Where required (due to fault level considerations), Current Limiting Circuit Breakers shall be used to reduce fault current levels to less than 5kA r.m.s., alternatively 7,5 kA "let-through-current". The circuit breakers to be used shall be the manually operated, trip-free type, with adjustable magnetic\thermal trips in each phase.
- 4.30.12 All fuses shall be of the HRC type, with minimum rupturing capacity to suit the system fault levels at 400 volts. Spare fuses of 25% of the total quantity, with a minimum of three of each size and type, including control circuit fuses shall be provided.
- 4.30.13 Isolators shall be of the 'on load' type, and of ample rating for the maximum load applicable. Live side terminals on all isolators must be shrouded or otherwise insulated against inadvertent contact.
- Isolators installed within the switchpanels shall be housed in separate enclosures, the door of which shall be interlocked with the switch operator, to prevent the door from being opened unless the switch is in the open position, and prevent closing of the disconnect switch while the door is open, unless a manual by-pass is actuated, also to prevent closing of the disconnect switch until the door hardware is fully engaged. The stem operating the isolator shall not be less than 12mm in diameter, and shall not protrude more than 100mm. Provision shall be made for padlocking the disconnect switch in the open position only, with up to three 10mm shackle padlocks regardless of whether the door is open or closed.
- 4.30.14 Air break circuit breakers shall be of the double break type, and shall have a continuous rating not less than the total full load rating of the equipment. They shall have a fault capacity suitable for the design level of the system. They shall have adjustable overloads, covering the operating range of the equipment served. which shall be series tripping up to 800 Amp and C.T. operated above this value.
- 4.30.15 Moulded case air circuit breakers shall be rated to comply with a minimum fault level of 6kA, and a current rating to suit the load and shall be fitted with thermal overloads and instantaneous magnetic, over-current release.
- 4.30.16 Current transformers shall be air insulated and shall have an accuracy within 2% of the 0-100% scale output. One leg of the secondary winding shall be solidly earthed.
- 4.30.17 Magnetic contactors shall not be smaller than N.E.M.A. size 1 or equivalent, with encapsulated operating coils rated at 220 Volt, 50Hz. Each starter is to be furnished with one spare N.O. (Normally Open), and one N.C. (Normally Closed), auxiliary contacts rated at 5 amperes. Each starter shall also have provisions for adding two additional sets of auxiliary contact, either normally open or normally closed. Contacts and coils shall be replaceable without removing the entire contactor from the cubicle.
- 4.30.18 Motor Starters shall comply with BS 775 and N.E.M.A. specifications, and shall have thermal overload relays, which shall be of the bimetallic, ambient temperature compensated, manual reset type. Overload relays shall be resettable at any time after tripping, without rendering the relays inoperative. All terminals shall be shrouded, and the contact mechanism shall be trip-free, so that the snap action contacts cannot be held closed against continued overload. The ultimate trip current of overload devices shall be nominal 115% of the motor full load current.

With special hard starting, e.g. centrifugal fans, it may be necessary to increase the nominal value, but in no case shall the overload ultimate trip current exceed 130% of the motor full load current.

- 4.30.19 Control relays shall be either of the heavy duty industrial type, 600 volt with minimum 10 ampere replaceable contacts and shall be equipped with 110 volt, 50 Hz holding coils for continuous operation within a voltage range of 100 to 120 volts. Holding coils shall be replaceable without removing the entire relay from the cubicle or; alternatively the control relays may be of the plug-in type, hermetically sealed in plastic containers.
- 4.30.20 Phase failure SEQUENCE PROTECTION Relays shall be arranged to shunt trip the incoming breakers so that on failure, or phase reversing, the plants will stop. The relays shall be equal to **ELECTROMATIC**.
- 4.30.21 Timers shall be of the totally electronic unit type similar or equal to **SIEMENS**.
- 4.30.22 Sequence controllers to start plant with a minimum of 20 seconds time delay between each start-up of motors of 3kW and over shall be provided to avoid heavy current inrush on plant start-up. Sequence controllers shall be totally electronic unit type, and shall automatically recycle to zero position after power interruption, and on normal plant shutdown.
- 4.30.23 Pilot lights shall be of the neon or incandescent type, equal to **SIEMENS** with round 'Plexiglass' lenses. The colours of the lenses shall be as noted below:-
- | | |
|------------------|-------|
| Indication | Amber |
| Operation | Green |
| Failure or Alarm | Red |
- 4.30.24 Reset Pushbuttons shall be similar in appearance and size to the pilot lights, equal to **SIEMENS**, and shall be mounted adjacent to the red failure or alarm pilot lamps on the switch-panels.
- 4.30.25 When indicated on the Wiring Diagrams only, the main incoming switch of the switch panel shall be fitted with a kWh-meter, three Ammeters and one Voltmeter with selector switch.

Kilowatt-hour meters shall be fitted as specified on the Drawings. The meters shall have 6 digits and manual reset knob. Above 100 Amp the kWh-meter shall be fitted with current transformers.

Ammeters shall be fitted in the power circuits of all motors of 5kW and over, and where specified or shown on the Drawings. Ammeters over 50 Amps shall be operated by current transformers of the ring type. Ammeters shall have an accuracy of 2% of the scale range or better. For non-inductive loads the scale of ammeters shall not exceed the maximum current drawn by more than 40%. Motor ammeters shall be suitable for the starting current of the motor, and shall have an extended scale in the region of the operating current.

Volt meters shall be of the moving iron or moving coil type.

All indicating instruments shall be of the flush mounted square face pattern with 96mm dials.

- 4.30.26 Each control circuit shall be protected with a single pole circuit breaker. Controls shall be suitable for 220 volt operation.
- 4.30.27 Terminal boards, or blocks, shall be mounted in each switchpanel for all external connections, and shall be so located that they are readily accessible from the front of the switchpanel, and not in the wiring gutter, leaving it completely free for power and control wiring. If terminal blocks are of the 'split= disconnect type the female part shall be secured to the removable unit cubicle, and the male part shall be free and of a closepin type. The disconnect type terminal blocks shall be held together with screws or clamps. Terminal strips shall be properly labelled, and panel field wiring shall be marked accordingly by the means of numbered ferrules. Not more than one incoming and one outgoing wire shall be fixed to any one terminal.

Labels showing the unit designations shall be provided adjacent to each of the terminals.

- 4.30.28 The switchpanels shall be fully labelled with engraved white ivory labels having 6mm high black lettering. The labels shall be fixed securely to switchpanel cover or chassis plates by means of small, self-tapping screws, to identify all switchgear, relays, instruments and controls, etc., on the face of, or inside, the switchpanels.

Equipment operating above 250 volts shall be fitted also with a red danger label.

Embossed Tape or Labels fixed with adhesive will not be accepted.

The Sub-contractor shall be responsible for marking all switchgear and other equipment on the Wiring Diagrams with the wording of the labels to be used.

All cable terminals shall be clearly identified by permanent labels.

Every wire inside, and outside, the switchboard shall be fitted with ferrules, and shall be labelled with identical numbers at both ends.

All terminal numbers and wire identification numbers shall correspond with identical numbers which must be shown on the wiring and control Diagrams.

- 4.30.29 Work tests may be witnessed at the discretion of the Engineer, who shall be given one week's prior notice in writing of the date on which they will take place. Three copies of Wiring Diagrams and ladder type schematic Diagrams, complete with terminal numbers, shall be sent to the Engineers at least fourteen days before testing can be commenced.

Testing shall be carried out on all completed equipment, including:

- ☐ High voltage insulation and insulation resistance tests to earth and between phases.
- ☐ Satisfactory operation of relays shall be proved.
- ☐ Closing and opening operation of all starters and contactors shall be satisfactorily demonstrated.
- ☐ All mechanical interlocks shall be satisfactorily demonstrated.
- ☐ Satisfactory operation of current and voltage instruments.
- ☐ Operation of all control circuits shall be proved by simulating operation of switching devices in the external circuit.

In addition, all components parts shall comply with the type specified in the S.A.B.S. or B.S. Standards.

The pre-delivery tests is not a final acceptance test, and does not absolve the Sub-contractor from his responsibility for the switchpanels.

All protective devices throughout shall be correctly set by the Sub-contractor to the approval of the Engineer. Before any circuit is energised, the data for correct setting is to be established.

The Sub-contractor shall be responsible for the complete electrical installation, i.e. the selection of equipment of appropriate rating and capacity, including the rupture of fuses and circuit breakers, all as covered under this Sub-contract.

- 4.30.30 Provide for each item of equipment located out of sight of the electrical switchpanel serving same, a remote-on-load isolator housed in a dustproof case. Where isolators are located in positions exposed to weather, they shall be of a waterproof type fitted with suitable watertight cable entry glands.

4.31 ELECTRICAL WIRING

- 4.31.1 Electrical wiring shall comply fully with the S.A.B.S. Code of Practice for the Wiring of Premises, and the additional requirements of the local authorities who have jurisdiction over the Site of Works, as well as being in accordance with best modern practice.
- 4.31.2 Main power incomers to plant rooms will be provided by others, excluding making-off of cables within the electrical switchpanels provided by the air conditioning Sub-contractor, who shall attend upon, and liaise with whoever brings power cabling to his switchpanels.
- 4.31.3 Conduits shall be galvanised to S.A.B.S. specification. All joints shall be screwed. No conduit less than 20mm shall be used. Conduit fittings and boxes shall be of galvanised iron to S.A.B.S. specification.
- 4.31.4 Galvanised conduits and conduit fittings shall be installed in positions exposed to weather, or in moist surrounding. Where galvanising has been removed by threading, cutting, etc., the exposed parts shall be suitably treated with cold galvanising to render them weatherproof and rust resistant.
- 4.31.5 Conduit shall either be screwed and locknuttred on both sides, and bushed on the inside of the box or appliances in which it is terminated. Only solid brass bushes shall be used. Alternatively, and particularly in distribution boards, conduits shall be terminated with couplings and brass male bushes. PVC conduit will be allowed where it complies with local regulations.
- 4.31.6 Conduit in roof spaces shall be run parallel, and at right angles to roof members, and shall be secured to these members by means of saddles and screws.
- 4.31.7 No conduit is to cross an expansion joint in the structure without an approved arrangement for crossover. Where details of the crossover are not given, the Sub-contractor shall refer to the Engineer for instructions.
- 4.31.8 The Sub-contractor shall notify the Engineer in good time before any conduits in concrete are covered, so that tubing may be inspected and checked before concrete is cast, and shall attend on the Engineer during such inspections.
- 4.31.9 Conduit for future requirements shall be terminated with boxes and overlapping cover plates, and fitted with galvanised steel draw-wires. Where such conduit terminations project from the wall or slab, they shall be fitted with couplings and plugs. Such terminations in exposed positions shall be sealed with bitumen and protected with weatherproofing paint.
- 4.31.10 Inspection facilities shall be provided as specified in S.A.B.S. 0142-1981, Clause 5.4.1.d.
- 4.31.11 Exposed conduits shall be fitted with steel saddles of same finish as conduits, fixed at centres not exceeding 2 meters.
- 4.31.12 Conduit boxes to be cast in concrete shall be secured to shuttering by means of 5mm screws and nuts, unless some other method of fixing is approved by the Engineer.
- 4.31.13 Drawboxes and blank boxes in R.C. slabs, columns or in walls shall be fitted with substantial oversized metal coverplates, fixed with countersunk screws, before surrounding surfaces are painted. Drawbox positions must be approved and care shall be taken that they do not affect the appearance of the building adversely. Where possible a single coverplate shall be fitted for a number of adjacent drawboxes.
- 4.31.14 Drawboxes in roof spaces which are only accessible above ceilings, shall not be installed in positions where clearance from ceiling to roof is less than 1 meter.
- 4.31.15 Blank switch and plugboxes shall be fitted with blank coverplates and screws to match those specified for switches and switch sockets.

4.31.16 Mounting heights of boxes shall be as indicated on the Drawings which shall refer to the distance between the centre of the outlet box and the finished floor level, unless otherwise specified or indicated. Where two similar outlets occur adjacent to each other, these shall line up accurately horizontally, unless otherwise indicated.

4.31.17 When chasing of brickwork is carried out by the Sub-contractor due care shall be taken to prevent damaging of walls during chasing. He must ensure that other trades are not held up owing to delays in such work. Damage to brickwork will be made good by the building contractor.

Under no circumstances is facebrick, or other finished surfaces, to be chased without the permission of the Engineer.

Where it is necessary to chase structural concrete, the permission of the Structural Engineer must first be obtained. Where this is not done and the structure is chased without permission, the Sub-contractor will be held responsible for any damage to the structure which may be caused.

4.31.18 All wiring shall, unless otherwise specified, be carried out with P.V.C. insulated cable to S.A.B.S.150-1970.

4.31.19 Plastic insulated (P.V.C.\S.W.A.) cables shall be to S.A.B.S. 150-1970, and addenda thereto and shall consist of P.V.C. insulated conductors, P.V.C. beddings, galvanised steel wire armouring and a P.V.C. sheath.

P.V.C.\S.W.A. Cable ends shall be made off with approved glands. The glands shall be of the type in which the armouring is clamped between tapered cones compressed by the action of a screw and in which the gland is secured to the outlet casing by means of screwing, and/or locknutting.

Neoprene shrouds shall be used to cover the junction of the cable and the base of the gland.

4.31.20 The wiring in all Plant rooms shall be supported on cable trays or in cable ducts.

Cable supports for single, or not more than a group of three cables, shall be equal to **UNISTRUT** die-cast cable cleats with **UNISTRUT** type P-1000 channel, fixed to walls or overhead slab, at not exceeding 600mm pitch. Cables supported in this manner shall be properly straightened and neatly run to the full satisfaction of the Engineer.

Cable trays shall be run strictly in horizontal or vertical planes, any change of level, however, being done with a 45E slope. Where cables leaving trays drop down to equipment, use minimum tray width of 150mm and two vertical **UNISTRUT** supporting channels fixed to horizontal tray at top and floor at bottom.

4.31.21 All earthing shall be carried out in accordance with wiring regulations, earthing connections being executed with appropriate copper earthing strip, using brass bolts, nuts and washers to ensure continuity to main building earth provided by others.

Each run of P.V.C.\S.W.A. multi-core cable shall carry an additional conductor to be used for earth continuity, and shall be properly made-off for this purpose.

4.31.22 Connections to vibrating equipment shall be made with metal sprague on conduited systems, a separate earth continuity conductor being run outside the flexible conduit.

On cable systems, leave sufficient cable slack to allow free cable movement to take up vibration.

All connections to vibrating equipment shall be made so as not to impose strain on conduits, cables, conductors or equipment, and shall be of sufficient length to allow full adjustment of motors on slide rails.

4.32 INSTRUMENTS

- 4.32.1 Provide and install instruments where shown on the applicable drawings, or mentioned herein as follows. All instruments shall be installed within Plant rooms where possible, and shall be mounted at eye level, and, if necessary, remote sensors shall be provided to ensure eye level accessibility. All instruments shall be installed in positions not affected by plant vibration.

Instruments shall be of the circular dial type, having equal sized dials between 75mm and 100mm in diameter, unless otherwise specified, and the same finish in either stainless steel or chrome plate. All panel mounted instruments shall be suitable for flush mounting and fixing from within the panels, without screws projecting through the panels.

Instruments shall be provided with pointers, or have painted on their dials, green lines to indicate the normal operating ranges of the services indicated, and red lines to indicate minimum and/or maximum limits.

- 4.32.2 Air and water temperatures shall be measured with alcohol in glass type thermometers, which shall have a guaranteed accuracy within 1% around the entire dial range, and a means for recalibrating the instruments on site. Thermometer ranges shall be suitable for the service and shall not exceed 50% above, or below, the normal operating temperatures for each instrument.

Stems or bulbs sensing temperatures in pipes shall be fitted into oil filled wells, and bulbs in ducts or plena, shall be neatly fitted on insulated brackets to the satisfaction of the Engineer.

- 4.32.3 Air pressure gauges shall be 50mm dial, scaled from 0 to 150% of normal operating pressure.

- 4.32.4 Inclined pressure differential manometers shall be installed to indicate the resistance to the air flow over all banks of filters. Each manometer shall be fitted with a spirit level to ensure proper horizontal mounting, and pointers to indicate the initial pressure drop, and when the filter media has to be changed.

- 4.32.5 Static pressure indicators shall be of the diaphragm actuated, dial and pointed type graduated to read from 0 to 50% more than the maximum allowable static pressure, and shall be installed to sense the leaving main supply duct pressure. The gauges shall be connected to static pressure taps of approved design.

4.33 EQUIPMENT BASES

4.33.1 Provide, as called for in Part V or as indicated on the Drawings, equipment bases of the applicable type as specified below:

4.33.2 Inertia bases shall comprise a reinforced concrete pad of mass one and half times that of the equipment to be mounted upon it. A welded mild steel tray, suitably reinforced and of sufficient depth to contain the required weight of concrete, shall be provided by the Sub-contractor. Welded into such trays shall be a suitable template complete with the necessary ragbolts suitable for rigidly affixing the equipment to the base, once concrete has been cast in. The Principal Contractor will pour concrete into the tray and smooth plaster it with coloured granolithic finish. The steel tray is to be positioned on an 80mm high smooth plastered "housekeeping" plinth, such plinth provided by the Principal Contractor and 150mm larger than the steel tray all round. The inertia base shall be separated from the plinth by suitable vibration isolators, as later detailed. Proper provisions in the design and construction of the steel tray shall be made for the attachment of the necessary vibration isolating mountings.

4.33.3 Floating steel bases shall be shop-fabricated from mild steel channel sections of sufficient strength and rigidity using welded joints. Such bases shall, unless otherwise called for elsewhere or noted on Drawings, be of rectangular shape, and at least 80mm larger in all plan dimensions than the equipment to be mounted onto it. The construction of the base shall be such that proper provisions are incorporated for attaching laterally, or fitting beneath it, vibration isolators of the type which each application may require. The principal Contractor will provide a level "housekeeping" plinth on which to mount the aforementioned steel base, the plinth to be 100mm minimum larger than the base all round.

4.33.4 Static plinths, 80mm minimum high, shall be provided by the Principal Contractor for mounting non-vibrating equipment upon them, the plinths to be rectangular in shape unless otherwise shown on the Drawings, and 100mm larger all around than the equipment to be mounted upon them.

The Sub-contractor shall provide and position, where required, a channel iron frame, with mitred welded corner joints, and sheet metal bottom tray for the Principal Contractor to fill with concrete. The finish of the plinths shall be tinted granolithic.

4.33.5 Anti-vibration mountings shall be utilised in conjunction with the aforementioned bases, as relevant and as indicated on the Drawings for the following listed items of equipment.

All anti-vibration mountings shall be installed in full accordance with their manufacturer's application instructions, the model numbers mentioned herein referring to equipment of Mason Industries Inc., as locally supplied by **E.M. ARNOT**, although other approved makes would also be acceptable.

4.33.6 All equipment bases and anti-vibration mountings shall be corrosion free.

Equipment	Minimum Static Deflection	Type of Mounting	Model
Air Conditioning units Air Handling units and condensing units on concrete floors or bases		Neoprene Vibration Pads	NK or WMW
Cooling Towers over non-occupied area		Neoprene Vibration Pads	NK or WMW
Over occupied areas	To suit fan speed	Helical Spring with levelling adjustment	SLR
Centrifugal Pumps over non-occupied areas		Neoprene Vibration Pads	NK or WMW
Over occupied areas	19mm	Helical Spring with levelling adjustment	CIP
Axial Flow Fans	6mm	Neoprene in sheer and compression	30N

- 4.33.7 Full details of floating steel bases and all anti-vibration mountings selections shall be approved by the Engineer prior to the mounting being ordered, and the bases fabricated.
- 4.33.8 Where applicable, the Sub-contractor shall exercise particular care to prevent damage to the roof slab when hoisting, positioning and connecting the air conditioning units, and shall note that he will be held responsible for repairs caused as a result of this installation.
- 4.33.9 All equipment, and particularly that which is mounted on the roof, shall operate without objectionable noise or vibration being transmitted to the full satisfaction of the Engineer.
- 4.33.10 All cut joints and holes drilled within ducting, equipment casings, supports, stands, platforms, suspension brackets and supporting cable trays shall be fully protected against corrosion.

4.34 EQUIPMENT SUPPORTS

- 4.34.1 Where equipment supports, stands, platforms and suspension brackets are indicated, specified or necessary for ductwork, pipework, etc., the Sub-contractor shall provide supporting structures capable of carrying the load without distortion, affixed to the building structure in such a manner as not to subject it to undue stress.

Supporting of any rotating equipment shall incorporate vibration mountings of the type and selection specified in the applicable clauses referring to equipment bases herein.

All methods of suspension or supports shall be submitted to the Engineer for approval, and for reference to the Structural Engineer where necessary, prior to manufacture or installation.

- 4.34.2 Generally, supports shall preferably be proprietary products such as Unistrut, or failing this, shall be of mild steel sections, purpose fabricated for their application. Under no circumstances whatever will sheet metal straps be accepted as a supporting method. All supports shall cradle the item to be supported; supports shall not be rivetted or welded to the equipment to be carried, except in exceptional circumstances approved by the Engineer. Rod hangers shall not exceed one meter in length, and shall be of minimum diameter 12mm. For longer suspensions use mild steel angles. Angle iron supports shall be of 25mm x 3mm minimum. All supporting structures for equipment shall be hot dip galvanised.
- 4.34.3 Fastening methods shall employ **REDHEAD** or **RAMSET** anchor bolts, or their equivalent, for fixing supports to the building structure, it not being permissible to utilise gunpowder shot-driven bolts for this purpose, unless approval be obtained.
- 4.34.4 Pipework supporting holderbats shall be the product of a recognised manufacturer of such equipment, reinforced shop-fabricated saddles or similar devices. On insulated pipework, reinforced shop-fabricated saddles are to be used, up to and including Ø300 pipes. These saddles are to be placed at support points, and are to be clamped around the pipe. The insulation is to be taken to the edges of these saddles, joints are to be sealed, and the necessary vapour seal and reinforcing taken over the complete section. For piping with a diameter of more than 300mm, hardwood inserts consisting of two half-round, machine cut pieces timber shall be clamped around the pipe, insulation being cut away at such points, to allow proper installation of the supports. Wooden inserts shall be of the same thickness as adjoining insulation and 50mm longer than the width of the holderbat support, to permit correct finishing of the insulation and vapour sealing to them.
- 4.34.5 Cables and flexible pipes shall be supported on Unistrut, or equivalent, perforated galvanised cable trays, manufactured by specialists. Shop-fabricated trays or racks not being acceptable. The cable tray shall be suspended, or bracketed, using suitable mild steel angles.

4.35 NOISE AND VIBRATION

- 4.35.1 Particular care shall be taken in the selection, application and installation of all equipment used to ensure that it operates below the maximum allowed noise levels, specified in Part V hereof, and with the least vibration possible, all to the full satisfaction of the Engineer.
- 4.35.2 The following measures shall be taken where necessary, whether specifically called for or not, all to ensure quiet, vibration-free operation of the equipment forming part of the air conditioning and ventilation installations.
- 4.35.3 Rectangular ductwork in the vicinity of critical areas shall be provided with internal acoustic insulation.
- 4.35.4 Anti-vibration cuff connections of flexible joints shall be used on ductwork where it joins vibrating equipment such as fans and air conditioning units.
- 4.35.5 Pipework connecting rotating or vibrating machinery shall be provided with anti-vibration flexible joints, all as previously specified.
- 4.35.6 Equipment shall be mounted on vibration isolators of the correct type and selection, dependent upon deflection requirements versus vibrating frequency.
- 4.35.7 Pipework and ductwork shall be suspended, or mounted, using suitable supports with vibrating isolators to prevent transmission of vibration from them to the structure to which they are attached, where necessary only.
- 4.35.8 Suitable sound attenuating devices shall be incorporated within ductwork to reduce airborne noise to acceptable levels, as indicated on the Drawings and specified in Part V hereof.
- 4.35.9 If in the opinion of the Engineer, any equipment operates with, or transmits from it, objectionable vibrations or noise above the levels specified for the individual areas, it will be necessary to rectify or replace, such equipment to the full approval of the Engineer at no additional cost to the Owners.

4.36 PAINTING AND CLEANING

- 4.36.1 No untreated metal surfaces shall be permitted on the project. Items which are not galvanised or similarly protected against corrosion shall be painted, as later detailed herein. No equipment, hangers, brackets, etc. , shall be permitted to be delivered on site in unprotected form; they shall be factory-coated with an approved zinc-rich primer coat before despatch from their place of manufacture.
- 4.36.2 Painting shall comprise the following consecutive processes. First thoroughly clean, descale and degrease all surfaces, in accordance with acknowledged good practice, follow with a good coating of approved zinc-rich primer, and finish with two coats of quality high-gloss enamel of an acceptable make. Final finish shall be to the full approval of the Engineer.
- 4.36.3 With the exception of ducting and piping, items with a galvanised finish, such as cable trays, need not be painted, but shall be properly cleaned with a suitable proprietary galvanised iron cleaning fluid.
- 4.36.4 Particular care shall be taken that appropriate primers be used as a basis for painting, and that paint be of high quality manufacture, all to provide a completely satisfactory finish to the approval of the Engineer. It shall be noted that galvanised surfaces are to be treated to ensure proper bonding of paint.
- 4.36.5 Whereas it would not be necessary to paint any ductwork or conduits installed in roof voids, shafts, masonry ducts, etc., or where not normally visible, it is a requirement that such equipment be properly cleaned, treated with two coats of rustproofing paint if not galvanised, or not metal subject otherwise to rust.
- 4.36.6 All equipment on the project shall be colour-coded in accordance with standards recognised in the Republic of South Africa and, where possible, to comply with relevant South African Bureau of Standard Colour Codes. (S.A.B.S. 1091-1975).

General colour coding for the various items of equipment shall otherwise be as follows. The numbers given in the schedule refer to the colour code numbers of S.A.B.S. 1091-1975. (Any alternative colours shall be approved by the Engineer).

All equipment shall be painted in accordance with colour code given and where factory painted items such as the Air Conditioning Units, Cooling Towers and Pumps are not painted a specified colour, they shall be repainted by the Sub-contractor.

Factory painted equipment which is required to be repainted to comply with the specified colour code shall be rubbed down prior to being given two coats of gloss enamel paint, or as required in accordance with the paint manufacturer's recommendations, and depending upon the type of paint applied at the factory.

EQUIPMENT	COLOUR	CODE No . (SABS 1091-1975)
Air Conditioning Units	Cream	C66
Air Handling Units	Cream	C66
Fans - Axial Flow	Silver	-
Pipework -Mains Water	White	G80
Condenser Water	Green	E14
Chilled Water	Blue	E14
Drains and Overflow	Black	-
Copper - cleaned, polished then coated with	Clear Lacquer	-
Ductwork - Supply, Return & Exhaust	Cream	C66
Switchpanels & Control panels	Orange	-
Electric Wiring Trays or struts	Orange	-
Belt Guards	Red	A11
Equipment Bases	Black	-
Supports & Steelwork	Cream	C 66

- 4.36.7 On completion of the installation the Sub-contractor shall clean all equipment properly, remove all superfluous materials from the site, make good black granolithic finished equipment bases with black concrete paint, sweep out Plant rooms and make the Plant completely presentable before calling upon the Engineers to accept the plant after completion of the 'Preliminary Tests'.

4.37 LABELLING AND IDENTIFICATION

- 4.37.1 All equipment shall be labelled and identified using white Traffolite labels having 10mm high black lettering engraved on them; where two similar items exist, they shall additionally be numbered for clarity in identification. Labels shall be neatly bolted to the equipment with brass fasteners.
- 4.37.2 Belt guards and items of plant containing belt driven equipment shall be fitted with a label stating the number of, and the size of the belts for each V-belt drive. The labels shall be of the same type and dimensions and shall be fixed as specified above for all equipment.
- 4.37.3 Designate and identify each automatic control device such as 3-way valve, thermostat, damper motor etc., and fit to each a white Traffolite label having 5mm high black lettering, the label to be bolted to equipment with brass fasteners. Prepare a complete control Diagram of the installation and label with relevant designations mentioned above, all to form part of plant operating instructions which are later mentioned herein.
- 4.37.4 Label pipes with directional arrow neatly stencilled onto finished pipework or in the form of a durable proprietary transfer. Arrows shall be at not more than 5 meter intervals and not less than 100mm long, of good colour contrast to equipment colour background.
- 4.37.5 Identify all Plant rooms as 'Air Conditioning' or 'Air Handling Plant Room' with 5mm thick engraved P.V.C. sheet notices having 25mm high black lettering on a white background.
- 4.37.6 Provide and install all necessary notices required in terms of 'Governmental and Local Authorities' laws, such as "No Entry to Unauthorised Persons", at all Plant room entrance doors, etc. Such notices to be silk screened onto 3mm thickness P.V.C. sheet, as obtainable from Messrs Mine Safety Appliances.
- 4.37.6 All labels and identification designations shall correspond to the numbers/labels as specified on the drawings and in the plant operating instructions.

4.38 COMMISSIONING AND TESTING - PRELIMINARY TESTS ON COMPLETION

- 4.38.1 Following completion of the Works, or any portion of the Works as specified or directed by the Engineer, the Sub-contractor shall balance, set and test the Works or portion of the Works, in accordance with the following requirements, to establish the capacity and satisfactory performance of the Plant.
- 4.38.2 All balancing, setting and testing shall be done by the Sub-contractor entirely at his own expense. The Sub-contractor shall provide all facilities and apparatus for the testing of the Plant, and shall carry out such tests as may be necessary to satisfy the Engineer that the Plant meets with the requirements of the Specifications.
- 4.38.3 The Sub-contractor shall also carry out, or attend upon, all tests required by Government and Local Authorities who have jurisdiction over the Works, and shall obtain all necessary certificates of approval and acceptance, and shall provide the Engineer with triplicate copies of all such certificates prior to, or at such time as providing the Engineer with copies of his "Preliminary Test" report.
- 4.38.4 All test instruments shall be checked for accuracy by the manufacturer's, supplier's or approved laboratory, and certified copies of certificates showing the degree of accuracy shall be supplied to the Engineer together with the "Preliminary Test" reports.
- 4.38.5 Gauges, thermometers, ammeters and other instruments specified as part of the permanent Plant may be used for test purposes, providing that the Sub-contractor ensures that all such instruments are accurately calibrated. The Sub-contractor shall check the accuracy and calibrate all such instruments against laboratory tested instruments.
- 4.38.6 The Sub-contractor shall when required, provide the Engineer with equipment selection and performance data for all major items of plant, such as Air Conditioning Units, Air Handling Units, Cooling Towers, Pumps, Fans and Sound Attenuators.
- 4.38.7 The Sub-contractor shall keep full and proper written records of all tests conducted and commissioning information, such data to be properly indexed and clearly set down to form part of the Operating and Maintenance manuals called for in the Specification.
- 4.38.8 The Engineer reserves the right to inspect any item of equipment during manufacture or before delivery to site. The Sub-contractor shall make available any item for such inspection.
- 4.38.9 Electrical switchpanels shall be inspected by the Engineer at their place of manufacture, prior to delivery to Site. At such inspection and testing, the Sub-contractor shall demonstrate the functioning of the switchpanel to the Engineer. Any defects in materials, finishes and operation of the switchpanels shall be corrected at their place of manufacture, prior to delivery to site.
- 4.38.10 The Sub-contractor shall, on handing over the installation or any portion thereof to the Engineer, also provide the necessary certificates as proof of having conducted a satisfactory electrical test to the requirements of the electricity supply authority, such certificate emanating from such authority, and permitting full use to be made of the installation without the need for further tests.
- 4.38.11 The Sub-contractor shall properly test and call for inspection by the Engineer, any work which is to be covered, concealed, built-in, otherwise closed up or rendered inaccessible, before such closing up takes place. The Engineer may require any work of this nature which he has not been called on to inspect before closing up, to be uncovered or made accessible, entirely at the Sub-contractor's expense, making good included.
- 4.38.12 Prior to the "Final Tests" to be attended by the Engineer, the Sub-contractor shall balance, set and test the following to establish the capacity and performance of the Plant. All such "Preliminary Tests" shall be recorded by the Sub-contractor, who shall provide the Engineer with three typed copies of all test recordings which shall set out procedure, data and instrument readings obtained, as compared with the specified capacities and the manufacturer's name plate ratings where applicable. Such "Preliminary Test" reports shall be accompanied by one preliminary draft set of Operating and Maintenance Instructions prepared in accordance with the requirements as detailed herein.

- 4.38.13 On receipt of an acceptable preliminary test report and draft copy of the Preliminary Operating and Maintenance Instructions, the Engineer shall advise the Sub-contractor in writing so that he may arrange for the "Final Test" and issue of the Acceptance Certificate's.

THE "PRELIMINARY TESTS" SHALL INCLUDE THE FOLLOWING:

- 4.38.13.1 Drains shall be tested for proper functioning by pouring water down them at a rate of at least four times normal drainage.
- 4.38.13.2 Field assembled refrigerant piping and apparatus shall be tested with dry carbon dioxide or nitrogen, plus a small amount of refrigerant. Test procedures shall be in accordance with the latest edition of the American Standard Safety Code for Mechanical Refrigeration. Leaks in pipe joints shall be corrected by remaking the joints. Caulking will not be permitted. The vacuum test shall follow the pressure test.

Charging of the equipment with refrigerant shall follow the vacuum test as closely as is practicable to minimise the possibility of air, or moisture, being returned to the system. After charging and prior to capacity tests, joints in refrigerant piping and apparatus shall be checked with a halide torch or other equally sensitive leak detector. If leaks are found, the system shall be pumped down and the leaks corrected.

- 4.38.13.3 Capacities of Air Conditioning Units, Fans and other equipment shall be determined by operating tests of not less than four hours duration, after stable conditions have been established. Test procedures shall be in accordance with applicable portions of **ASME** and other recognised test codes, as far as field conditions permit. Capacities shall be based on temperatures and air quantities measured during such tests.

Temperature differences required for determining capacities shall be measured by thermometers having graduations that permit interpolations having an accuracy of $\pm 0,5^{\circ}\text{C}$.

Air quantities may be measured by Pitot tube, anemometer or velometer, depending on the velocity and other conditions of flow.

Check alignment of all equipment drives prior to setting into operation.

- 4.38.13.4 Air systems shall be checked for obstructions, and balanced to provide the required air quantities at each outlet, without objectionable noise and draughts, and so that the velocity of the air is relatively uniform over the area of the outlet.

Velocity meters may be used to test all outlets and for duct velocities up to 1,5 m/s, above which velocities shall be measured with Pitot tubes. Properly capped openings shall be provided in ducting as required. Final setting of all volume adjusting devices shall be permanently marked.

Should it be necessary to re-balance any air system due to partitioning or repartitioning of the conditioned space after the specified conditions have been obtained and accepted by the Engineer in writing, then such re-balancing shall be carried out as an extra to the Sub-contract and shall be authorised, by the issue of a "Variation Order", by the Engineer.

- 4.38.13.5 All automatic controls and safety devices shall be checked for correct performance and satisfactory operation, and set to the respective settings required.
- 4.38.13.6 All electrical switchpanels shall be checked for the correct functioning of all components, electrical interlocks, all time clocks, time delay relays and automatic control devices shall be set for their correct function.
- 4.38.13.7 The full load running current of all electrically operated equipment shall be recorded and compared with the manufacturer's name plate ratings, which shall be recorded, together with any other relevant data stamped on the name plates. All overload protection devices shall be set to the correct values, which shall be recorded.

4.38.13.8 The Sub-contractor shall ensure that the plants operate satisfactorily and uninterrupted for a period of 7 days prior to the final acceptance by the Engineer. Evidence of this, for air conditioning systems, shall be given in the form of a 24 hour long, continuous recording of temperature and humidity, which recording shall cover at least 50% of the areas handled by any one plant and shall be handed over to the Engineer prior to inviting him to the "Final Tests" and acceptance of the completed installation.

The original recorded graphs shall be supplied to the Engineer, and the Sub-contractor shall also obtain and provide the Engineer with the daily maximum dry and wet bulb temperature readings recorded in the area, on the same days as the inside conditions are recorded. Such information may be obtained from local weather stations.

4.39 OPERATING AND MAINTENANCE INSTRUCTIONS

4.39.1 The Sub-contractor shall furnish to the engineer before the Works are taken over, such Operating and Maintenance Instructions, together with Drawings of the Works as completed, and in sufficient detail to enable the Employer to operate, maintain, dismantle, re-assemble and adjust all parts of the Works.

The Works shall not be considered to be completed for the purpose for taking over until the required Instructions and Drawings have been supplied to the Engineer.

4.39.2 A draft copy of all written instructions shall be submitted to the Engineer for approval together with the required copies of the "Preliminary Test" report, as previously specified herein, prior to the preparation of the final copies.

THE "OPERATING INSTRUCTIONS" SHALL INCLUDE THE FOLLOWING:

4.39.3 Instruction Manuals comprising the following sections bound in a blue coloured vinyl plastic covered folder, with the name of the project typewritten on a card inserted into a clear plastic covered cardholder on the front cover.

4.39.3.1 INDEX (in detail)

4.39.3.2 DESCRIPTION OF PLANT (as installed)

4.39.3.3 OPERATION OF PLANT (as installed) to include:

- ☐ Automatic and manual start-up and shut-down procedure.
- ☐ Operation and Sequence of all automatic controls.
- ☐ Scheduled description of all Control and Safety Instruments; listing function, make, model number, range and differential (when applicable), and setting of each instrument.
- ☐ Functions of all switches, indication lamps, reset buttons and alarms; and instructions for adjusting and re-setting all controls and cut-out switches.

4.39.3.4 PLANT AND EQUIPMENT

Scheduled list of all major plant and equipment to include Description, Make, Model Number and supplier's name and address.

4.39.3.5 TEST REPORT

Copy of "Final Test" report as accepted by the Engineer. (Draft copy of "Operating Instructions" for Engineer's approval shall contain a copy of the "Preliminary Test" report.)

4.39.3.6 MAINTENANCE INSTRUCTIONS

In schedule form setting out each item of plant, and the description as necessary for preventative maintenance of the Plant as installed.

4.39.3.7 SPARE PARTS

List of spare parts supplied (in accordance with these Specifications), with detailed description of each part, make, model or part number and Supplier's name and address.

4.39.3.8 DESCRIPTIVE LITERATURE

To include manufacturer's operating and maintenance instructions, performance curves or charts and spare parts lists where applicable, and where available.

4.39.3.9 DRAWINGS

List of all Drawings and photographically reduced, Size A3, copies of all “as installed” Drawings and Diagrams to include the following:

Plant layout Drawings showing the actual positions and sizes of all plant and equipment, ducts, pipes, the location of all dampers, valves and controls, and the measured air quantities at all air intake and discharge points.

Control and Wiring Diagrams and Schematic Piping Diagrams noting, where applicable, the normal and abnormal gauge readings, control points, scale settings and time settings, differential bands, throttling ranges, time relays and the overload settings and actual rated amperages of all electrical components, and any other relevant variable and adjustable items, to permit checking and adjustments, controls and motor functions.

4.39.3.10 COPIES OF INSTRUCTIONS IN PLANT ROOMS

As required in compliance with Government and Local Regulations.

4.39.4 A copy of the “Operation of Plant” instructions shall be mounted within a glazed or plastic covered frame in the Plant rooms, in positions to be approved by the Engineer.

4.39.5 Copies of the Schematic Piping Diagrams and the Control and Wiring Diagrams shall be mounted within glazed or plastic covered frames in the Plant rooms in positions to be approved by the Engineer.

4.39.6 Copies of Government Acts and Local Regulations, as required, shall be mounted within glazed or plastic covered frames in the Plant rooms, in positions to be approved by the Engineer.

4.39.7 The Sub-contractor shall instruct the Employer's personnel in the correct operation and use of the Plants. For this purpose the Sub-contractor shall allow for the time of a competent instructor for a total of four hours on Site, and one return trip to the Site for the purpose of providing such instruction.

4.39.8 During this period the Sub-contractor shall fully explain the layout, operation and maintenance of the plant to the Employer or the Employer's Representative.

At the conclusion of this period of instruction the Sub-contractor shall obtain from the Employer an acknowledgement, in writing, that the instruction has been properly given for the prescribed period. Two copies of the acknowledgement shall be forwarded to the Engineer.

4.39.9 The Sub-contractor shall supply the Employer or Tenant with a plant log book that will reflect all call-out or routine service visits.

4.40**SPARE PARTS**

4.40.1 The Sub-contractor shall deliver the following spare parts to the Employer's for safe-keeping by the latter in order that repairs to the Plant can be executed with minimal delay, such parts being provided packaged in complete sets, each duly labelled with their function.

- ONE set of matching V-belts for each different belt drive;
- ONE set of bearings for each different fan size;
- ONE pilot lamp bulb for each pilot light specified on the drawings to match those installed in the Electrical Switchpanel, and a bulb extractor if required;
- ONE set of filters for each Air Conditioning and Ventilation system is to be handed to the Client's Representative on final completion of the Works;
- TWELVE months supply of chemicals for the Chemical Dosing Plant, where applicable.
- ONE complete set of "O"-rings and filter for the electronic water treatment unit.

The necessary chemicals for bacterial, legionella and algae control shall be included for the purpose of water treatment required to supplement the non-chemical electronic water treatment unit.

4.41 MAINTENANCE

4.41.1 The Sub-contractor shall maintain and service the Plant, in accordance with the following requirements for a period of twelve months calculated from the date of the "Acceptance Certificate" or, in the event of more than one certificate having been issued by the Engineer, from the respective dates so certified.

4.41.2 During the "Maintenance Period" the Sub-contractor shall maintain and service the Plant regularly at monthly intervals, and make good any Defects in accordance with the provisions of these Specifications.

4.41.3 The Maintenance of the Plant shall be carried out during normal working hours and at each service the Sub-contractor shall attend to the following: -

4.41.3.1 Report to an official nominated by the Employer on arriving and again on leaving the Works. Such person shall complete and sign the monthly "Service Report".

4.41.3.2 Check the function of each item of the Plant including all automatic controls and safety devices, for correct operation and lubrication, adjust, clean and/or replace components and ancillaries as necessary.

4.41.3.3 Clean all washable air filters, and check all disposable media type air filters serving the air conditioning plants, for pressure drops, fitting additional filter material, if required.

4.41.3.4 Check all refrigeration systems for leaks, refrigerant dryness, sufficient oil in the compressors, sufficient refrigerant gas or any other defect.

4.41.3.5 Check the electrical switchpanels replacing any burnt contacts or pilot lamp bulbs which have failed.

4.41.3.6 Take and record Wet and Dry Bulb temperatures in each of the conditioned areas and outside. Temperature readings shall be taken with a reliable sling psychrometer, and all readings shall be recorded on the "Service Report".

4.41.3.7 Attend to any complaints made with respect to the Plant, by the official nominated by the Employer's, being the only person authorised to instruct the Sub-contractor or make any complaint, (other than the Engineer.) No other person shall have any right to instruct, or make any complaint to the Sub-contractor.

While attending to any Defects and the Servicing of the Plant, the Sub-contractor shall not unduly disturb the functions of the occupants in the areas concerned.

4.41.3.8 The one year maintenance period shall commence on the date of the issue of the "Acceptance Certificate". The first service to take place 1 month after date of "Acceptance Certificate". The Sub-contractor shall notify the Engineer and Client in writing, 14 days prior to this service, so that the Engineer and the Client's Representative may be present during the services.

4.41.3.9 It is an explicit condition of this enquiry that all work carried out in pursuance of this tender enquiry will be guaranteed against failure, or defect whatsoever, for a period of 12 months from the time of Acceptance by the Client.

Any costs for labour, materials, etc., which the Sub-contractor incurs whilst maintaining the above guarantee for the specified period shall be borne by the Sub-contractor.

4.42 DRAINS

- 4.42.1 Provide all necessary drain piping, laid to suitable falls, from every item requiring such drainage. Such drains shall be run to the adjacent relevant drain points shown on the Drawings.
- 4.42.2 Drainage pipework shall be adequately sized and carried out generally in medium grade galvanised piping, all connections to equipment being effected with conical faced unions or flanges.
- 4.42.3 All drains from cooling coil pans for condensate disposal shall be fitted with proprietary U-traps to prevent backflow, or non-drainage due to negative air pressures.
- 4.42.4 Drainage pipework of longer than 4,5m run shall be provided with cleaning eyes on all bends to facilitate maintenance.

4.43 **EXCLUSIONS**

- 4.43.1 The Tendered price shall specifically be understood to **EXCLUDE** all the following items, it being stressed that such items will be provided by others to details given by the successful Tenderer, and approved in writing by the Engineer.
- 4.43.2 The provision of all Plant rooms and equipment spaces shown on the Drawings, complete with level floors, lighting, suitable airtight access doors (except Trox or equal plantroom doors), and any other builder's work, as relevant as indicated on the Drawings.
- 4.43.3 The provision and making good of any openings required through walls, floors, ceilings and roofs, as well as any timber framing or flashing necessary for same.
- 4.43.4 All concrete work associated with the provision of equipment bases as detailed herein.
- 4.43.5 Any item, comprised of timber, bricks, mortar or concrete which can reasonable be construed as builder's work, together with the building-in of any item required.
- 4.43.6 The architectural concealment of any equipment to be installed by the successful Tenderer. This would apply particularly to piping and ducting.
- 4.43.7 The provision of masonry shafts as shown on the Drawings, complete with smooth internal plastered finish.
- 4.43.8 All openings in glazing in windows for the installation of exhaust fans.
- 4.43.9 The provision of mains water supply points, each terminating in a gate type isolating valve within three meters of the equipment it serves, as indicated on the attached Drawings.
- 4.43.10 Drainage points will be provided in the positions, and of the sizes indicated on the Drawings, such drains for general equipment drainage and condensate disposal.
- 4.43.11 The bringing up, and connecting to, the incoming terminals of the main isolators in each switchpanel of suitably rated 380 volt, 3 phase 4 wire electricity supplies, in the positions indicated on the drawings. Suitably rated 380 volt, 3 phase, 4 wire electricity supplies to any remote fans or equipment in the positions indicated on the drawings. Suitably rated 220 volt, single phase switched socket outlets for propeller type exhaust fans in the positions indicated on the Drawings.
- 4.43.12 Any other item mentioned in these Specifications, or on the accompanying Drawings as being expressly for the provision of others.

PART V

DETAILED SPECIFICATION

SECTION FIVE

DETAILED SPECIFICATION

<u>CLAUSE</u>		<u>PAGE NUMBERS</u>
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5.2

SCOPE OF WORK

The General Technical Specification forms part of this tender document.

By submitting a tender it shall be assumed that the subcontractor has studied this document.

5.2.1

The Contract, as detailed in these Specification Documents and the accompanying Drawings, comprises of the manufacture, supply, transport and delivery, hoisting, installation, testing, setting in operation, leaving in complete working order, and guarantee of the entire air conditioning plant and, except so far as the contract otherwise provides, the provision of all labour, materials, contractor's equipment and everything, whether of a temporary or permanent nature required in and for such manufacture, supply, offloading, hoisting, installation, testing, setting in operation, leaving in complete working order, guarantee so far as the necessity for providing the same is specified in or reasonably to be inferred from the contract.

5.2.2

No Builder's Work shall be included in this contract and all such work, as later herein specified as being specifically excluded from this contract, shall be carried out by others in accordance with the Drawings and details provided by the Engineer or the contractor as applicable and as provided herein.

5.2.3

Work by Main Contractor:

- All equipment plinths, bases and plantrooms. Metal plinth formers to be provided by HVAC Subcontractor.
- All plant enclosures
- All penetrations through walls, slabs, ceilings and steelwork
- Making good of all openings after installation of ductwork and equipment
- Waterproofing of all duct or piping entries to building through roofs, walls or the structure
- Cut outs in doors and installing door grilles supplied by Air Conditioning Contractor

5.2.4

Work by Plumber:

- Water supply points terminating in valves
- Drain points.
- All as indicated on drawings.

5.2.5

Work by Electrical Contractor:

- Mains incoming power supplies to air conditioning plants made off on isolators
- Emergency power change over contactors, wiring to air conditioning plants and change over signal
- Wall boxes and conduit in brick walls or partitions for air conditioning controls
- All as shown on drawings.
- Electrical power supplies to all ventilation fans. Air conditioning contractor to provide all starters, wiring and manual test facility for each fan.

NOTE:

1. All final terminations in the air conditioning panels by the air conditioning sub-contractor.
2. All air conditioning panels to be "top-entry" type.
3. Power distribution from air conditioning plantroom distribution boards to ceiling mounted air outlets is by the air conditioning sub-contractor.
4. All final connections between local isolators outdoor units and ventilation fans by the Air Conditioning Sub-Contractor.
5. All site wiring between outdoor and indoor units including controls by Air Conditioning Sub-Contractor.

POWER SUPPLIES BY ELECTRICAL CONTRACTOR

- | | | |
|-----|---|-------------------------|
| 1. | Voltage | 400/230V $\pm 5\%$ |
| 2. | Fault Levels | |
| 2.1 | Chiller Plantroom | 25 kA |
| 2.2 | Other floor plantrooms, fan, etc. | As detailed on drawings |
| 3. | Fans etc., supplied with power directly from the electrical contractor shall have overload protection to be provided by the Contractor. | |

5.2.6 Fire Detection Contractor:

Smoke/fire detection signals wired to air conditioning control boards, for each unit and/or system (Contractor to provide potential-free contact for signal termination).

5.2.7 The specification documentation shall include the tender drawings:

Air conditioning and ventilation lower ground floor	M-1000
Air conditioning and ventilation ground floor	M-1001
Air conditioning and ventilation first floor	M-1002
Air conditioning and ventilation second floor	M-1003
Air conditioning and ventilation third floor	M-1004
Air conditioning and ventilation fourth floor	M1005
Air conditioning and ventilation fifth floor	M-1006
Air conditioning and ventilation roof plant layout	M-1007
Chilled Water and Heating Water Pipe Schematics	M-1020

5.3 **PROGRAMME**

5.3.1 Building work will commence in the near future and the air conditioning contractor will be required to commence work immediately on receipt of instructions to proceed.

5.3.2 The installation of air conditioning is to comply with the builders program.

Refer to – Notes to Tenders:

5.3.3 The entire air conditioning and ventilation installation must be commissioned, tested and Taken Over by the Engineer as noted in paragraphs 5.5.2, 5.7.1, and 5.11.1 Commissioning Programme.

5.3.4 When the successful sub-Contractor is notified of the success of his Tender after the Tender closing date, thereupon the sub-Contractor shall IMMEDIATELY put the work in hand, notwithstanding the fact that no official Subcontract will by this time have been entered into. During the period prior to the signing of an official sub-Contract, but during which the work must in terms of the above be proceeded with, the work will be administered by the Engineer as if, in fact, such document had already been in force.

5.3.5 The sub-Contractor shall be required within TWO WEEKS after acceptance of his Tender, to submit to the Engineer for his approval a Programme showing the order in which the Works will be executed. Such Programme shall show the times for the preparation of all drawings, ordering and delivery times promised by the suppliers for each major item of Plant, manufacturing and delivery times for all manufactured items, installation times and the programmed dates for testing and commissioning the Plant.

The Programme shall be prepared in consultation with the Principal Contractor and the execution of the Works shall be programmed so as to keep pace with the Building Programme. The sub-Contractor shall submit TWO copies of his Programme to the Engineer for approval and after approval by the Engineer in writing the Subcontractor shall supply copies to the Principal Contractor. After submission to and approval by the Engineer of such Programme, the sub-Contractor shall adhere to the order of procedure and method stated therein unless he obtains the written permission of the Engineer to vary such order or method. The submission to and approval by the Engineer of such Programme shall not relieve the sub-Contractor of any of his duties or responsibilities under the sub-Contract.

5.3.6 The times required for the submission of Drawings, pursuant to Clauses 5.4.3 and 5.4.4 hereof, are as follows:

Builder's Work Drawings
Shop Drawings

within **TWO WEEKS**
within **ONE WEEK**.

5.4 DRAWINGS

5.4.1 Tender Drawings

The Drawings accompanying this Specification are as numbered below, and shall be deemed to indicate the general layout and requirements only and are not Shop Drawings.

The Engineer shall provide the Contractor, free of charge, with three sets of Specification Documents, to include the Tender Drawings.

5.4.2 All equipment, ducting, pipes and fittings and electrical equipment shall conform to the Standard Technical Specification. Where the standard specification is contradicted by the Detailed Technical Specification, the Detailed Technical Specification shall apply.

5.4.3 Architectural and Structural Drawings

The sub-Contractor shall ensure that he is in possession of all information required for the installation of the Works and shall, if necessary, obtain copies of all relevant Architectural and Structural Drawings from the Architect and Structural Engineer, so named elsewhere in this Specification.

5.4.4 Builder's Work Drawings

All Builder's Work and work to be carried out by others in accordance with the Specification has been indicated on the Tender Drawings. The Contractor shall check, approve, add to or alter such drawings as may be necessary to suit the Plant offered by him, and accepted by the Engineer, within the time stipulated in Clause 5.3.4 on Page V/3 hereof from date of acceptance of his Tender and shall submit to the Engineer in duplicate any revision which shall be made to such Drawings.

Such Builder's Work Drawings shall indicate the location and extent of all foundations, bases, openings, timber frames and all other Builder's Work and the capacities and/or dimensions of all electrical and water supply points, the method of terminating such supplies and the position of the connection points, the position and dimensions for all water drainage connections and any other work to be provided by others for the Works, as detailed in these Specifications.

The Drawings shall be drawn to scale and in sufficient detail to enable the Builder to execute the work without any misunderstanding.

Within a reasonable period after receiving such Drawings, the Engineer shall signify his approval, or otherwise, and one signed copy of the approved Drawing shall be returned to the sub-Contractor.

When approved, the following number of copies of each such Drawing shall be delivered to each of the following:

Quantity Surveyor	1 copy
Main Contractor	3 copies
Architect	2 copies
Structural Engineer	1 copy
Electrical Engineer	1 copy
Fire Services Engineer	1 copy

5.4.5

Shop Drawings

The sub-Contractor shall submit to the Engineer, for approval within the time stipulated in Clause 5.3.6 on Page V/3 hereof duplicate copies of all Shop Drawings as required for the manufacture and installation of the Works or as the Engineer may reasonably require.

All Shop Drawings for work outside of plantrooms shall be drawn to a scale of not smaller than one in fifty and all Drawings of work within plantrooms shall be drawn to a scale of not smaller than one in twenty-five. All details shall be drawn to a scale to show the detail required.

Within a reasonable period after receiving such Drawings, the Engineer shall signify his approval, or otherwise, in writing and one signed copy of each approved Drawing shall be returned to the sub-Contractor.

The sub-Contractor shall not, unless otherwise directed by the Engineer, in writing, commence with any work prior to the approval of the relative Shop Drawings. Work installed prior to the approval of Shop Drawings shall be liable to rejection by the Engineer and removal and/or replacement by the sub-Contractor, at his cost, if it is considered by the Engineer to deviate from the Specification.

The sub-Contractor shall also supply copies of all approved Drawings in accordance with the requirements of Clause 37 of Part IV (Operating and Maintenance Instructions) of the Specification.

Drawings approved as above described shall not be departed from except as authorised by the Engineer.

The Engineer shall have the right at all reasonable times, to inspect at the factory of the sub-Contractor, all Drawings of any portion of the Works.

5.4.6

Mistakes in Drawings

Any expense resulting from an error or omission in or from delay in delivery of the Drawings, shall be borne by the Subcontractor.

The sub-Contractor shall be responsible for any discrepancies, errors, or omissions in the Drawings and other particulars supplied by him, whether such Drawings and particulars have been approved by the Engineer or not, provided that such discrepancies, errors, or omissions are not due to inaccurate information or particulars furnished in writing to the sub-Contractor by the Engineer or the Architect. The Employer shall be responsible for Drawings and information supplied in writing by the Engineer or the Architect and for the details of special work by either of them.

5.5 DESCRIPTION OF HVAC SYSTEM

5.5.1 CHILLED WATER/HEATING WATER PLANT

The Chilled Water/Heating Water plant consist of 1 Off Air – cooled chiller (energy raisers type) complete with primary and secondary pumps, buffer tanks, etc. The chillers, pumps and buffer tanks are located in a plant area at roof level.

Chilled/Heating water shall be distributed to the AHU's serving the various floors.

The chiller shall be controlled via the integrated chiller controls and building management system.

Outside the programmed occupation period the chiller can be started if any of the air handling units is started and the chilled/heating water control valve is more than 10% open.

Supply and return water temperatures and chilled/heating water pump status are monitored from the BMS operational terminal.

5.5.2 AIR CONDITIONING PLANT

5.5.2.1 The 6 off floors are served from a number of variable volume chilled water air handling units air handling units within plant rooms on the actual floors, ground floor has one off air handling unit and floors 1 – 5 have 2 off air handling units each.

The air- handling units shall comprise of supply fans, cooling coils, heating coils, filter, controls and safeties, etc. All motors shall be premium efficiency motors.

Chilled and heating water shall be fed to this air –handling units via insulated steel piping from the chilled/healing water generator.
insulated sheet metal ducting, attenuators and distributed to the space via variable volume and fixed volume supply air registers, wall mounted temp control thermostats shall be located in various rooms, these thermostats shall drive the diffuses to a minimum stop (closed position) when the rooms are not occupied.

Recirculated air shall be returned through return air grilles and ducted back to the air-handling units.

The required heating in winter shall be provided by means of heating water generated by the energy raiser chillers.

The air-handling unit shall be automatically controlled to provide the required temperature conditions in summer and winter and shall be switched on and off automatically by means of the BMS programmed for the operating hours required.

5.5.2.2 Patch Rooms/ UPS rooms shall be provided with run/ standby midwall air cooled split units..

5.5.2.3 Security Room shall be air conditioned with a ceiling mounted air-cooled ceiling cassette unit.

Outside air shall be introduced into the unit from the AHU serving the office areas.

The outdoor unit shall be mounted in the Basement at high level.

5.5.3 MECHANICAL VENTILATION SYSTEM

5.5.3.1 All ablution areas shall be mechanically ventilated through axial flow extract fans and ducting systems. The extract fan motors shall be of the premium efficiency type.

- 5.5.3.2** The MLV and Transformer Room shall be mechanically ventilated through axial flow fans and ducting systems, the extract fans shall be thermostatically controlled.
The extract fan motors shall be of the premium efficiency type.

5.5.3.3 BASEMENT 2 PARKING

The Basement Parking will be mechanically ventilated to comply with the National building Regulations at an extraction rate of 7.5 ℓ/s/m².

There will be a total of 1 Axial Flow Fans located along the rear wall of the basement. The air will be drawn through extract air grilles.

The fan shall be controlled via space mounted CO sensors.

Replacement air will be introduced via the main entrance gates into the parking.

5.5.4 CHILLED WATER GENERATORS

The chiller shall be of the air cooled type incorporating screw compressors and operating on R134a.

The chiller will also have a heat recovery feature for heating water generation.

The chiller is to be installed on spring anti-vibration mounts.

Tenderers are to base their main offer on the use of 'Clivet' chillers.

The following makes may be offered as alternatives:

TRANE, CARRIER

5.5.5 CONTROL SYSTEM:

5.5.5.1 Building Monitoring System (BMS):

BMS shall control the HVAC system.

5.5.5.2 Chiller Control:

The BMS time schedule starts and stops the chillers and chilled and heating water pumps. After receipt of the start signal the chillers operate via their inherent control systems.

Outside of the programmed occupation period the chillers can be started if any of the air handling units are started and the chilled water control valve is more than 10% open.

Supply and return water temperatures and chilled and heating water pumps status are monitored from the BMS operator's terminal.

5.5.5.2.1 Chiller Management System:

The controls for the chillers includes an existing "multiple parallel chiller" control facility. The chiller management system shall be interfaced with BMS and shall be BACnet compatible.

The management system shall provide the following features:

- Centralised monitoring computer for single point for analysis, alarm notification and fault diagnosis.

- Direct communication with chiller control panels for interrogation of the chillers from the workstation or remotely via a modem. The system shall have the ability to dial out in the event of an alarm.
- Expandability to control auxiliaries such as pumps, valves, etc.
- Chiller sequencing and set point control.
- Chiller rotation based on operating hours.
- Lead lag sequencing.
- Soft loading when system supply temperature is far from set point.
- Time of day scheduling.
- Trend logging.
- Event logging.
- Status and control of Binary/analogue inputs and outputs
- Preventative planned maintenance scheduling.
- Fault indication.
- Staggered start to prevent all controlled equipment from simultaneously restarting after a power outage.

The chiller management system shall also perform the following as well:

- Starting and stopping the primary chilled and heating water pumps 2 off.
- Starting and stopping the secondary chiller and heating water pumps 6 off and control the speed of the variable speed pumps via differential pressure sensing in the secondary chilled heating water piping system.

The chiller control sequencing shall be based on supply water temperature to add a chiller and on bypass flow (via flowmeter by others) to subtract a chiller.

The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. The mouse shall be used to quickly select and switch between multiple applications. This shall be accomplished through the use of Microsoft Windows.

5.5.5.3 Air Handling Units:

The BMS time schedule starts and stops air handling units at the programmed times.

Supply air fan status and dirty filter conditions will be monitored by the BMS.

Adequate space must be allowed inside the AHU fresh/return air plenum for the BMS panel.

5.5.5.4 Split System Air Conditioning Units:

The BMS system shall be interfaced with the systems controllers via BACNET. All the information shall be displayed on the BMS.

5.5.6 CHILLED WATER AND HEATING WATER PUMPS

Chilled water and heating water pumps shall be of the direct drive centrifugal type incorporating mechanical seals, stainless steel shafts and bronze impellers.

The maximum operating speed is to be 1450 RPM.

Impellers shall be not more than 80% of the maximum diameter for the particular size pump.

Pump assemblies are to be installed on spring anti-vibration mounts.

Tenderers are to base their main offers on the use of **Grundfos NK pumps**.

Motors shall be premium efficiency type.

The following makes may be offered as alternatives:

KSB

The secondary chilled water pumps shall be speed control by YASKAWA frequency converters and pump motors used are to be compatible with this type of speed controller.

5.5.7 **CHILLED AND HEATING WATER PIPING**

Chilled and heating water reticulation shall be carried out in BSS 1387 medium black pipe, welded down to 65mm diameter and screwed below this size.

5.5.8 **CHILLED WATER PIPE INSULATION**

Chilled and heating water piping shall be insulated with polyisocyanurate (PIC) foam insulation (35 kg/m³ density) sections secured with adhesive and reinforced tape. The insulation thickness to conform with the required standards. Vapour seal using one layer foil to Mylar secured with adhesive and silver aluminium foil tape. Clad using 0.5mm thick galvanised sheet metal secured with metal strapping, so as not to damage or tear the vapour barrier. No pop rivets are to be used.

5.5.9 **AIR HANDLING UNITS/PLANTS**

Chilled water airhandling units shall be of the double skin vertical variable/constant volume type incorporating copper aluminium coils and Fibatron WP77 washable filters.

Tenderers are to allow in their price for one additional row on the cooling coils over and above that calculated as being necessary, i.e.

Calculated	=	4,6 row 10 fpi
Allow	=	6 row 10 fpi

A maximum of 10 fpi will be allowed.

All cooling coils shall have a heavy gauge grade 304 stainless steel casting fitted with a 1,2 mm thick grade 304 stainless steel condensate pan.

Fan speed for variable air volume systems is to be controlled by Yaskawa frequency converters and tenderers are to ensure that fan motors used are compatible with this type of speed controller.

The motors shall be premium efficiency type.

Airhandling units are to be mounted on rubber pads.

The electrical switchboard, BMS controls, etc., shall be mounted to the plantroom walls

Tenderers are to base their price on the use of **CLIVET Units**

The following makes may be offered as alternatives:

AIR OPTIONS AIR HANDLING UNITS

VIKING

HEAT PUMP INTERNATIONAL

As this is an existing building with access to the plantrooms being difficult, tenderers to ensure that allowances are made for the Air handling units to be assembled on site in the plantrooms.

5.5.10 VARIABLE VOLUME SUPPLY AIR OUTLETS

Variable volume outlets shall be of the low velocity low pressure type suitable to drop into a 600 x 600 ceiling grid.

The self contained controls shall be modular enabling simple and economical change over from slave to master configuration and vice versa. The master diffusers shall be controlled via the BMS.

The controls shall include an automatic reversing function to fully open the diffuser when the air handling unit is in heating mode.

Tenderers are to base their main offer on **RICKARD**.

The following makes may be offered as alternatives:

**KRANTZ
TROX**

5.5.11 AXIAL FLOW FANS

Axial flow fans are to be of the long casing direct drive type.

Fan casings are to be galvanised.

Fans are to be installed on anti vibration springs.

Tenderers are to base their main offer on the use of **DONKIN/ AMS**.

The following makes may be offered as alternatives:

**ZIEHL
SYSTEMAIR**

5.5.12 ELECTRICAL SWITCHBOARDS AND WIRING

5.5.12.1 GENERAL

Electrical switchboards shall be constructed and wiring carried out in accordance with Part IV of this specification and the electrical schematics which form part of this documentation.

All switchboards shall be pre-wired and tested prior to delivery to site.

Switchboards shall be wired in such a way as to provide safe sequenced and automatic start up and operation of the systems. All necessary interlock and time delay relays etc. are to be allowed in the price.

The main offer shall be based on the use of Yaskawa variable speed drives for the variable volume unit supply fan motors.

Alternatives may be offered under separate cover.

All wiring from the air conditioning switchboards to all individual components of the air conditioning and ventilation systems is to be carried out as part of the air conditioning contract.

5.5.12.2 MAIN CHILLED WATER PLANTROOM SWITCHBOARD

The Main electrical switchboard in the chilled water plantroom is fed from supplies and busbars supplied by others. The incoming circuit breakers/isolators shall be compact or masterpact from Merlin and Gerlin or Schneider. Power factor correction shall be by others. Each feeder will be

separately metered by others.

All switchgear must be Merlin and Gerlin or Schneider.

The switchboard's fault level is 25 kA.

The switchboard shall be fully type tested board to comply with SANS 10142-1 latest amendment.

5.5.12.3 AIR HANDLING UNIT AND ALL OTHER SWITCHBOARDS

The air handling switchboards is fed from local electrical distribution boards by others. The incoming supply will be terminated directly into the main circuit breakers/isolators by the Site Electrical Contractor.

All HVAC electrical distribution boards to be top entry.

The switchboards fault level is 15 kA.

The electrical and BMS switchboards for air handling units that are within plantrooms will be mounted on the unit exterior.

Switchboards shall be type tested boards to comply with SABS SANS 10142-1 latest amendment where required.

All switchgear must be Merlin and Gerlin or Schneider.

5.5.12.4 ELECTRICAL LOAD SCHEDULE

Equipment Ref	Location	Power			TOTAL	Fed From
		V/Ph	kW	kVA	kVa	
	Roof Plant					
CWG.1	CHILLER 1 (running)	400/3	350	411.7	411.7	ACDB1
SCHWP1	SECONDARY CHILLED WATER PUMP 1	400/3	11.0	12.9	12.9	ACDB1
SCHWP2	SECONDARY CHILLED WATER PUMP 2	400/3	11.0	12.9	12.9	ACDB1
SCHWP3	SECONDARY CHILLED WATER PUMP 3	400/3	11.0	12.9	12.9	ACDB1
SHWP1	SECONDARY HEATING WATER PUMP 1	400/3	11.0	12.9	12.9	ACDB1
SHWP2	SECONDARY HEATING WATER PUMP 2	400/3	11.0	12.9	12.9	ACDB1
SHWP1	SECONDARY HEATING WATER PUMP 3	400/3	11.0	12.9	12.9	ACDB1
EAF.1	TOILETS 1 ST TO 5 TH FLOORS	400/3	1.8	2.11	2.11	ACDB1
EAF.2	TOILETS GROUND FLOOR	400/3	0.45	0.53	0.53	ACDB1
ACDB1	TOTAL		418.25	492.05	492.05	

Equipment Ref	Location	Power			TOTAL	Fed From
		V/Ph	kW	kVA	kVa	
EAF.15	BASEMENT PARKING	400/3	6	7.05	7.05	ACDB2
ACDB2	TOTAL		6	7.05	7.05	

Equipment Ref	Location	Power			TOTAL	Fed From
		V/Ph	kW	kVA	kVa	
EAF.16	Transformer and LV Room	400/3	0,45	0.53	0.53	ACDB3
ACDB3	TOTAL		0.45	0.53	0.53	

Equipment Ref	Location	Power			TOTAL	Fed From
		V/Ph	kW	kVA	kVa	
EAF.18	HT Room	400/3	0,2	0.25	0.25	ACDB4
ACDB4	TOTAL		0.2	0.25	0.25	

ACDB	AHU.1	AHU.2	AHU.3	AHU.4	AHU.5	AHU.6	AHU.7	AHU.8	AHU.9	AHU.10	AHU.11
Supply Air Fan Motor Size (kW)	10	6	6	6	6	6	6	6	6	6	6
Total Reheater Capacity (kW)	21	12.5	18.5	14	16	14	15	11	10	16	16
Voltmeter	√	√	√	√	√	√	√	√	√	√	√
Ammeter	√	√	√	√	√	√	√	√	√	√	√
Selector Switch	√	√	√	√	√	√	√	√	√	√	√
Fire Interlock	√	√	√	√	√	√	√	√	√	√	√
Manual-Off-Auto Switch	√	√	√	√	√	√	√	√	√	√	√
Run & Fault Lights	√	√	√	√	√	√	√	√	√	√	√
Variable Speed Drive	√	√	√	√	√	√	√	√	√	√	√
Air Pressure Switch	√	√	√	√	√	√	√	√	√	√	√
Re-Heaters Enabled Light	√	√	√	√	√	√	√	√	√	√	√
System 400V/3 Phase/4 Wire	√	√	√	√	√	√	√	√	√	√	√
Total (kVA)	36.47	21.76	28.82	23.53	25.88	23.53	24.70	20.00	18.82	25.88	25.88
Fault Level (kA)	15	15	15	15	15	15	15	15	15	15	15
Incoming cable entry: Top	√	√	√	√	√	√	√	√	√	√	√
Outgoing cable exit: Top	√	√	√	√	√	√	√	√	√	√	√
Panel access: Front	√	√	√	√	√	√	√	√	√	√	√
Labels: English	√	√	√	√	√	√	√	√	√	√	√
Control Wiring: 1,5 mm²	√	√	√	√	√	√	√	√	√	√	√
Construction: 2 mm Sheetmetal	√	√	√	√	√	√	√	√	√	√	√
Paint Finish: Orange	√	√	√	√	√	√	√	√	√	√	√

Equipment Ref	Location	Power V/Ph	Summer		TOTAL	Fed From
			kW	kVA	kVa	
MWSU.12	FIFTH FLOOR NORTH PATCH ROOM	240/1	1.5	1.76	1.76	Local Isolator
MWSU.11	FIFTH FLOOR NORTH PATCH ROOM	240/1	1.5	1.76	1.76	Local Isolator
EAf.21	FIFTH FLOOR TOILET	240/1	0.5	0.6	0.6	Local Isolator
MWSU.10	FOURTH FLOOR NORTH PATCH ROOM	240/1	1.5	1.76	1.76	Local Isolator
MWSU.9	FOURTH FLOOR NORTH PATCH ROOM	240/1	1.5	1.76	1.76	Local Isolator
EAf.5	FOURTH FLOOR STORE ROOM 2	240/1	0.5	0.6	0.6	Local Isolator
EAf.4	FOURTH FLOOR STORE ROOM 1	240/1	0.5	0.6	0.6	Local Isolator
EAf.3	FOURTH FLOOR STORE ROOM 3	240/1	0.5	0.6	0.6	Local Isolator
MWSU.8	THIRD FLOOR NORTH PATCH ROOM	240/1	1.5	1.76	1.76	Local Isolator
MWSU.7	THIRD FLOOR NORTH PATCH ROOM	240/1	1.5	1.76	1.76	Local Isolator
EAf.6	THIRD FLOOR SENSITIVE STORE ROOM	240/1	0.5	0.6	0.6	Local Isolator
EAf.7	THIRD FLOOR SENSITIVE STORE ROOM	240/1	0.5	0.6	0.6	Local Isolator
MWSU.6	SECOND FLOOR NORTH PATCH ROOM	240/1	1.5	1.76	1.76	Local Isolator
MWSU.5	SECOND FLOOR NORTH PATCH ROOM	240/1	1.5	1.76	1.76	Local Isolator
MWSU.4	FIRST FLOOR NORTH PATCH ROOM	240/1	1.5	1.76	1.76	Local Isolator
MWSU.3	FIRST FLOOR NORTH PATCH ROOM	240/1	1.5	1.76	1.76	Local Isolator
EAf.8	FIRST FLOOR STORE ROOM 1	240/1	0.5	0.6	0.6	Local Isolator
MWSU.2	GROUND FLOOR EAST PATCH ROOM	240/1	1.5	1.76	1.76	Local Isolator
MWSU.1	GROUND FLOOR EAST PATCH ROOM	240/1	1.5	1.76	1.76	Local Isolator
CCU.1	GROUND FLOOR SECURITY ROOM	240/1	2.8	3.2	3.2	Local Isolator
EAf.9	GROUND FLOOR ARCHIVES/ STORAGE	240/1	0.5	0.6	0.6	Local Isolator
EAf.10	GROUND FLOOR ARCHIVES/ STORAGE	240/1	0.5	0.6	0.6	Local Isolator
EAf.11	GROUND FLOOR ARCHIVES/ STORAGE	240/1	0.5	0.6	0.6	Local Isolator
EAf.12	GROUND FLOOR FILE STORAGE	240/1	0.5	0.6	0.6	Local Isolator
EAf.13	GROUND FLOOR ARCHIVES/ STORAGE	240/1	0.5	0.6	0.6	Local Isolator
EAf.14	GROUND FLOOR STORE ROOM	240/1	0.5	0.6	0.6	Local Isolator
MWSU.13	LOWER GROUND UPS Room	240/1	2.8	3.2	3.2	Local Isolator
MWSU.14	LOWER GROUND UPS Room	240/1	2.8	3.2	3.2	Local Isolator
CWU-01	LOWER GROUND SECURITY GREEN ROOM	240/1	1.5	1.76	1.76	Local Isolator
CDU-01	LOWER GROUND SECURITY LOBBY	240/1	4.5	5.29	5.29	Local Isolator

5.5.12.5 SWITCHBOARDS

ACDB-1	INCOMING MAINS	CWG.1	SCHWP.1	SCHWP.2	SCHWP.3	SHWP.1	SHWP.2	SHWP.3	EAF.1	EAF.2	
Motor Size (kW)		350	11.0	11.0	11.0	11.0	11.0	11.0	1.8	0.45	
Voltmeter	√										
Ammeter	√ per phase with MDI										
Selector Switch	√										
Pilot light for Power on	√										
Fire Interlock									√	√	
Manual-Off-Auto Switch		√	√	√	√	√	√	√	√	√	
Run & Fault Lights		√	√	√	√	√	√	√	√	√	
Variable Speed Drive			√	√	√	√	√	√			
Ammeter		√									

System: 400V/3 Phase/4 Wire
 Total kVA 492.05
 Fault Level: 25 kA
 Incoming cable entry: Top (Busbar will be used on incoming supply)
 Outgoing cable exit: Top
 Panel access: Front and Rear
 Labels: English
 Control Wiring: 1,5 mm²
 Construction: 2 mm Sheetmetal
 Paint Finish: Orange

NOTE:

Switchboard to be fully type tested board to comply with SANS 10142-1 latest amendment.
 All switchboards must be Merlin and Gerlin or Schneider.

5.5.12.5 SWITCHBOARDS

ACDB-2 - ESSENTIAL SUPPLY		
	INCOMING MAINS	EAF.15
Motor Size (kW)		6
Voltmeter	√	
Ammeter	√ per phase with MDI	
Key Selector Switch	√	
Pilot light for Power on	√	
Fire Interlock		√
Key Manual-Off-Auto Switch		√
Run & Fault Lights		√
Motorised Dampers		√
Air Pressure Switch		√
Variable Speed Drive		√

System: 400V/3 Phase/4 Wire
 Total kVA: 7.05
 Fault Level: 15 kA
 Incoming cable entry: Top (Busbar will be used on incoming supply)
 Outgoing cable exit: Top
 Panel access: Front and Rear
 Labels: English
 Control Wiring: 1,5 mm²
 Construction: 2 mm Sheetmetal
 Paint Finish: Red

NOTE:

Switchboard to be fully type tested board to comply with SANS 10142-1 latest amendment.
 All switchgear must be Merlin and Gerlin or Schneider.

ACDB-3		
	INCOMING MAINS	EAF.16
Motor Size (kW)		0,45
Voltmeter	√	
Ammeter	√ per phase with MDI	
Selector Switch	√	
Pilot light for Power on	√	
Fire Interlock		√
Manual-Off-Auto Switch		√
Run & Fault Lights		√
Variable Speed Drive		
Air Pressure Switch		√
Ammeter		

System: 400V/3 Phase/4 Wire
 Total kVA 0,53
 Fault Level: 15 kA
 Incoming cable entry: Top (Busbar will be used on incoming supply)
 Outgoing cable exit: Top
 Panel access: Front and Rear
 Labels: English
 Control Wiring: 1,5 mm²
 Construction: 2 mm Sheetmetal
 Paint Finish: Orange

NOTE:

Switchboard to be fully type tested board to comply with SANS 10142-1 latest amendment.
 All switchgear must be Merlin and Gerlin or Schneider.

5.5.12.5 SWITCHBOARDS

ACDB	AHU.1	AHU.2	AHU.3	AHU.4	AHU.5	AHU.6	AHU.7	AHU.8	AHU.9	AHU.10	AHU.11
Supply Air Fan Motor Size (kW)	10	6	6	6	6	6	6	6	6	6	6
Total Reheater Capacity (kW)	21	12.5	18.5	14	16	14	15	11	10	16	16
Voltmeter	√	√	√	√	√	√	√	√	√	√	√
Ammeter	√	√	√	√	√	√	√	√	√	√	√
Selector Switch	√	√	√	√	√	√	√	√	√	√	√
Fire Interlock	√	√	√	√	√	√	√	√	√	√	√
Manual-Off-Auto Switch	√	√	√	√	√	√	√	√	√	√	√
Run & Fault Lights	√	√	√	√	√	√	√	√	√	√	√
Variable Speed Drive	√	√	√	√	√	√	√	√	√	√	√
Air Pressure Switch	√	√	√	√	√	√	√	√	√	√	√
Re-Heaters Enabled Light	√	√	√	√	√	√	√	√	√	√	√
System 400V/3 Phase/4 Wire	√	√	√	√	√	√	√	√	√	√	√
Total (kVA)	36.47	21.76	28.82	23.53	25.88	23.53	24.70	20.00	18.82	25.88	25.88
Fault Level (kA)	15	15	15	15	15	15	15	15	15	15	15
Incoming cable entry: Top	√	√	√	√	√	√	√	√	√	√	√
Outgoing cable exit: Top	√	√	√	√	√	√	√	√	√	√	√
Panel access: Front	√	√	√	√	√	√	√	√	√	√	√
Labels: English	√	√	√	√	√	√	√	√	√	√	√
Control Wiring: 1,5 mm ²	√	√	√	√	√	√	√	√	√	√	√
Construction: 2 mm Sheetmetal	√	√	√	√	√	√	√	√	√	√	√
Paint Finish: Orange	√	√	√	√	√	√	√	√	√	√	√

NOTE:

Switchboard to be fully type tested board to comply with SANS 10142-1 latest amendment.

All switchgear must be Merlin and Gerlin or Schneider.

5.5.13**AUTOMATIC CONTROL SYSTEM AND B.M.S.**

The air conditioning and ventilation systems shall be controlled by a BMS system. The BMS system will be priced by a selected sub-contractor, but the following items must be costed as part of this tender:

1. Overheat Stats.
2. Airflow switches.
3. Sockets and wells for sensors.
4. Waterflow switches and sockets.
5. Variable speed motor drives.
6. Fitting of control valves only.
7. Chilled and Condenser Water Bypass Valves.
8. Chilled and Heating Water Flow Meter.
9. Variable volume diffusers including actuators only.
10. The supply and installation by all motorised dampers. Actuators by the BMS contractor.

5.5.14**SPARE PARTS**

This shall be provided as per Clause 4.40 as detailed in Part IV.

5.5.15**GENERAL**

- All requirements as contained in Part IV of this specification shall be adhered to.
- Tenderers are to allow for carrying out 12 service and maintenance visits to the plant during the first year of operation and for a full twelve months guarantee as detailed in Part IV.
- Three copies of the Operating and Maintenance Manuals and As Built Drawings, as detailed in Part IV, are required including CD (electronic format of complete manual and as-built drawings).

The tenderer is to note and make provision for the following:

- Two complete set of filters, to be changed prior to the complex opening and 12 months thereafter.
- All flexible ducting carrying conditioned air shall be pre-insulated wiremold available from Europair.
- The following spare parts shall be provided:
 - One set of matched V-belts for each different belt drive.
 - One set of bearings for each different fan size and gland packing for the pump.
 - One pilot bulb for each pilot light.
 - Twelve months supply and chemicals for the Dosing Plant where applicable.
- The instrumentation required at the air handling plants for measuring water pressure and temperature shall comprise SISCO ¼" test plug of solid brass into suitably sized welded socket. One SISCO master test kit comprising two 2½" pressure gauges and two 5" stem thermometers, all necessary adaptors and a sturdy carrying case shall be provided.

5.5.16 **AUTOMATIC CONTROL SYSTEM AND B.M.S.**

Tenderers shall base their main offer on the use of **JOHNSON CONTROLS (JCI)**

Alternatives may be offered for the following systems:-

LANDIS AND STAefa/SIEMENS/TRANE SUMMIT ALERTON

The new BMS shall not be connected into the Centre network.

The final detailed design, supply, installation, wiring and commissioning of the control system shall be carried out by the specialist controls company.

The air cooled chillers shall be supplied complete with their own controls. These units must, however be connected to the main BMS via Bacnet **protocol. (Bacnet over IP)**

Graphics is required for each plantroom and AHU's and all floors.

All conduits shall be in galvanised steel (bozal)

5.5.16.1 **Variable Volume Units**

Cooling and heating shall be controlled in a sequential manner by means of a proportional cooling valve and heating valve.

The control strategy will be to supply a temperature to the zones in order to satisfy the demands of the sensors placed at strategic positions in the zones, as per the floor layout drawings.

If more effective control can be achieved, the supply air temperature shall be reset as a function of outside air temperature, % S/A Volume (fan speed) or space temperature.

The actual strategy will be determined and finalised at the time of commissioning.

Differential static pressure will be maintained by varying the speed of the supply air fan, in a proportional manner, to the dictates of a 0 -10 volt D.C. signal.

Chilled and heating water valves are to be of the 2-way type.

The diffusers shall have electrical heaters were indicated.

5.5.16.2 **Chilled Water Generators**

Chilled water generators are Clivet screw machines.

Chillers are to be controlled on leaving water temperature and low ambient control is to be included.

5.5.16.3 **General -**

- The pressure drop across all valves must be selected to ensure that the valve will have complete authority over the water flow through the coils, at the specified water quantities.
- The supply of all automatic control valves and their actuators is to be by the controls specialist.
- Installation will be by the air conditioning contractor.
- The cost of all software and programming is to be included in the tender price.
- All control wiring is to be carried out by the controls specialist.

- The equipment and software offered shall be current manufacture. No custom made products shall be allowed.
- Temperature sensors shall have an accuracy of + 0,2°C over their range.
- The use of multiplexers will not be acceptable.
- All digital outputs are to be electrically isolated from the digital controller by interface relays.
- On resumption of power, after a power failure, equipment must start up automatically to the dictates of the start up schedule, at timed intervals.
- All equipment starting at the same time will not be permitted.

5.5.16.4

GENERAL SPECIFICATION

The Heating ventilation and air conditioning sub-contractor shall employ a Controls Specialist Company who is well established in South Africa, is reputable and who shall be responsible for the design, engineering, documentation, supply, installation, commissioning, hand over, guarantee and maintenance of the BMS (Building Management System) and to implement the sequence of operation as shown on the drawings. This Controls Specialist Company shall hereinafter be shown as the BMS Contractor.

The sub-contractor's main tender offer shall be based on **Johnson Control BMS system**.

Work includes

A Basic Requirements:

1. BMS Contractor shall provide:-

- a. A fully integrated building management system (BMS), preferable UL listed, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, including colour graphic workstation.
- b. Complete temperature, pressure etc. control system to be DDC as specified herein.
- c. All wiring, conduit, panels for all temperature, humidity, pressure, etc. controls.
- d. All final electrical connections to each stand-alone Application Specific controller and DDC Controller. Pick up power from the nearest MCC (A/C Motor Control Centre) of A/C DB (Electrical Distribution Board).
- e. The BMS Contractor shall be responsible for all electrical work associated with the BMS control system and as called for on the Drawings.
 - 1) Perform all wiring in accordance with all local and national codes. In particular:
 - a) SABS codes of Practice for Wiring of Premises.
 - b) The Occupational Health and Safety Act.
 - c) National Building Regulations Specifications and Codes of Practice issued by the SABS and British Standard Institute.
 - 2) The HVAC contractor shall provide 220 volt, 10 amp circuits and circuit breakers from normal and/or emergency power panels for the DDC systems.
 - 3) Surge transient protection shall be incorporated in the design of the system to protect electrical components in all DDC Controllers, Application Specific Controllers and operator's workstations.

- 4) All low voltage control wiring throughout the building whether exposed or concealed shall be run in **galvanised steel conduit**. Any exceptions must be approved by the Engineer prior to installation.

2. The HVAC Contractor will provide.

- a. The installation of all wells and openings for water monitoring devices such as flow switches, flow sensors etc as required by the BMS contractor.
- b. Installation of control valve bodies.
- c. All package unit and chiller controls.
- d. Installation of damper actuators and ensure free movement of these dampers.
- e. Installation of smoke dampers; outdoor air, exhaust air and vent dampers; with adjacent access doors where required.

B. General Product Description:

1. The building management system (BMS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection.
2. The Building Management System shall consist of the following:
 - (a) Application Specific Controllers (ASC)
 - (b) Variable Program Controllers (VPCs).
 - (c) Master Direct Digital Controllers (MDDC)
 - (d) Portable operator's terminal(s).
 - (e) Personal computer operator workstation(s).
3. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, Application Specific Controllers (ASC), Variable Program Controllers (VPC), Master Direct Digital Controllers (MDDC) and operator devices.
4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each Application Specific Controllers (ASC), Variable Program Controller (VPC) shall operate independently by performing its own specified control, and alarm management. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
5. The Master Direct Digital Controllers (MDDC) Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other (MDDC) Controller or combination of (MDDC) Controllers on the Level 1 communication network without dependence upon another interfacing processing device. MDDC Controllers shall also be able to send alarm reports to multiple operator workstations without dependence upon another interfacing processing device.
6. Networking Communications
 - A. The design of the BMS shall consist of network operator workstations and Master Direct Digital Controllers (MDDC). The network architecture shall consist of two communication levels.

(a) Level 1 - A high performance peer-to-peer network, operating on an IP Ethernet network operating at 10 or 100 Mb/s between the Master DDC Controllers and the Operator Computer Workstations.

(b) Level 2 - A communication network shall be installed between the Master DDC Controllers and Programmable Controllers and Application Specific Controllers.

The Level 2 network will operate at a minimum 9600 Baud.

Quality Assurance

- A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be the manufacturer's latest standard design that complies with the specification requirements.

Locally produced substitutes may be offered only as alternatives to the main offer.

- B. Install system using competent workmen who are fully trained in the installation of temperature control equipment.
- C. All electronic equipment shall conform to the requirements of Governing Radio Frequency Electromagnetic Interference.
- D. Design and build all system components to be fault-tolerant.
1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3 Hertz variation in line frequency.
 2. Static, transient and short-circuit protection on all inputs and outputs.
 3. Network-connected devices to be A.C. coupled or equivalent so that any single device failure will not disrupt or halt network communication.
 4. All real time clocks and data file RAM to be battery-backed for a minimum 72 hours and include local and system low battery indication.
 5. It must be possible to receive and print out alarms at a central location even when the operator's workstation at that location is non-operational or taken out of service for periodic maintenance.

Submittals

Before the BMS Contractor is appointed by the A/C Contractor the proposed BMS Contractor must submit a copy of this specification showing whether their system conforms with each clause and if not they must submit a detailed schedule of deviations together with a full description of how their system accomplishes the specific requirement.

The engineer reserves the right to reject the proposed BMS Contractor if there are any deviations to the specification.

PRODUCTS

Control Valve Bodies

- A. Control valve body construction:
 - (a) forged brass
 - (b) Bronze
 - (c) Cast Iron Steel.
- B. Control valve bodies will have a minimum operating rating of PN16 (16 Bar).
- C. Operating Fluid Temperature Limits - 2°C to 100°C

Control Valve Actuators

- A. Electric Motorised Control Valve Actuators will consist of the following:
 - (a) Minimum close-off pressure rating for electric valve / actuator combinations - 400kPa
 - (b) Mechanical Manual override facility

Application Specific Controllers (ASC):

The ASC must have the facility to be programmed and commissioned locally, in situ via a portable hand held programming tool or a portable laptop computer.

The ASC will have the facility to communicate on the Level 2 communication network at a 9600 Baud.

The application specific controllers (ASC) will be dedicated to the control of the following:

- (a) Master Diffuser Control for space temperature control.
- (b) Monitoring of miscellaneous I/O in the facility.
- (c) Switching control of miscellaneous I/O in the facility.

The ASC (application dependent) must consist of the required I/O facility for the specific application.

a. Analogue inputs:

- 1) 0-10 Vdc
- 2) RTDs

b. Digital inputs

- 1) Dry contact closure
- 2) Pulse Accumulator
- 3) Digital Counters

c. Analogue outputs:

- 1) 0 to 10Vdc

d. Digital outputs:

- 1) On / Off Control (via interposing relay)
- 2) Pulse Control
- 3) Duration Adjust Type Control (Heater Triac Control)

4) Proportion Adjust Type (Diffuser Control)

Variable Program Controllers (VPC):

The Variable Program Controller (VPC) must have the facility to be programmed and commissioned locally, in situ via a portable Laptop, or via the BMS operator Computer Terminal.

The Variable Program Controller must have the facility to operate in an independent standalone mode, when the BMS Master Controller is not in use, or in an integrated BMS mode when connected to the Master DDC Controller.

The (VPC) will have the facility to communicate on the Level 2 communication network with the Master DDC Controller at 9600 Baud.

(1) The (VPC) will be supplied and fitted with the following features:

The (VPC) will be dedicated to the control of the following:

- (a) All primary Air Conditioning plant control.
- (b) Fan Coil unit Control
- (c) Pump Control
- (d) Any other primary or Secondary electro mechanical plant Control

The (VPC) is to have the following facilities in order to meet the control requirements, as specified by the engineer.

Each (VPC) will be supplied with an Integral User Interface (LCD Alpha Numeric Display)

The integral Liquid Crystal Display (LCD) user interface for the Programmable Controller shall have the minimum features:

- Two display rows with four alphanumeric characters (13 segment)
- Blue- or red-colored background
- Graphic status icons: for example - compressor, alarm, high pressure, low pressure, maintenance, heat, cool, defrost, and electric heat symbols
- Keypad with four push buttons
- Navigation menu to access all relevant control information associated with the control routines.

The integral user interface (LCD) must be fully configurable within the application design and typically provide:

- Access key for modification of control parameters.
- Access key for override facilities.
- Display of status information
- Display and modification of setpoints
- Display and modification of configuration parameters, Proportional bands, integration values etc.
- Clearing and acknowledgement of active alarms
- Background lighting with red color when an alarm condition exists

Variable Program Controllers (VPC):

Minimum Required I/O:

The VPC will be supplied with a minimum I/O configuration (refer below) to ensure control system flexibility and system product standardisation. All respective I/O will conform to the variable configuration setup listed below.

VPC - Type-1 - I/O Count::

4 x Analogue Inputs
5 x Digital Inputs
2 x Analogue Outputs
6 x Digital Inputs

VPC - Type - 2 - I/O Count:

6 x Analogue Inputs
12 x Digital Inputs
2 x Analogue Outputs
6 x Digital Inputs

VPC - Type - 3 - I/O Count:

6 x Analogue Inputs
8 x Digital Inputs
4 x Analogue Outputs
8 x Digital Inputs

I/O Configuration Flexibility:

All respective I/O will conform to the variable configuration setup listed below.

Analogue Inputs:

The VPC analog inputs shall be configurable to accept a wide range of analogue input signals, either **passive** or **active** in the related Analog Input object setup configuration.

Passive Sensor:

The passive sensor (resistance) inputs shall have preconfigured linearization characteristics within the application software. For these sensors, the measurement range shall be fixed.

Active Sensor:

The ranges of active sensor (voltage) inputs shall be preconfigured in the respective configuration parameters within the application software. These parameters, HighRange and LowRange, shall define the equivalent values for reading at high (10 V, 4.5 V) and low (0 V, 0.5 V) signal inputs.

Voltage inputs from differential pressure transducers shall be linearized by a square root function (SQRT), which shall operate over the entire range of the input.

The measurement unit of the analogue value shall also be configurable to enable the controller to transmit the measured value via the network in the appropriate format.

The measurement unit of the analogue value shall also be configurable to enable the controller to display the relevant units of measurement, at the controllers integral Liquid Crystal Display (LCD) user interface.

Configurable units of measurement are to include:

- Temperature
- Percentage
- Air Pressure
- Liquid Pressure
- Flow
- Concentration (ppm = parts per million)
- Voltage

Each Analogue shall have a configurable filter object in the (VPC) application software for the reduction of signal instability and to limit the rate of change of the input value.

Digital Inputs:

The (VPC) controller shall accept digital (binary) inputs from voltage free contacts.

The Digital Input objects in the (VPC) application software shall provide the interface between the hardware digital input channels and the control logic.

A digital input shall be active depending on its polarity setting. The default setting shall be **Normally Open** or **Direct**, meaning that the input is active (true) when the contact is closed.

Digital Transition Counter Input:

The (VPC) shall feature transition counter inputs as a configurable option on the digital inputs. The transition counter imputer shall sample a pulse signal with a minimum ON time of 10 ms and a minimum OFF time of 10 ms.

The Input Counter object shall provide the interface between the digital input, acting as a transition counter, and the control application. The totalized value shall be stored in non-volatile memory during a power interruption to the (VPC) controller and retrieved by the object after power restoration. Any pulses during the power interruption shall not be counted.

For example, the transition counter counts the number of times an item of equipment is started.

For informational purposes and energy management, the (VPC) shall use the transition counter as a totalizer for energy consumption measurement.

The measurement unit of the digital input state or transition counter shall also be configurable to enable the controller to transmit the status or value in an alpha / numeric description, via the network in the appropriate format.

The measurement unit of the digital input state or transition counter shall also be configurable to enable the controller to display the status or value in an alpha / numeric description at the controller's integral Liquid Crystal Display (LCD) user interface.

Analog Outputs:

The (VPC) shall provide analogue outputs which shall be configured as 0-10 VDC (each at 3 mA maximum) or PWM at 100 Hz.

You can configure the analog outputs for direct or reverse acting in the application software. You can limit by high limit (MaxOutput) and low limit (MinOutput) values.

PWM Analog Output:

The (VPC) shall as an option, provide the facility for PWM configuration of the Analogue Outputs to provide additional flexibility and capability to drive and command a PWM compatible opto-isolated fan speed controller.

The measurement unit of the analogue output shall also be configurable to enable the controller to transmit the status and value in an alpha / numeric description via the network in the appropriate format.

The measurement unit of the analogue output shall also be configurable to enable the controller to display the status and value in an alpha / numeric description at the controller's integral Liquid Crystal Display (LCD) user interface.

Digital Outputs:

The digital output objects in the (VPC) application software shall provide the interface between the hardware digital output channels and the control application.

The (VPC) shall have the facility to override a digital output and modify its value via the supervisory system.

The (VPC) shall have the facility to override a digital output and modify its value via the controller's integral Liquid Crystal Display (LCD) user interface.

The (VPC) configuration software shall provide the facility to configure digital output objects to the following output types:

- **On/Off Output**

This output type commands the DO (triac or relay) to switch on or off depending on the input request.

- **Hermetic Compressor Output**

This output type features all the functions required to switch a hermetic compressor. This output type should provide the logic, interlocking, and timing features required for such applications.

- **Duration Adjusting Type (DAT) Output**

This output type commands the DO (typically a triac) to switch on or off with a time based duty-cycle proportional to the numeric input request. The (VPC) configuration software shall provide the facility to set a minimum On/Off time to avoid very short On pulses with the low range value (Output at 0%) and very short Off pulses when the value falls close to the high range value (Output at 100%).

- **Position Adjusting Type (PAT) (Incremental Control) Output**

This output type commands a pair of DOs (typically triacs) to drive a synchronous reversible electric actuator in one of the two directions in response to a change in the numeric input request.

A PAT output gives modulating control by using the configured actuator full-stroke (fully open to fully close) time to drive the actuator for a part of that time base in proportion to the change in the controlling numeric input. For example, for a 100-second actuator to achieve 40% open, the actuator runs 40 seconds from the fully closed position.

The (VPC) configuration software shall provide the facility to adjust a dead band, in percent of full-stroke time, to avoid driving the actuator for very small changes in the output signal. This reduces unnecessary wear on the drive mechanism.

The PAT Object requires two digital output channels, typically triacs. One triac is switched on when the output must increase; the other triac is switched on when the output must decrease. The polarity of the PAT shall be configurable to change the increasing and decreasing physical channels without the need to rewire.

At the 0 or 100% position, the duration of switching increases by a configurable value (ResyncAmount) to ensure that the valve or other controlled device is completely at its end position. When the estimated position remains fixed to 0 or 100% for a time equal to a configurable period (typically 2 hours), a synchronization action shall occur according to the ResyncAmount configurable parameter.

When the output remains in a fixed position for more than a configurable period, the PAT output shall apply the anti-sticking function, if enabled, to exercise the device and the drive mechanism. This is particularly useful for water valves that require regular activity of the inner parts to keep them free to move.

The measurement unit of digital output, DAT or PAT shall also be configurable to enable the controller to transmit the status or value in an alpha / numeric description, via the network in the appropriate format.

The measurement unit of the configurable to digital output, DAT or PAT shall also be configurable to enable the controller to display the status or value in an alpha / numeric description at the controller's integral Liquid Crystal Display (LCD) user interface.

Variable Program Controller (VPC) - Control and Calculation Facilities:

The VPC configuration software shall provide the following program flexibility to achieve the desired control functions to comply with the Engineer's design.

Numeric:

- Average
- Calculation
- Comparator
- Event Counter
- Butterworth Filter
- Integrator - Multi Stage Control with Equal Run & Lead / Lag
- Maximum Value Calculation
- Minimum Value Calculation
- Psychrometric Calculation - Wet Bulb, Enthalpy etc.
- Ramp
- Sample & Hold
- Selector
- Span
- Segment
- Time Counter
- Timer
- Storage element

Control:

- Economizer
- Fan Controller
- On\Off Controller
- PI controller
- Summer Winter Compensation

Logic:

- And
- Or
- Enumeration Override
- Enumeration Logic
- Output override logic
- PLC

Alarm:

- Analog Alarm
- Compressor Envelope
- Manual Reset Binary Alarm
- Out of range

Special:

- Emergency/Application mode
- Exception Days
- Binary Sequencer
- General Setpoint
- Occupancy mode
- Real Time Clock
- Time & Date
- Real Time Clock Enhanced
- Sensor Failure
- System Resource
- Temperature Setpoint
- Load Manager
- Occupancy Time Scheduler

- Optimal start Stop
- Semi-hermetic Compressor
- Sequencer
- Time scheduler
- Source Mode

Master Direct Digital Controller (MDDC)

A single MDDC or a network of multiple MDDC devices within a building shall provide monitoring and control, alarm and event management, data exchange, trending, energy management, scheduling, and data storage.

The MDDC shall have an embedded user interface to support concurrently connected Web browsers with password access control and the security protection technology of the Information Technology (IT) industry.

Master Direct Digital Controller Required Feature	Master Direct Digital Controller Requirements
Communication Using Commonly Accepted IT Standards at the Automation and Enterprise Level	Facilitates the installation of the system on the existing IT infrastructure within a building or enterprise and use standard IT communication services over the company intranet, Wide Area Network (WAN), or public Internet with firewall protection.
Web-Based User Interface	Facilitates access to system data in the MDDC from any supported Web browser device connected to the network including remote users connected by dial-up telephone or an Internet Service Provider (ISP).
Site Director Function	Facilitates access to all data on one site through one device. The device designated as the Site Director coordinates the display of data from multiple NAE devices for easy navigation through the entire site.
Support for Web Services at the Automation Network Level	Facilitates the user to develop facility-specific advanced data interfaces and applications.
User Interface and Online System Configuration Software Embedded in NAE	Facilitates configuration, commissioning, data archiving, monitoring, commanding, and system diagnosis from any device with Web browser software and does not require separate workstation software.
Supervision of Application Specific Controllers (ASC), Variable Program Controllers (VPC) and IP Devices	Facilitates connectivity to network standards for complete flexibility in the selection of field devices.
Multiple Connection Options for Data Access	Facilitates connection of a Web browser via the Internet Protocol (IP) network using the Ethernet port or directly to an RS-232 serial port. For a dial-up connection, the use of an optional internal or external modem will be required.

MDDC Networking

MDDC's shall have multiple connection port options that provides the facility to build an extremely flexible network at the automation and enterprise level of your system, as well as at the field controller and data acquisition levels.

Web Browser Access

Access shall be facilitated to the building systems, through the MDDC with a supported Web browser on a desktop or laptop computer. The computer shall not require any special workstation software other than the browser and a standard Java® plug-in. The Web browser accesses the MDDC directly over the IP network, or via the Internet or public telephone service.

IP Ethernet Network

The MDDC's shall connect directly to an IP Ethernet network running at 10 or 100 Mbps. Multiple MDDC's shall communicate with each other over the network, while one MDDC shall have the facility to perform the function as the Site Director.

The Site Director shall perform the function of control of the point of access to the network on the site from a user interface device. The data transmission on the network shall use standard IT protocols, services, and formats.

Networks in different buildings may be interconnected using standard WAN technologies and network service providers. The speed of transmission depends on the technology used.

Remote MDDC

The MDDC shall have the facility to be accessed remotely over standard WAN infrastructures, the Internet using an ISP line, or over the public telephone network using a modem and the Point-to-Point Protocol (PPP). The MDDC shall offer an optional internal modem or support an external modem.

Application and Data Server (ADS)/ Extended Application and Data Server (ADX)

The ADS/ADX is an optional software package running on a computing platform that provides a location for storage of the system configuration database, trend logs, alarm logs, audit trails, and graphics. Also, the ADS/ADX can be configured as the Site Director to allow more concurrent users and coordinate access to all components on a site via a Web browser connected over the network, Internet, or telephone line via dial-up communication. The software supports standard IT firewall technologies for protection against unauthorized access.

Field Networks and Protocols

The MDDC shall offer the ability to pass data from one field network to another and transmit data from the field network to the enterprise and automation level of the network. This feature shall facilitate the system to operate as one virtual control network.

Automation Level Communication

MDDC's shall communicate on an internal system data using peer-to-peer messaging over the IP Ethernet network. Each MDDC device shall share data and have access to information on all other NAE nodes on the network to coordinate the overall functions of the building controls.

Software for Efficient Building Operation**System Security**

The MDDC shall have the facility to recognize legitimate users through the entry of a user ID and a password at the Web browser user interface. User access data shall be encrypted in the transmission and in the NAE database. The security administrator shall manage user profiles and accounts at a site or system level. The authorization levels shall range from configuring the complete system to only viewing one section of the system or site. The system administrator shall assign user ID's, password, and specific MDDC data access privileges in each user account.

System User Interface

The embedded MDDC user interface shall provide formatted data and graphic screens to any supported Web browser. Authorized users shall simply log on to the MDDC device from the Web browser to access the user interface. This embedded user interface shall be suitable for smaller networks and remote locations where a dedicated computer platform to support a user interface is not required.

If a MDDC or ADS/ADX has been defined as the Site Director, it shall provide access to all other MDDC's or ADSs/ADXs on the same network site and combine data for presentation on a single screen on the connected Web browser. In larger installations, a MDDC shall pass its data to an ADS/ADX on the network that acts as Site Director. Access shall be provided to data from a MDDC or ADS/ADX at any point in the network with a Web browser.

Basic Access

Basic Access is a mode of operation allowing users with Basic Access user accounts access to a subset of the standard user interface capabilities based on their assigned permissions. Basic Access user accounts shall be created by system administrators using the Security Administrator system.

Basic Access shall meet the user interface requirements for most building operators. Basic Access shall be provided on all of the MDDC's and servers but shall be the primary user interface in the Master Direct Digital Controllers.

Monitoring and Control

The MDDC software shall specifically be designed to meet the needs of building owners and managers to efficiently monitor and control all the mechanical and electrical systems in a typical building such as:

- . • HVAC units
- . • central equipment including chillers and boilers
- . • lighting and electrical distribution
- . • power generation and energy monitoring equipment
- . • interfaces to security and fire detection systems

The MDDC shall monitor equipment by collecting data from the field control devices, then coordinating the required commands and sending them to the equipment at the required priority.

Access to information via a navigation tree shall represent the logical grouping of network devices and point data names defined when configured in the system. The system shall offer navigation using graphic images or a created customized navigation tree with groups and names based on device location in the building or on system groups.

Global Search

This enhanced search feature shall permit the search in the MDDC system for multiple objects that meet specific criteria based on naming and object type. The global search shall provide the ability to manage lists of objects, which can be used by other features for commanding, trending, reporting, and object selection.

Transaction Recording

All user actions performed through the MDDC, including logon and logoff, commands to equipment, changes to parameters, and changes to the system configuration shall be recorded in the MDDC audit trail log.

Alarm and Event Processing

When a value exceeds a defined limit or changes to an off-normal state, the MDDC shall have the facility to send alarm or event messages to online Web browsers, pagers, e-mail servers, enterprise level Network Management Systems, and serial printers.

The message routing shall depend on the source, time, and type of the event. The information shall also be stored immediately in a local log file on the MDDC later transmitted to a site log file on an ADS/ADX, and shall have the facility to be viewed at a later time from a Web browser to trace the history of alarms and events on the site.

The alarm and event information may include a predefined message to facilitate a fast response to the system problem. Only authorized users with the appropriate password authority will have the ability to acknowledge or clear an alarm, where after the site log file will automatically be updated.

Historical Trend Data

The MDDC shall support trending of any monitored value at user-defined periods ranging from one minute to one week. Alternatively, trending may be configured based on Change-of-Value (COV) sampling. Initially trend logs shall be stored in the MDDC. Trend log information shall be transferred to a historical database on the ADS/ADX at user-defined intervals or when the MDDC files are nearly full.

Trend logs shall be useful for analyzing the performance of building control systems and locating the source of system problems.

Totalization Data

Analog and pulse totalization features in the MDDC shall monitor the use of energy and other consumables. The generation of reports for cost allocation within a facility or to support energy and cost reduction programs shall be a standard.

Event and runtime totalization features, including the number of times specific events occur and how long

equipment has been in operation, provide data for servicing and maintenance programs and for early identification of possible system problems.

Trend Studies

The enhanced trend feature shall provide the user with the view to multiple trend extensions based on the selection of items from the results of a global search or from the navigation tree. This trend feature provides another option in trending.

Scheduling

The scheduling feature shall provide the user to define building occupancy periods and the start and stop times for mechanical or electrical equipment. Operating parameters, such as temperature set points and power consumption limits, shall be set according to time of day.

The scheduling of an event for one or more days of the week, for a holiday, or for particular calendar dates. Schedules shall be defined in one MDDC for the whole site or for just the equipment controlled by that MDDC. Each MDDC shall use a graphical user interface to simplify setting up the schedules from a Web browser.

Network-Wide System Interlocking

Interlocking shall enable the MDDC to take information from one or more field controllers, make logical comparisons, and issue a set of control instructions to other field controllers anywhere on the network. Interlocking shall also facilitate the sharing of analog or binary data between controllers.

Optimal Start

The Optimal Start feature, shall automatically determine the correct time to start heating and cooling systems to ensure that the facility is ready for occupants at the scheduled time. It shall automatically adjust to seasonal variations and minimize the energy used.

Demand Limit and Load Rolling

Demand Limit and Load Rolling (DLLR) feature shall provide the ability to monitor energy meters for electricity, gas, steam, or water, and control energy consuming building loads to maintain energy use to user specified limits.

Demand Limit shall be used to manage utility demand charges, based on either fixed interval or sliding window metering strategies. Load Rolling shall be used to turn off or lower the operating levels of selected equipment to reduce total facility energy consumption. Comfort overrides shall be used to help prioritize which pieces of equipment are eligible for shedding.

MDDC Hardware Features

Depending on the individual model and associated capacities, the MDDC shall provide the following features:

- industrial Single Board Computer (SBC)
- nonvolatile solid-state Flash memory to store all programs and data
- standard Universal Serial Bus (USB) connections
- battery backup to save data from Dynamic Random Access Memory (DRAM) into Flash memory when primary power to the NAE is interrupted
- real-time clock with battery backup
- Light-Emitting Diodes (LEDs) to indicate power, communications, and fault, to allow easy servicing
- optional internal modem
- removable screw terminals for 24 VAC power and field network bus connections
- standard 9-pin sub-D connectors for RS-232-C serial ports
- RJ-11 telephone line connector for internal modem
- RJ-45 connector for Ethernet connection

MDDC Series Technical Comparison

Features	MDDC (Large System)	MDDC (Medium System)	MDDC (Small System)
Number of Level 2 Networks	2	1	1
Maximum Number of Addressable Devices per Level 2 Network	100	100	50
Maximum Number of Data Objects	5,000	2,500	2,500
Model with Internal Modem	Available	Available	Available
RS-232-C Serial Ports	2	1 or 2	1 or 2

USB Serial Ports	2	1	1
RS-485 Ports	2	Available	Available
Ethernet Ports	1	1	1

Technical Specifications

MDDC - Medium & Small System

Power Requirement	Dedicated nominal 24 VAC, Class 2 power supply (North America), Safety Extra-Low Voltage (SELV) power supply (Europe), at 50/60 Hz (20 VAC minimum to 30 VAC maximum)
Power Consumption	25 VA maximum
Ambient Operating Conditions	0 to 50°C (32 to 122°F); 10 to 90% RH, 30°C (86°F) maximum dew point
Ambient Storage Conditions	-40 to 70°C (-40 to 158°F); 5 to 95% RH, 30°C (86°F) maximum dew point
Data Protection Battery	Supports data protection on power failure. Rechargeable NiMH battery: 3.6 VDC 500 mAh, with a typical life of 5 to 7 years at 21°C (70°F); Product Code Number: MS-BAT1020-0
Processor	192 MHz Renesas™ SH4 7760 RISC processor
Memory	128 MB Flash nonvolatile memory for operating system, configuration data, and operations data storage and backup 128 MB Synchronous Dynamic Random Access Memory (DRAM) for operations data dynamic memory
Operating System	Microsoft® Windows® CE embedded
Network and Serial Interfaces	One Ethernet port; 10/100 Mbps; 8-pin RJ-45 connector One optically isolated RS-485 port; 9600, 19.2k, 38.4k, or 76.8k baud (depending on protocol) One RS-232-C serial port with standard 9-pin sub-D connector that supports standard baud rates. There is a second serial port, on models without an internal modem, that supports an optional, user-supplied external modem. One USB serial port with standard USB connector that supports an optional, user-supplied external modem. Option: One telephone port for internal modem; up to 56 Kbps; 6-pin RJ-11 connector (NAE models with an optional internal modem have one RS-232-C serial port only.)
Housing	Plastic housing material: ABS + polycarbonate UL94-5VB Protection: IP20 (IEC 60529)

Technical Specifications

MDDC - Large System

Power Requirement	Dedicated nominal 24 VAC, Class 2 power supply (North America), Safety Extra-Low Voltage (SELV) power supply (Europe), at 50/60 Hz (20 VAC minimum to 30 VAC maximum)
Power Consumption	50 VA maximum
Ambient Operating Conditions	0 to 50°C (32 to 122°F); 10 to 90% RH, 30°C (86°F) maximum dew point
Ambient Storage Conditions	-40 to 70°C (-40 to 158°F); 5 to 95% RH, 30°C (86°F) maximum dew point
Data Protection Battery	Supports data protection on power failure. Rechargeable gel cell battery: 12 V, 1.2 Ah, with a typical life of 3 to 5 years at 21°C (70°F); Product Code Number: MS-BAT1010-0

Clock Battery	Maintains real-time clock through a power failure. Onboard cell; typical life 10 years at 21°C (70°F)
Processor	400 MHz Geode GX533 processor
Memory	512 MB Flash nonvolatile memory for operating system, configuration data, and operations data storage and backup. 256 MB Synchronous Dynamic Random Access Memory (DRAM) for operations data dynamic memory for all models
Operating System	Microsoft Windows XP® embedded
Network and Serial Interfaces	One Ethernet port; 10/100 Mb; 8-pin RJ-45 connector Two optically isolated RS-485 ports; 9600, 19.2K, or 38.4K baud; pluggable and keyed 4 position terminal blocks Two RS-232-C serial ports, with standard 9-pin sub-D connectors, that support all standard baud rates Two USB serial ports, standard USB connectors support an optional, user-supplied external modem
Housing	Plastic housing with internal metal shield Plastic material: ABS + polycarbonate UL94-5VB Protection: IP20 (IEC 60529)
Compliance	United States UL Listed, File E107041, CCN PAZX, UL 916, Energy Management Equipment UL Listed, File S4977, UUKL 864 - 9th Edition, Smoke Control Equipment (MS-NAE55x0-1U models only) UL Listed, UUKL 864 - 8th Edition, Smoke Control Equipment (MS-NAE5510-0U model only) FCC Compliant to CFR47, Part 15, Subpart B, Class A
	Europe CE Mark, EMC Directive 89/336/EEC, in accordance with EN 61000-6-3 (2001) Generic Emission Standard for Residential and Light Industry and EN 61000-6-2 (2001) Generic Immunity Standard for Heavy Industrial Environment

PERSONAL COMPUTER OPERATOR INTERFACE/WORKSTATION HARDWARE

- A. Personal computer operator workstations shall be provided for command entry, information management, network alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability.

Provide one workstation in the Security Office on the ground floor and shall consist of:

1. desktop PC is
2. minimum 8000 MByte RAM
3. 2 TB hard drive
4. mouse
5. 101 key enhanced keyboard
6. 19" LCD video display unit. Separate controls shall be provided for colour, contrasts and brightness. The screen shall be non-reflective.
7. high speed report printer (dot matrix)
8. high speed alarm printer (dot matrix)

Alarm printer shall be independently interfaced to the network such that its operation is not dependent on a connection to the video terminal or computer workstation.

9. minimum requirements for the printers:-
 - a) Epson FX-870 or IBM PPS-2.
 - b) 32K Buffer to store complete graphics for printing.
10. CD plus disc drive for loading software.
11. Lan/ Network connection
12. 2 kVA – 30 minute UPS.

WORKSTATION OPERATOR INTERFACE

- A. Basic Interface Description:

1. Operator workstation interface software shall minimise operator training through the use of English language prompting, English language point identification and industry standard PC application software. The software shall provide, as a minimum, the following functionality:-
 - a) Graphical viewing and control of environment.
 - b) Scheduling and override of building operations.
 - c) Collection and analysis of historical data.
 - d) Definition and construction of dynamic colour graphic displays.
 - e) Editing, programming, storage and downloading of controller databases.
- a) Level 5 = All privileges
- b) A minimum of 50 unique passwords, including user initials, shall be supported.
- c) Operators will be able to perform only those commands available for their

- respective passwords. Menu selections displayed shall be limited to only those items defined for the access level of the password used on log-on.
- d) The system shall automatically generate a report of log-on/log-off time and system activity for each user.
 - e) User-definable automatic log-off timers of from 5 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.
2. Provide a graphical user interface which shall minimise the use of a typewriter style keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change set points from graphical displays through the use of a mouse.
 - a) Provide functionality such that all operations can also be performed using the keyboard as a backup interface device.
 - b) Provide additional capability that allows at least 10 special function keys to perform often-used operations.
 3. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. The mouse shall be used to quickly select and switch between multiple applications. This shall be accomplished through the use of Microsoft Windows.

Provide functionality such that any of the following may be performed simultaneously, and in any combination, via user-sized windows:

 - a) Dynamic colour graphics and graphic control.
 - b) Alarm management coordinated with DDC Controllers.
 - c) Time-of-day scheduling.
 - d) Trend data definition and presentation.
 - e) Graphic definition.
 - f) Graphic construction.
 4. Multiple-level password address protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.
 - a) A minimum of five levels of access shall be supported:-
 - 1) Level 1 = view all applications, but perform no database modifications.
 - 2) Level 2 = Custodial privileges plus the ability to acknowledge alarms.
 - 3) Level 3 = All privileges except system configuration.
 - 4) Level 4 = All configuration privileges except passwords.
 5. Software shall allow the operator to perform commands including, but not limited to, the following:
 - a) Start-up or shutdown selected equipment.
 - b) Adjust set points.
 - c) Add/modify/delete time programming.
 - d) Enable/disable process execution.
 - e) Lock/unlock alarm reporting for points.
 - f) Enable/disable totalisation for points.
 - g) Enable/disable trending for points.
 - h) Override PID loop set points.
 - i) Enter temporary override for points.
 - j) Define holiday schedules.
 - k) Change time/date.
 - l) Automatic daylight savings time adjustments.
 - m) Enter/modify analogue alarm limits.

- n) Enter/modify analogue warning limits.
 - o) View limits.
 - p) Enable/disable demand limiting for each meter.
 - q) Enable/disable duty cycle for each load.
6. Reports shall be generated and directed to displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:-
- a) A general listing of all points in the network.
 - b) List of all points currently in alarm.
 - c) List of all points currently in override status.
 - d) List of all disabled points.
 - e) List of all points currently locked out.
 - f) DDC Controller trend overflow warning.
 - g) List all weekly schedules.
 - h) List of holiday programming.
 - i) List of limits and headbands.
7. Summaries shall be provided for specific points, for a logical point group, for a user selected group or groups or for the entire facility without restriction due to the hardware configuration of the building automation system. Under no conditions shall the operator need to specify the address of the hardware controller to obtain system information.

B. Scheduling:

1. Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Provide the following spreadsheet graphic types as a minimum:-
 - a) Weekly schedules.
 - b) Zone schedules.
 - c) Monthly calendars.
2. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Each schedule shall include columns for each day of the week as well as holiday and special day columns for alternate scheduling on user-defined days. Equipment scheduling shall be accomplished by simply inserting occupancy and vacancy times into appropriate information blocks on the graphic. In addition, temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.
3. Zone schedules shall be provided for each building zone as previously described. Each schedule shall include all commendable points residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Scheduling and rescheduling of points may be accomplished easily via the zone schedule graphic.

- 4 Monthly calendars for a 24-month period shall be provided which allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

C. Collection and Analysis of Historical Data.

1. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting.
2. Trend data report graphics shall be provided to allow the user to view all trended point data. Reports may be customised to include individual points or pre-defined groups of at least 6 points. Provide additional functionality to allow any trended data to be transferred easily to an off-the-shelf spreadsheet package such as Lotus 1-2-3. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.
3. Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both static and/or real-time dynamic point data. A minimum of 4 points may be viewed simultaneously on a single graph, with colour selection and line type for each point being user-definable. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be colour-coded to match the line colour for the corresponding point.
 - a) Static graphs shall represent actual point data that has been trended and stored on disk. Exact point values may be viewed on a data window by pointing or scrolling to the place of interest along the graph. Provide capability to print any graph on the system printer for use as a building management and diagnostics tool.
 - b) Dynamic graphs shall represent real-time point data. Any point or group of points may be graphed, regardless of whether they have been redefined for trending. The graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. As with static graphs, exact point values may be viewed and the graphs may be printed.

D Dynamic Colour Graphic Displays

1. Colour graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, shall be provided by the BMS contractor to optimise system performance analysis and speed-up alarm recognition.

To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC Controllers including Application Specific Controllers.

E System Configuration and Definition

1. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.
3. Dynamic temperature, humidity, flow, pressure etc values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.
4. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several graphics at a time to analyse total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
5. Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays.
 - a) The BMS contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (eg fans, cooling coils, filters, dampers, etc) complete mechanical systems (eg constant volume-terminal reheat, VAV, etc) and electrical symbols.
 - b) The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:-
 - 1) Define symbols.
 - 2) Position and size symbols.
 - 3) Define background screens.
 - 4) Define connecting lines and curves.
 - 5) Locate, orient and size descriptive text.
 - 6) Define and display colours for all elements.
 - 7) Establish correlation between symbols or text and associated system points or other displays.
 - c) Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points which aids the operator in the analysis of the facility.
2. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
 - a) Add/delete/modify stand-alone DDC Controller panels.
 - b) Add/delete/modify operator workstations.
 - c) Add/delete/modify application specific controllers.
 - d) Add/delete/modify points of any type and all associated point parameters and tuning constants.
 - e) Add/delete/modify alarm reporting definition for points.
 - f) Add/delete/modify control loops.
 - g) Add/delete/modify energy management applications.
 - h) Add/delete/modify time and calendar-based programming.
 - i) Add/delete/modify totalisation for points.
 - j) Add/delete/modify historical data trending for points.
 - k) Add/delete/modify custom control processes.

- l) Add/delete/modify any and all graphic displays, symbols and cross-reference to point data.
 - m) Add/delete/modify dial-up telecommunication definition.
 - n) Add/delete/modify all operator passwords.
 - o) Add/delete/modify alarm messages.
3. Definition of operator device characteristics, DDC Controllers individual points, applications and control sequences shall be performed using instructive prompting software.
- a) Libraries of standard application modules such as temperature, humidity and static pressure control may be used as "building blocks" in defining or creating new control sequences. In addition, the user shall have the capability to easily create and archive new modules and control sequences as desired via a word processing type format. Provide a library of standard forms to facilitate definition of point characteristics. Forms shall be self-prompting and incorporate a fill-in-the-blank approach for definition of all parameter. The system shall immediately detect an improper entry and automatically display an error message explaining the nature of the mistake.
 - b) If programming must be done with the PC workstation off-line the BAS contractor shall provide at least 2 operator workstations.
 - c) Inputs and outputs for any process shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).
 - d) Provide the capability to backup and store all system databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller. Similarly, changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.
 - e) Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed.
- F. It must be possible to use a word processing and/or spreadsheet program such as WINDOWS WORD or EXCEL while the operating software is on line so that alarms and system events continue to be received.

Field Devices

- A. All devices and equipment shall be of the same manufacture.
- B. Temperature Sensors.
- C. Humidity Sensors.
- D. Pressure/Differential Pressure Sensors.
- E. Dampers Operators.
- F. Automatic Control valves.
- G. Overheat Safety / Fire Stats.
- H. Differential Pressure Switch.
- I. Electronic-to-Pneumatic Transducers.

INSTALLATION

All extra-low voltage BMS cables shall be run in screened twisted pair cables. They shall be drawn into conduit or trunking and protected as agreed with the engineer to suit the various environmental, social and mechanical locations. Cable specifications shall meet the manufacturers requirements, particularly respecting over-all resistance and capacitance limits. Where possible no joints will be allowed in cables, where these prove necessary the cables shall be jointed using an approved housing, securely fixed and having cable securing clamps. Any such connecting boxes shall be shown on the record drawings. No BMS data cable shall be installed in the same conduit as any power cable nor affixed within 25mm if surface/tray mounted. Where cables are run in trunking or with others clipped to tray of a similar type they shall be identified either by colour or labels every 2m.

Care shall be taken to ensure that the manufacturer's recommendations with respect to earthing data cables and DDC Controllers are obeyed.

Each BMS field device shall be identified (internally on space temperature and humidity sensors) with a common code used on points and wiring schedules, parts lists,. Control strategy, MCP and installation diagrams/drawings.

Where a device is fitted with Auto/Man/Off switches, a common circuit shall monitor their auto condition, which shall cause an alarm when any switch is moved from the auto position.

All BMS cables shall be suitably with sleeves at the termination's. These shall be recorded on the installation diagrams and wiring schedules.

Sensors, actuators, switches and all field devices shall be mounted according to the manufacturers instructions. All will be installed with clearance to allow for servicing and the conduit connected by methods to allow easy replacement.

The VAV units are all fitted with speed-controllers and the control system provided is to be fully compatible with the equipment.

The supply temperature for these units is reset by a signal received from the room temperature controllers. Up to 20 room thermostats per air handling unit may be installed.

The room variable air volume diffusers are to be controlled as shown on the schematic drawings. Setpoint adjustment and temperature indication shall be via the BMS.

The controller must incorporate a remote sensor complete with manual set point adjustment. The controller must have facilities to limit the effective set point adjustment at the sensor from zero to ± 5 deg C with respect to the set point as set via the Operator's Terminal.

The controller must be able to modulate up to 4 VAV diffuser actuators of 3 VA capacity each and switch via an adjustable time proportioning signal up to 43 kW heater via a 24 vac, 3 VA relay/contractor installed at each diffuser. Where more than 3 slave units are required per master then the necessary relays must be included to cater for this requirement.

Selected diffuser controllers will provide room temp feedback to the air conditioning unit controllers to off-set the respective supply temperatures.

The minimum requirements for the BMS monitoring and control of the VAV diffuser controls are:-

- a) temperature indication
- b) set point adjustment
- c) damper position indication
- d) heater status
- e) override heater control (switch off)

Where DDC Controllers switch circuits having potentially different mains voltage supply feeds, extra low voltage relay circuit shall be employed. A notice shall be fixed inside the outstation detailing how all mains feeds into it can be isolated. Consideration shall be given to employing an extra low voltage control circuit for motor starter and contractor coils and shall be mandatory where MCP with separate cubicles for motor starters are employed.

In each riser cupboard and Plantroom through which network cables pass and not having an outstation a loop of cable will be made to allow future system expansion.

Network cable will be supplied with at least two spare pairs to allow for future system expansion.

COMMISSIONING

The BMS specialist shall be responsible for the full commissioning of his system and any other controls equipment supplied by him. Commissioning shall be in accordance with the "CIBSE Commissioning Code; Series C, Automatic Controls".

All safety interlocks, overrides and fail-safe conditions are to be operational prior to starting the plant.

Sensors shall be checked to ascertain accuracy within limits, pressure switches checked for switch points and hysteresis.

All the necessary test equipment and materials used in commissioning shall be supplied by the BMS specialist. All test equipment shall have valid test certificates.

Trend graphs will be provided to demonstrate the stable control of the plant. Simulated inputs will be employed to check stability over the design environmental range.

EQUIPMENT CONTROLLED/MONITORED BY THE BMS

The equipment shall be controlled and monitored as per the control schematics, including:

(BMS - Indicates control, BMS(S) - Indicated status indication)

DDC Controller(s) located within the chiller plant electrical panel will provide the control for the a/c plant as shown on the control schematics.

In addition to the BMS being able to reflect the status of all plant controllers, including the position of all valves and actuators, input from all sensors and value of all set points, additional sensors shall be provided for the monitoring of building supply water temperature (1 off) and return chilled water temperature from the secondary systems.

DDC Controller(s) will control the fresh air systems as shown on the control schematic drawings.

Chilled water air handling units are located in plantrooms through-out the building. Stand-alone controllers will provide the control as indicated on the control schematics.

5.5.16.5

BMS POINTS LISTS

EQUIPMENT REF NO	CWG1	SCHWP.1/2/3	SHWP.1/2/3
Analogue Inputs (AI)			
Leaving WaterTemp	2		
Return Water Temp	2		
Space Temp 1			
Space Temp 2			
Space Temp 3			
Outside Air Temp			
Duct Static Pressure			
TOTAL AI's	4		
Digital Input (DI)			
Fire Signal Status			
Run	1	3	3
Fault	1	3	3
Air Pressure Switch Status			
Filter Dirty Pressure Switch			
Remote on/off			
Power Supply			
Demand Control			
TOTAL DI's	2	6	6
Analogue Output (AO)			
Chilled Water Valve			
Heating Master Valve			
Pump Variable Speed Drives		3	3
Dampers			
TOTAL AO's	0	3	3
Digital Output (DO)			
Stop/Start	1	3	3
Heaters Step 2			
Heaters Step 3			
Reheaters Enable			
TOTAL DO's	1	3	3

5.5.16.5 BMS POINTS LISTS

Area Served	Ground Floor	First Floor South	First Floor North	Second Floor South	Second Floor North	Third Floor South	Third Floor North	Fourth Floor South	Fourth Floor North	Fifth Floor South	Fifth Floor North
HVAC BMS POINTS LISTS	AHU.1	AHU.2	AHU.3	AHU.4	AHU.5	AHU.6	AHU.7	AHU.8	AHU.9	AHU.10	AHU.11
Ch.W flowrate rate (l/s)	4.75	3.455	3.455	3.455	3.455	3.455	3.455	3.455	3.455	3.455	3.455
Type of Plant	VAV	VAV	VAV	VAV	VAV	VAV	VAV	VAV	VAV	VAV	VAV
Analogue Inputs (AI)											
Supply Air Temp	1	1	1	1	1	1	1	1	1	1	1
Return Air Temp	1	1	1	1	1	1	1	1	1	1	1
Space Temp 1	1	1	1	1	1	1	1	1	1	1	1
Space Temp 2	1										
Space Temp 3											
Outside Air Temp	1	1	1	1	1	1	1	1	1	1	1
Duct Static Pressure	1	1	1	1	1	1	1	1	1	1	1
End of Line Ch.W Temp											
End of Line H.W. Temp											
CO ₂ Sensor											
TOTAL AI's	6	5	5	5	5	5	5	5	5	5	5
Digital Input (DI)											
Fire Signal Status	1	1	1	1	1	1	1	1	1	1	1
Run	1	1	1	1	1	1	1	1	1	1	1
Fault	1	1	1	1	1	1	1	1	1	1	1
Air Pressure Switch Status	1	1	1	1	1	1	1	1	1	1	1
Filter Dirty Pressure Switch	1	1	1	1	1	1	1	1	1	1	1
Remote on/off	1	1	1	1	1	1	1	1	1	1	1
Remote Temperature sensor/Set Point Adjuster	12	12	12	12	12	12	12	12	12	12	12
TOTAL DI's	18	18	18	18	18	18	18	18	18	18	18
Analogue Output (AO)											
Chilled Water Valve	1	1	1	1	1	1	1	1	1	1	1
Heating Water Valve	1	1	1	1	1	1	1	1	1	1	1
Variable Speed Drives	1	1	1	1	1	1	1	1	1	1	1
AHU Economy Cycle Dampers											
Supply Air PRDE Dampers											
TOTAL AO's	3	3	3	3	3	3	3	3	3	3	3
Digital Output (DO)											
Stop/Start	1	1	1	1	1	1	1	1	1	1	1
Heaters Step 2											
Heaters Step 3											
Reheaters Enable	1	1	1	1	1	1	1	1	1	1	1
TOTAL DO's	2	2	2	2	2	2	2	2	2	2	2

5.5.16.5 BMS POINTS LISTS

Area Served	Toilets first to fifth floors	Toilets Ground Floor	H.T Room	Basement Extract	Transformer and LV room extract
HVAC BMS POINTS LISTS	EAf.1	EAf.2	EAf.18	EAf.15	EAf.16
Ch.W flowrate rate (l/s)					
Type of Plant					
Analogue Inputs (AI)					
Supply Air Temp					
Return Air Temp					
Space Temp 1					
Space Temp 2					
Space Temp 3					
Outside Air Temp					
Duct Static Pressure					
End of Line Ch.W Temp					
Ch.W Energy Meter					
CO ₂ Sensor				2	
TOTAL AI's				2	
Digital Input (DI)					
Fire Signal Status	1	1	1	1	1
Run	1	1	1	1	1
Fault	1	1	1	1	1
Air Pressure Switch Status					
Filter Dirty Pressure Switch					
Remote on/off					
Remote on/off sensor					
TOTAL DI's	3	3	3	3	3
Analogue Output (AO)					
Chilled Water Valve					
Heating Water Valve					
Variable Speed Drives				1	
AHU Economy Cycle Dampers					
Supply Air PRDE Dampers					
TOTAL AO's				1	
Digital Output (DO)					
Stop/Start	1	1	1	1	1
Heaters Step 2					
Heaters Step 3					
Reheaters Enable					
TOTAL DO's	1	1	1	1	1

5.6 SITE CONDITIONS AND INSIDE CONDITIONS REQUIRED

5.6.1 SITE CONDITIONS

5.6.1.1	Altitude	Approximately 1700 m
5.6.1.2	Outside Design Conditions	Summer 32°C db and 18,0°C wb Winter 2,0°C db
5.6.1.3	Electrical Supply	400 volt, 3 phase 50 cycle, 4 wire

5.6.2 INSIDE CONDITIONS REQUIRED

Temperatures	Summer	23,0°C db ($\pm 1,5.C$)	
	Winter	20,0°C db ($\pm 1,5.C$)	
Relative Humidity	50% RH		
Noise Levels	Open Plan Offices		Maximum NC40
	Cellular Offices		Maximum NC35
	Maximum external noise level		45dBA at Boundary

5.6.3 PEOPLE DENSITY

Our calculations have allowed for the following number of people to these areas:

Open Plan - Offices	-	1 Person per 7 m ²
Meeting Rooms	-	1 Person per 4 m ²
Foyers	-	1 Person per 10 m ²
Board Rooms	-	1 Person per 4 m ²
Coaching Rooms	-	1 Person per 4 m ²
Training Rooms	-	1 Person per 4 m ²

5.6.4 OUTSIDE AIR VENTILATION RATES

Fresh air at a rate of 12.5l/s per person (150%improvement), have been allowed for in accordance with the National Building Regulations SANS 10400 Part O Table 2.

5.6.5 LIGHTING LOADS

Our calculations have allowed for a lighting load equivalent to the following in all areas:

Meeting/Board Rooms	-	10 W/m ² average
Foyers	-	10 W/m ² average
Canteen	-	10 W/m ² average
Open Plan Offices	-	10 W/m ² average

5.6.6 **MEASURES TO REDUCE NOISE AND VIBRATION**

- In plant rooms on the roof slab, all equipment is to be placed on spring mounts with a minimum deflection of 10 mm.
- The chillers are to be placed on inertia bases, equal to the chiller mass, on spring mounts and neoprene strips.
- Piping and ducting to be hung on springs mounts inside Plant rooms and then for a distance of 10 m outside the respective plant room.
- Double hemispherical flexible couplings are to be used on piping connections to chillers, pumps, etc.

DUCT DESIGN AIR VELOCITY

NR LEVEL	TERMINAL DUCTS	BRANCH DUCTS	MAIN DUCTS	ATTENUATOR PASSAGES
45	5	7,1	10	20
40	4	6	8	20
35	3,5	5	7,1	16
30	2,8	4	5,7	12,5
25	2,2	3,1	4,5	10
20	1,8	2,6	3,6	10

Velocities are indicated in m/s.

Terminal ducts are those onto which grilles and diffusers are connected.

5.7 **EQUIPMENT CAPACITIES REQUIRED FOR THE AIR CONDITIONING INSTALLATION**

5.7.1 **CHILLED WATER GENERATORS**

UNIT NO		CWG.1
Location		Roof Level
Make		Clivet
Model		WDAT-SL3 440.2
Number off		1
Cooling Capacity Performance:		
Cooling Capacity	kW	1073
Power Input	kW	350
Outdoor Air	°C	32
Evaporator:		
Water Temperature Inlet	°C	12
Water temperature outlet	°C	6
Water Flow	l/s	42.4
Pressure Drop	kPa	22.8
Heat Pump Performance:		
Heating Capacity	kW	1073
Power input	kW	350
Outdoor Air	°C	-2
Water Temperature Inlet	°C	40
Water Temperature Outlet	°C	45
Water Flow	l/s	42.4
Pressure drop	kPa	22.8
Fans:		
Number		16
Air Flow	m³/s	94
Pumps:		
Number		2
Compressors:		
Type		Screw
Number		2
Refrigerant		R134
Electrical Data:		
Power Supply	V/P/Hz	400/3/50
Maximum Running Current	A	600
Maximum starting current	A	809
Maximum Power Input	kW	350
Dimensions and Weight:		
Length	mm	8691
Height	mm	2668
Width	mm	2246
Weight	kg	8200

NOTE

- * Units to be complete with 2 primary Chilled Water Pumps and 2 primary Heating Water Pumps.
- * primary circuits in chiller must contain non-return valve
- * All motors to be Premium Efficiency Type

5.7.2 CHILLED WATER CIRCULATING WATER PUMPS

UNIT NUMBERS		SCHWP1	SCHWP2	SCHWP3
Location		Roof Level	Roof Level	Roof Level
Make		Grundfos	Grundfos	Grundfos
Model		NK 65-315/303 / 11KW	NK 65-315/303 / 11KW	NK 65-315/303 / 11KW
No off		1	1	1
Type		Centrifugal End Suction	Centrifugal End Suction	Centrifugal End Suction
Capacity	l/s each	21.57	21.57	21.57
Total Head (kPa)		300	300	300
Maximum Discharge Pressure	kPa			
Selected Impeller Diameter	mm			
Maximum Impeller Diameter	mm			
Pump Speed	rpm	1450	1450	1450
Variable Speed Drive		Yes	Yes	Yes
Efficiency	Operating%			
Maximum Efficiency for Impeller Diameter	%			
Power Absorbed	kW			
Motor Nameplate Rating	kW			
NPSH Required	kPa			
Type of Coupling		Flexible	Flexible	Flexible
Seal Type		Mechanical	Mechanical	Mechanical
Mounting		Vibration Isolating Base	Vibration Isolating Base	Vibration Isolating Base
Power Supply		400/3/50	400/3/50	400/3/50

NOTE

- * Pump Heads indicated are for tendering purposes only. The Contractor shall determine final pump heads once equipment has been selected.
- * All motors to be Premium Efficiency Type.

5.7.3 HEATING WATER PUMPS

UNIT NUMBERS		SHWP1	SHWP2	SHWP3
Location		Roof Level	Roof Level	Roof Level
Make		Grundfos	Grundfos	Grundfos
Model		NK 65-315/303 / 11KW	NK 65-315/303 / 11KW	NK 65-315/303 / 11KW
No off		1	1	1
Type		Centrifugal End Suction	Centrifugal End Suction	Centrifugal End Suction
Capacity	l/s each	21.57	21.57	21.57
Total Head (kPa)		300	300	300
Maximum Discharge Pressure	kPa			
Selected Impeller Diameter	mm			
Maximum Impeller Diameter	mm			
Pump Speed	rpm	1450	1450	1450
Variable Speed Drive		Yes	Yes	Yes
Efficiency	Operating%			
Maximum Efficiency for Impeller Diameter	%			
Power Absorbed	kW			
Motor Nameplate Rating	kW			
NPSH Required	kPa			
Type of Coupling		Flexible	Flexible	Flexible
Seal Type		Mechanical	Mechanical	Mechanical
Mounting		Vibration Isolating Base	Vibration Isolating Base	Vibration Isolating Base
Power Supply		400/3/50	400/3/50	400/3/50

NOTE

- * Pump Heads indicated are for tendering purposes only. The Contractor shall determine final pump heads once equipment has been selected.
- * All motors to be Premium Efficiency Type.

5.7.4 CHILLED WATER AIR HANDLING UNITS

UNIT REFERENCE NUMBER		AHU.1	AHU.2-11
Area Served		Ground Floor	Floors 1-5
System Type		VAV	VAV
Number of units		1	10
Manufacturer		Clivet	Clivet
Model		AQX21	AQX18
Cooling Capacity	Total kW	120	80
Supply Air	m ³ /s	6	4
Return Air	m ³ /s	4.8	3.2
Outside Air (minimum)	m ³ /s	1.2	0.8
Outside Air	°C – DB/WB	32.0/18.0	32.0/18.0
Entering	°C – DB/WB	26.1/16.6	26.1/16.6
Leaving DB/WB	°C – DB/WB	12.7/11.8	12.7/11.8
Chilled Water (Entering & Leaving)	°C	12.0/6.0	12.0/6.0
Chilled Water Flow Rate	l/s	4.75	3.455
Heating Capacity	kW	80	60
Air Entering/Leaving	°C – DB	13.3/21.7	13.3/21.7
Hot Water (Entering & Leaving)	°C	40.0/45.0	40.0/45.0
Hot Water Flow Rate	l/s	3.864	2.899
Variable Speed Drive		Yes	Yes
S/A Fan Type		EC	EC
Fan Motor	kW	2 x 3	2 x 2
Fan Static	Pa	600	600
Return Air Sound Attenuator	W x H x L	1500x500x1200	1100x450x1200
Supply Air Sound Attenuator	W x H x L	1500x500x1200	1100x450x1200

NOTES:

- The switchboard is to be mounted plantroom wall.
- BMS panel to be mounted plantroom wall.
- All fan motors to be Premium Efficiency Type.

5.7.5 VENTILATION FANS

FAN REFERENCE NO	EAF.1	EAF.2	EAF.3	EAF.4
Area	Toilets Floors 1-5	Toilets Ground Floor	Fourth floor store room 3	Fourth floor store room 1
Make	Donkin	Donkin	AMS	AMS
Type	Axial	Axial	Ceiling Mounted	Wall Mounted
Model	Majax – 20-D-8	Majax – 15-B-4	CE250	WX9
Number of Fans	1	1	1	1
Air Volume m ³ /s	4.7	1	0.125	0.150
Size Ømm	630	400	250	230
Static Pressure Pa	270	200	50	50
Motor kW	1.75	0.35	0.05	0.05
Speed maximum rpm	1440	2880	2800	2800
Sound Attenuators	2 x Silax-P 1.5D	1 x Silax-P 1.5D	NIL	No
Temperature Rating				
Specification				
Variable Speed Drive	No	No		No
Power Supply	400/3/50	400/3/50	240/1/50	240/1/50
Non Return Dampers	No	No	No	

NOTES:

* All fan motors to be Premium Efficiency Type

FAN REFERENCE NO	EAF.5	EAF.6	EAF.7	EAF.8
Area	Fourth floor store room 2	Third floor sensitive store	Third floor sensitive store	First floor store room 1
Make	AMS	AMS	AMS	AMS
Type	Wall Mounted	Wall Mounted	Wall Mounted	Ceiling Mounted
Model	WX9	WX9	WX9	CE250
Number of Fans	1	1	1	1
Air Volume m ³ /s	0.150	0.150	0.150	0.125
Size Ømm	230	230	230	250
Static Pressure Pa	50	50	50	50
Motor kW	0.05	0.05	0.05	0.05
Speed maximum rpm	2800	2800	2800	2800
Sound Attenuators	No	No	No	NIL
Temperature Rating				
Specification				
Variable Speed Drive	No	No	No	
Power Supply	240/1/50	240/1/50	240/1/50	240/1/50
Non Return Damper				No

NOTES:

* All fan motors to be Premium Efficiency Type

5.7.5 VENTILATION FANS (continued)

FAN REFERENCE NO		EAF.9	EAF.10	EAF.11	EAF.12
Area		Ground floor archives/ store	Ground floor archives/ store	Ground floor archives/ store	Ground floor file storage
Make		AMS	AMS	AMS	AMS
Type		Wall Mounted	Wall Mounted	Wall Mounted	Wall Mounted
Model		WX9	WX9	WX9	WX9
Number of Fans		1	1	1	1
Air Volume	m ³ /s	0.150	0.150	0.150	0.150
Size	Ømm	230	230	230	230
Static Pressure	Pa	50	50	50	50
Motor	kW	0.05	0.05	0.05	0.05
Speed	maximum rpm	2800	2800	2800	2800
Sound Attenuators		No	No	No	No
Temperature Rating					
Specification					
Variable Speed Drive		No	No	No	No
Power Supply		240/1/50	240/1/50	240/1/50	240/1/50
Non Return Damper					

NOTES:

* All fan motors to be Premium Efficiency Type

FAN REFERENCE NO		EAF.13	EAF.14	EAF.16	
Area		Ground floor file storage	Ground floor store room 1	Lower ground Transformer/ LV room	
Make		AMS	AMS	Donkin/ AMS	
Type		Wall Mounted	Ceiling Mounted	Axial	
Model		WX9	CE250	Majax – 20-C-8	
Number of Fans		1	1	1	
Air Volume	m ³ /s	0.150	0.125	1,600	
Size	Ømm	230	250	500	
Static Pressure	Pa	50	50	180	
Motor	kW	0.05	0.05	0,45	
Speed	maximum rpm	2800	2800	1440	
Sound Attenuators		No	NIL	2 x Silax-P 1.5D	
Temperature Rating					
Specification					
Variable Speed Drive		No		No	
Power Supply		240/1/50	240/1/50	400/3/50	
Non Return Damper			No	No	

NOTES:

* All fan motors to be Premium Efficiency Type

5.7.5 VENTILATION FANS (continued)

FAN REFERENCE NO		EAF.18	EAF.21	
Area		Lower ground HT room	Fifth floor toilet	
Make		Donkin/ AMS	AMS	
Type		Wall Mounted – Axial fan	In Line Tube	
Model		FA 38/4	TD500/150	
Number of Fans		1	1	
Air Volume	m ³ /s	0.82	0.06	
Size	Ømm	400	150	
Static Pressure	Pa	50	100	
Motor	kW	0.21	0.06	
Speed	maximum rpm	1350	2800	
Sound Attenuators		No	2 x 600 Long	
Temperature Rating				
Specification				
Variable Speed Drive		No	No	
Power Supply		240/1/50	240/1/50	
Non Return Damper			No	

NOTES:

* All fan motors to be Premium Efficiency Type

5.7.6 SMOKE VENTILATION FANS

FAN REFERENCE NO		EAF.15	
Area		Lower ground floor	
Make		AMS	
Type		Axial	
Model		APS0804/14/35	
Number of Fans		1	
Air Volume	m ³ /s	8	
Size	Ømm	800	
Static Pressure	Pa	220	
Motor	kW	5	
Speed	maximum rpm	1440	
Sound Attenuators		2 x P 1.5D	
Temperature Rating		300°C @ 60 mins	
Specification		EN12101	
Variable Speed Drive		Yes	
Power Supply		400/3/50	
Non Return Damper		No	

NOTES:

* All fan motors to be Premium Efficiency Type

5.7.7 SPLIT AIR CONDITIONING UNITS

UNIT NO	MWSU.1&2	MWSU.3&4	MWSU.5&6	MWSU.7&8
Area Served	Ground Floor Patch Room	First Floor Patch Room	Second Floor Patch Room	Third Floor Patch Room
Number of Units	2	2	2	2
Type	Wall Mounted Inverter	Wall Mounted Inverter	Wall Mounted Inverter	Wall Mounted Inverter
Make	Midea	Midea	Midea	Midea
Refrigerant	R410A	R410A	R410A	R410A
Total Cooling kW	5.2	5.2	5.2	5.2
Ambient Temp °C	35	35	35	35
Heating kW	0	0	0	0

UNIT NO	MWSU.9&10	MWSU.11&12	MWSU.13&14
Area Served	Fourth Floor Patch Room	Fifth Floor Patch Room	Lower ground floor UPS room
Number of Units	2	2	2
Type	Wall Mounted Inverter	Wall Mounted Inverter	Wall Mounted Inverter
Make	Midea	Midea	Midea
Refrigerant	R410A	R410A	R410A
Total Cooling kW	5.2	5.2	7
Ambient Temp °C	35	35	35
Heating kW	0	0	0

UNIT NO	CCU.1	CWU-01	CDU-01
Area Served	Ground Floor Security Control Room	Lower Ground floor Security Green Room	Lower Ground floor Security Lobby
Number of Units	1	1	1
Type	Ceiling Cassette Unit	Through wall console unit – c/w self evaporating system	In-ceiling ducted split unit – inverter type
Make	Midea	MACLAREN	Midea
Refrigerant	R410A	R410A	R 410A
Total Cooling kW	7	4.1	10
Ambient Temperature °C	35	35	35
Heating kW	7	4.2	10

OUTDOOR UNITS TO BE BLYGOLD TREATED.

5.8 SCHEDULES

TO BE COMPLETED BY ALL TENDERERS

5.8.1 CHILLED WATER GENERATORS

UNIT NO		CWG.1
Location		Roof Level
Make		Clivet
Model		
Number off		
Cooling Capacity Performance:		
Cooling Capacity	kW	
Power Input	kW	
Outdoor Air	°C	
Evaporator:		
Water Temperature Inlet	°C	
Water temperature outlet	°C	
Fouling Factor	m ² °C/W	
Water Flow	l/s	
Pressure Drop	kPa	
Heat Pump Performance:		
Heating Capacity	kW	
Power input	kW	
Outdoor Air	°C	
Water Temperature Inlet	°C	
Water Temperature Outlet	°C	
Fouling Factor	m ² °C/W	
Water Flow	l/s	
Pressure drop	kPa	
Fans:		
Number		
Air Flow	m ³ /s	
Unitary power	kW	
Pumps:		
Number		
Compressors:		
Type		
Number		
Refrigerant		
Capacity steps		
Electrical Data:		
Power Supply	V/P/Hz	
Maximum Running Current	A	
Maximum starting current	A	
Maximum Power Input	kW	
Dimensions and Weight:		
Length	mm	
Height	mm	
Width	mm	
Weight	kg	

NOTE

- * Units to be complete with 2 primary Chilled Water Pump and 2 primary Heating Water Pump.
- * All motors to be Premium Efficiency Type

5.8.2 CHILLED WATER CIRCULATING WATER PUMPS

UNIT NUMBERS	SCHWP1	SCHWP2	SCHWP3
Location	Roof Level	Roof Level	Roof Level
No off	1	1	1
Type			
Capacity l/s each			
Total Head (kPa)			
Maximum Discharge Pressure kPa			
Selected Impeller Diameter mm			
Maximum Impeller Diameter mm			
Pump Speed rpm			
Variable Speed Drive			
Efficiency Operating %			
Maximum Efficiency for Impeller Diameter %			
Power Absorbed kW			
Motor Nameplate Rating kW			
NPSH Required kPa			
Type of Coupling			
Seal Type			
Mounting			
Power Supply			

NOTE

- * Pump Heads indicated are for tendering purposes only. The Contractor shall determine final pump heads once equipment has been selected.
- * All motors to be Premium Efficiency Type.

5.8.3 HEATING WATER PUMPS

UNIT NUMBERS	SHWP1	SHWP2	SHWP3
Location	Roof Level	Roof Level	Roof Level
No off	1	1	1
Type			
Capacity l/s each			
Total Head (kPa)			
Maximum Discharge Pressure kPa			
Selected Impeller Diameter mm			
Maximum Impeller Diameter mm			
Pump Speed rpm			
Variable Speed Drive			
Efficiency Operating %			
Maximum Efficiency for Impeller Diameter %			
Power Absorbed kW			
Motor Nameplate Rating kW			
NPSH Required kPa			
Type of Coupling			
Seal Type			
Mounting			
Power Supply			

NOTE

- * Pump Heads indicated are for tendering purposes only. The Contractor shall determine final pump heads once equipment has been selected.
- * All motors to be Premium Efficiency Type.

5.8.4 CHILLED WATER AIR HANDLING UNITS

UNIT REFERENCE NUMBER		AHU.1	AHU.2-11
Area Served		Ground Floor	Floors 1-5
System Type			
Number of units			
Manufacturer			
Model			
Cooling Capacity	Total kW		
Supply Air	m ³ /s		
Return Air	m ³ /s		
Outside Air (minimum)	m ³ /s		
Outside Air	°C – DB/WB		
Entering	°C – DB/WB		
Leaving DB/WB	°C – DB/WB		
Chilled Water (Entering & Leaving)	°C		
Chilled Water Flow Rate	l/s		
Heating Capacity	kW		
Air Entering/Leaving	°C – DB		
Hot Water (Entering & Leaving)	°C		
Hot Water Flow Rate	l/s		
Variable Speed Drive			
S/A Fan Type			
Fan Motor	kW		
Fan Static	Pa		
Return Air Sound Attenuator	W x H x L		
Supply Air Sound Attenuator	W x H x L		

NOTES:

- The switchboard is to be mounted plantroom wall.
- BMS panel to be mounted plantroom wall.
- All fan motors to be Premium Efficiency Type.

5.8.5 VENTILATION FANS

FAN REFERENCE NO	EA.F.1	EA.F.2	EA.F.3	EA.F.4
Area	Toilets Floors 1-5	Toilets Ground Floor	Fourth floor store room 3	Fourth floor store room 1
Make				
Type				
Model				
Number of Fans				
Air Volume m ³ /s				
Size Ømm				
Static Pressure Pa				
Motor kW				
Speed maximum rpm				
Sound Attenuators				
Temperature Rating				
Specification				
Variable Speed Drive				
Power Supply				
Non Return Dampers				

NOTES:

* All fan motors to be Premium Efficiency Type

FAN REFERENCE NO	EA.F.5	EA.F.6	EA.F.7	EA.F.8
Area	Fourth floor store room 2	Third floor sensitive store	Third floor sensitive store	First floor store room 1
Make				
Type				
Model				
Number of Fans				
Air Volume m ³ /s				
Size Ømm				
Static Pressure Pa				
Motor kW				
Speed maximum rpm				
Sound Attenuators				
Temperature Rating				
Specification				
Variable Speed Drive				
Power Supply				
Non Return Damper				

NOTES:

* All fan motors to be Premium Efficiency Type

5.8.5 VENTILATION FANS (continued)

FAN REFERENCE NO	EA.F.9	EA.F.10	EA.F.11	EA.F.12
Area	Ground floor archives/ store	Ground floor archives/ store	Ground floor archives/ store	Ground floor file storage
Make				
Type				
Model				
Number of Fans				
Air Volume m ³ /s				
Size Ømm				
Static Pressure Pa				
Motor kW				
Speed maximum rpm				
Sound Attenuators				
Temperature Rating				
Specification				
Variable Speed Drive				
Power Supply				
Non Return Damper				

NOTES:

* All fan motors to be Premium Efficiency Type

FAN REFERENCE NO	EA.F.13	EA.F.14	EA.F.16	
Area	Ground floor file storage	Ground floor store room 1	Lower ground LV room	
Make				
Type				
Model				
Number of Fans				
Air Volume m ³ /s				
Size Ømm				
Static Pressure Pa				
Motor kW				
Speed maximum rpm				
Sound Attenuators				
Temperature Rating				
Specification				
Variable Speed Drive				
Power Supply				
Non Return Damper				

NOTES:

* All fan motors to be Premium Efficiency Type

5.8.5 VENTILATION FANS (continued)

FAN REFERENCE NO	EAF.19	EAF.20	EAF.21	
Area	Lower ground floor pause area	Lower ground transformer room	Fifth floor toilet	
Make				
Type				
Model				
Number of Fans				
Air Volume m ³ /s				
Size Ømm				
Static Pressure Pa				
Motor kW				
Speed maximum rpm				
Sound Attenuators				
Temperature Rating				
Specification				
Variable Speed Drive				
Power Supply				
Non Return Damper				

NOTES:

* All fan motors to be Premium Efficiency Type

5.8.6 SMOKE VENTILATION FANS

FAN REFERENCE NO	EAF.15	
Area	Lower ground floor	
Make		
Type		
Model		
Number of Fans		
Air Volume m ³ /s		
Size Ømm		
Static Pressure Pa		
Motor kW		
Speed maximum rpm		
Sound Attenuators		
Temperature Rating		
Specification		
Variable Speed Drive		
Power Supply		
Non Return Damper		

NOTES:

* All fan motors to be Premium Efficiency Type

5.8.7 **SPLIT AIR CONDITIONING UNITS**

UNIT NO	MWSU.1&2	MWSU.3&4	MWSU.5&6	MWSU.7&8
Area Served	Ground Floor Patch Room	First Floor Patch Room	Second Floor Patch Room	Third Floor Patch Room
Number of Units	2	2	2	2
Type	Wall Mounted Inverter	Wall Mounted Inverter	Wall Mounted Inverter	Wall Mounted Inverter
Make				
Refrigerant				
Total Cooling kW				
Ambient Temp °C				
Heating kW				

UNIT NO	MWSU.9&10	MWSU.11&12	MWSU.13&14
Area Served	Fourth Floor Patch Room	Fifth Floor Patch Room	Lower ground floor UPS room
Number of Units	2	2	2
Type	Wall Mounted Inverter	Wall Mounted Inverter	Wall Mounted Inverter
Make			
Refrigerant			
Total Cooling kW			
Ambient Temp °C			
Heating kW			

UNIT NO	CCU.1	CWU-01	CDU-01
Area Served	Ground Floor Security Control Room	Lower Ground floor Security Green Room	Lower Ground floor Security Lobby
Number of Units	1	1	1
Type	Ceiling Cassette Unit	Through wall console unit – c/w self evaporating system	In-ceiling ducted split unit – inverter type
Make			
Refrigerant			
Total Cooling kW			
Ambient Temperature °C			
Heating kW			

OUTDOOR UNITS TO BE BLYGOLD TREATED.

5.9 AUTOMATIC CONTROLS

Make and Model Number:

Thermostats	_____
Safety Thermostat	_____
Fire Safety Thermostat	_____
Air Pressure Switch	_____
Damper Motors	_____
Step Controller	_____
Voltage Monitors	_____
Time Switches	_____

5.10 DUCTWORK

Fabrication by	_____
Installation by	_____

5.11 GRILLES

Make	_____
Model Number	_____
Material	_____

5.12 FIRE DAMPERS

Make	_____
Model Number	_____

5.13 DIFFUSERS

Make	_____
Model Number	_____
Material	_____

5.14 WEATHER LOUVRES

Make	_____
Model Number	_____
Material	_____

5.15 ATTENUATORS

Make	_____
Model Number	_____
Material	_____

5.16 NON-RETURN DAMPERS

Make	_____
Model Number	_____
Material	_____

5.17 HEAT RECOVERY WHEELS

Make	_____
Model Number	_____
Material	_____

5.18 SWITCHPANELS AND CONTROL BOARDS

Name of Manufacturer	_____
Make of	Isolators _____
	Motor Starters _____
	Relays _____
	Time Delay Relays _____
	Time Switches _____
	Rotary Switches _____
	Instruments _____

5.19 SUBLET WORK - where applicable

Tenderers to list any work or service which they intend to sublet and name the firm to whom they propose subletting the work.

<u>SERVICE</u>	<u>NAME OF FIRM</u>
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____