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PART IV – STANDARD SPECIFICATION

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1. DEFINITIONS AND ABBREVIATIONS

The following terms shall, unless the context otherwise requires, have the meanings hereunder assigned to them:-

'Approved' 'accepted' or 'directed'	As approved, satisfactory, accepted or directed as satisfactory by the Architect.
'Balancing'	Work adjustments and checks necessary to proportion the flow within the distribution system (sub-mains, branches, terminals) in accordance with specified design quantities.
'Commissioning'	Work necessary to place the installation and work covered by this specification into normal operating condition.
'Concealed'	Embedded in masonry or other construction, installed in furred spaces within double partitions or hung ceilings, in trenches, in crawl spaces or in enclosures.
'Exposed'	Not installed underground or concealed as defined above.
'Indicated' specifications.	As indicated, shown or noted as shown on drawings and/or
'Install'	To erect, mount and connect complete with all related accessories.
'Provide' operation.	To supply, install and connect up complete and ready for safe
'Similar' or	Of approved manufacture equal as regards to 'equal' materials, weight, size and efficiency of performance to product specified by name.
'Supply'	To purchase, procure, acquire and deliver complete with all related accessories.
'Testing'	Work and checks necessary to determine qualitative and quantitative performance of equipment, installation and workmanship.
'Wiring'	Conduit, fittings, wiring, junction and outlet boxes, switches, cut-outs and socket outlets and all related items.

'Work'	All labour, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation.

Abbreviations used in these documents shall means :-

'ASIB'	Automatic Sprinkler Inspection Bureau
'AFI'	Air Filter Institute
'AMCA'	Air Moving and Conditioning Association
'ASA'	American Standard Association
'ASHRAE'	American Society of Heating, Refrigeration and Air Conditioning Engineers
'ARI'	Air Conditioning and Refrigeration Institute (USA)
'ASME'	American Society of Mechanical Engineers
'ASTM'	American Society of Testing Materials
'AWWA'	American Water Works Association
'BSS'	British Standard Specification
'BSI'	British Standard Institute
'BS CP'	British Standard Code of Practice
'CIBS'	Chartered Institution of Building Services
'DIN'	German Standards Institute
'HVCA'	Heating and Ventilating Contractor's Association (UK)
'NBFU'	National Board of Fire Underwriters (USA)
'NBS'	National Bureau of Standards (USA)

'NEMA'	National Electrical Manufacturers Association (USA)
'NFPA'	National Fire Protection Association (USA)
'SABS'	South African Bureau of Standards
'SMACNA'	Sheet Metal and Air Conditioning Contractors National Association, Inc (USA)
'UL'	Underwriters Laboratories

2. COMPLIANCE WITH REGULATIONS AND STANDARDS

It shall be the responsibility of the Contractor to ensure that all equipment and methods used in the installation, comply with all relevant statutory regulations, and amendments thereto in particular the following :-

S.A.N.S. Code of Practice 10142, as amended, for the Wiring of Premises.

The Occupational Health & Safety Act of 1993, as amended.

Government, Provincial and Local Authorities Ordinances, Regulations, By-laws, Rules and other Statutory requirements.

Specifications and Codes of Practice issued by the South African Bureau of Standards and British Standards Institute. The former shall have precedence over the latter where both bodies have issued conflicting specifications or codes of practice.

The Contractor warrants the software contained in the equipment or systems that the Contractor provides for use by the Employer shall include, at no additional costs to the Employer, design and performance features and capabilities to ensure that the software will not be inaccessible and that the software will not provide invalid or incorrect results.

3. STORAGE OF MATERIALS

Materials shall be stored in areas allocated by the Contractor. Stored material shall be safely stacked and shall not overload floor construction beyond design limits.

4. ACCESSIBILITY

Equipment shall be installed so as to be readily accessible for testing, operation, maintenance and repair. Minor deviations from drawings may be made to accomplish this, but changes of magnitude or which involve extra costs shall not be made without approval of the Architect.

Platforms and ladders shall be provided where indicated for access to instruments and equipment in accordance with the requirements of authorities having jurisdiction.

All platforms shall have removable gratings, toe plates, and guard rails and shall be of riveted or welded structural steel with supports cross-braced on all four sides and welded to baseplates. The baseplates to be anchor bolted to concrete piers.

All ladders shall be of structural steel and suitably supported, and shall have minimum dimensions of 0,5 m width with 65 mm by 65 mm side rails and 30 mm diameter rungs.

5. SUPPORTS FROM OVERHEAD CONSTRUCTION

Where overhead construction does not permit fastening of supports, additional approved framing shall be provided.

Duct and pipe support brackets shall be firmly fixed to overhead construction by an approved system. "Shotfiring" of supports into concrete will not be accepted.

6. PAINTING AND PROTECTION AGAINST CORROSION

Where provision is not made for painting and protection of steel in either the relevant standard specification or in Part V of this specification the following procedure shall be adopted :-

Surfaces shall be thoroughly cleaned in accordance with SABS 064.

Surfaces shall then be primed with zinc chromate primer complying with Type 1 of SABS 679. Primer shall be applied to all metal surfaces irrespective of any external insulation to be applied.

Surfaces shall then be given two coats of paint complying with Type 1 of SABS 630. Colours shall be approved by the Architect. On insulated surfaces, paint shall be applied on the insulation.

Care shall be taken that all edges are covered to the same standard. Surfaces which have been damaged during installation shall be touched up to the same standard.

Wherever possible periodic repainting shall be made unnecessary by using zinc coated steel.

Zinc coating shall mean either zinc spraying, hot dip galvanising or electro-deposited zinc coating. The weight of coating shall be not less than 300 grams per square meter of surface covered.

Where zinc coated steel is sheared, pinched, drilled etc., it shall be re-coated with a zinc dust pigmented paint or a suitable polymerised resin paint. However, welding or brazing of zinc coated steel, followed by re-coating will not be permitted. Such fabrications shall be zinc coated after welding or brazing.

Where any equipment is installed in such a position as to expose finned coils to the elements, such equipment shall be fitted with an approved hail protection device.

Volatile Organic Compounds

Any paint/solvent based coating used for internally exposed pipes and air-conditioning ductwork, must have a VOC content of less than 200g/l.

7. IDENTIFICATION

All identification shall be legible, and shall be painted or fixed after completion of final finishes. Identification colours shall be in accordance with BS 1710 and/or as instructed or approved by the Architect.

Labels

A label shall be provided under each gauge, meter, instrument, pilot lamp, remote control switch, motor controller and panel mounted item and equipment identifying the equipment controlled by such items.

The labels shall consist of non-corroding material TRAFFOLITE with non-glossy appearance, engraved, block on a white background. All labels shall be of the screwed-on type.

Valve Tags and Charts

Aluminum numbered tags including letters to identify the system, shall be fastened by heavy brass chain to all valves indicated on the drawings.

The metal tags shall be 50 mm in diameter and 1 mm thick, and shall have stamped-in numbers and letters.

The Contractor shall be responsible for submitting a list of all valves and controls, giving location and function, together with diagrammatic charts featuring each piping system with valves and controls, identified by numbers and letters shown on the corresponding tags.

Piping

In addition to painting of external surfaces (including insulation), colour coded polyvinyl chloride bands shall be applied to pipes identifying their content and direction of flow.

Bands shall be provided to piping at valve locations, at points where piping enters or leaves a partition, wall, floor or ceiling and at least at every 10 m centres of straight runs. Where piping is concealed, bands shall be applied to valves or other devices whenever access is provided by doors or panels. Exit and entrance points to each vessel, tank or place of equipment shall be identified by bands. Insulated pipes shall be banded after insulation and painting work has been completed.

The band's width shall be minimum 200 mm wide for pipes up to 250 mm diameter and 400 mm wide for larger diameter piping. The pre-printed letters on band, identifying the services shall be of at least 20 mm high.

Piping of less than 25 mm nominal bore need not be colour banded but shall be painted all over with the identifying colour of its content.

Ductwork

All ductwork shall be identified by writing in words the service of the duct and by pointer showing the direction of flow. Markings shall appear at least at the point of origin and whenever ducting enters or leaves walls, floors or ceilings and for every 20 m centres of straight lines.

The identification letters shall be at least 50 mm high and the flow arrow 150 mm long.

Access Panels

Approved ceiling tile markers shall be provided in areas where removable ceilings or access panels are positioned to indicate the location of valves and/or other devices.

Colour Schedules

Unless otherwise indicated, the following colour schedules shall apply.

Note 1

All equipment, ducts, pipework, metal parts and insulated and plastered surfaces shall be throughly descaled, cleaned and painted with a priming coat and two coats of oil paint.

Note 2

Paint shall be of the highest quality super enamel as manufactured by Plascon or equal, and shall be applied strictly in accordance with the manufacturer's recommendations and directions Colour derived from PLASCON COMPUTACOLOUR are denoted (c.c.)

Note 3

All colour bands shall be 250mm long. In cases where banks of parallel pipes runs occur, the colour bands shall be of a uniform length and grouped together wherever possible.

Note 4

Colour bands, where specified or exposed services shall be applied at all entries to junctions, connections to appliances, bulkhead and wall penetrations and both sides of valves.

Bands shall be at 3 000mm centres on straight sections.

Note 5

Colour bands, where specified or concealed services shall be applied to all access points to ducts, shafts, ceilings, etc.

Note 6

In concealed accessible areas, the banding shall be applied to pipework or trunking at 2 000mm centres.

Note 7

Where chilled water, hot water or domestic hot water is clad with sheetmetal, it is to be painted continuously. Where unclad, it is to be banded.

PIPING - AIR CONDITIONING

Chilled Water flow and return	Midnight Blue G.116	Continuous	Continuous	-
Chilled water F & E	Midnight Blue G.116	Continuous	Continuous	-
Condenser water flow & return	Magic Green G.408	Continuous	Continuous	-
Condenser water F & E	Magic Green G.408	Continuous	Continuous	-
Computer boosted water supply	Sunlight yellow G.12	Continuous	Continuous	-
Treated water	Verda 9 (c.c.) M-37-4	Continuous	Continuous	-
Drains	Black G.2	Continuous	Continuous	-
Refrigerant (hot gas)	Copper Polish and Varnish	Continuous	Continuous	-
Refrigerant (liquid)	Copper Polish and Varnish	Continuous	Continuous	-
Refrigerant (suction)	Everest Grey G.71	Continuous	Continuous	-
Bleed water	P.W.D. Brown G.18	Continuous	Continuous	-

8. SOUND AND VIBRATION CONTROL

The Contractor shall be responsible for the rectification of any excessive noise and/or vibration caused by the operation of the air conditioning and ventilation system installed under this contract.

The Contractor shall be responsible for the detail design of concrete inertia blocks, if required or specified, but such blocks will be provided by others.

Each vibration isolation system shall be designed for a static deflection factor necessary to give maximum transmissibility as scheduled below :-

Maximum Permissible Transmissibility

PLANT/FOUNDATION/TYPE	ON SOLID	SUPPORTED FROM GROUND	SUPPORTED FROM STRUCTURE IN OCCUPIED AREA
Axial fan up to 7,5 kW incl. Centrifugal fan up to 4 kW incl. Centrifugal pump up to 4 kW incl.	50%	25%	5%
Axial fan 7,5 - 40 kW incl. Centrifugal fan 4 - 20 kW incl. Centrifugal pump 4 - 11 kW incl. Reciprocating compressor 7,5 - 40 kW incl.	30%	10%	3,5%
Axial fan over 40 kW incl. Centrifugal fan over 20 kW incl. Centrifugal pump over 11 kW incl. Reciprocating compressor over 40 kW	30%	3,5%	5%
Pipes *	10%	10%	10%

*Pipes up to 75 mm bore only if needed.

The sound control system shall provide for noise levels specified under the relevant clauses in Part V of the specification.

Isolation of Mechanical Equipment

All equipment shall, wherever possible, be orientated in such a way that maximum sound radiation patterns are directed so as to cause least disturbance. (Maximum sound radiation occurs in the direction in which fluid enters and leaves the equipment)

All rotating machinery shall be balanced. The critical speed shall be at least 20% above the operating speed.

Vibration isolation mountings shall be provided for all equipment. Mountings shall be installed in accordance with the manufacturer's instructions. However, the Contractor shall be responsible to ensure that amplitude of motion and vibration transmission will not exceed the specified limits.

Floor mounted equipment shall be erected on a concrete plinth, which shall protrude at least 25 mm above finished screeded floor level.

Isolators shall be selected to give both horizontal and vertical flexibility (compression and shear). The amplitude of motion due to operation of the supported equipment shall not exceed 3 mm.

Spring isolators shall be designed and installed in such a way that the ends of the springs are constricted to remain parallel during deflection. For stability, the outside diameter of springs shall be at least equal to their compressed height at rated load. Springs shall have a minimum additional travel to solid, equal to 20% of the rated deflection. Each spring mounting shall be set on 7 mm thick neoprene acoustical pads.

Suspension type supports, i.e. springs combined with suspension rods, shall be rendered dynamically damped where necessary, by the provision of suitable dynamic dampers (dashpots) arranged diagonally or onto vertical building faces.

Isolation of Piping and Ducts

All connections to equipment shall be sufficiently flexible to prevent excessive strain to allow the equipment freedom to move and to prevent plant vibration being conducted. Initially, special flexible connections may be omitted in a piping system and use shall be made of natural flexibility of resilient hangers or mountings for vibration isolation. However, flexible connections shall be inserted and other necessary adjustments shall be made, at the Contractor's expense, should the need arise.

All ductwork and piping within 15 m from connected vibration-inducing equipment shall be hung on resilient hangers. The first four hanger supports shall be capable of supporting piping at a fixed elevation during installation and, in addition, shall have a secondary adjustment to transfer the load to the spring element within the mounting, after the system has been filled with water.

The Contractor may be required to disconnect the piping after the installation is completed to demonstrate that no strain is exerted at the connections to the equipment.

Noise suppressors shall be installed downstream of all steam pressure reducing valves.

Where piping and ductwork passes through walls, floors or ceilings or plantrooms, acoustical seals shall be employed to confine airborne noises to the inside of such rooms.

Sound Attenuation

Sound attenuating units or treatment shall be provided as indicated and/or required to control the noise from air conditioning and ventilation systems to within the limits specified. Noise levels caused by the equipment shall not exceed the ambient noise levels by more than 7dB in each frequency on the site boundary.

It should be noted that the provisions for sound attenuation shown the Engineer's drawings (or the absence of same) are based on average published data for equipment noise and inherent attenuation. The Contractor shall, nevertheless produce his own calculations for noise levels in the areas specified, and provide additional silencing equipment and/or treatment if necessary.

To minimize the need for sound attenuation, fans shall be selected to operate near their maximum efficiency point when producing the required air quantity and static pressure.

Sound attenuators and acoustic treatment in ducts shall be proof against fire, fungus and erosion and not produce dust or come loose.

"Packaged" attenuators shall normally be flanged for bolted connections, and flexible duct connectors shall be used as shown or required.

Attenuators shall have an air resistance not exceeding 75 Pa measured at sea level at maximum air quantity.

Noise Measurement

The Contractor shall submit sound pressure levels measured on the completion of the installation, detailing the sound pressure levels in dB (re: $2x10^{-5}$ Pa), for the seven International Standard Octave Bands measured by means of a sound meter in at least six (6) areas within the building, as selected by the Architect.

Measurements for sound pressure level data shall be taken by the Contractor, or at his expense by an approved organization, under full or nearly full cooling and air flow conditions.

Noise level in the conditioned space through the operation of the unit at any operation point shall not exceed the specified internal, NC level with an 8 db room attenuation factor in each octave band. Due allowance shall be made for all attenuators required to meet the specified noise levels whether shown on the drawings or not. Operating of the unit shall not cause noise levels in the surrounding areas to be more than 7 db, in each frequency, above ambient noise levels at any boundary of the site.

9. INSULATION

All piping and ducting shall be insulated as specified below.

All insulation of piping, ductwork and equipment shall comply with BS 5970, provisions of BS5422. Test reports may be requested from an approved testing laboratory, at the Contractor's expense, to certify the declared thermal conductivity under operating temperature of the chosen insulating materials.

Insulation shall be applied in accordance with manufacturer's general instructions in a neat and workmanlike manner so as to present a smooth and even surface. The insulation shall be compatible with the surface to be insulated and shall not demonstrate or cause any corrosion or stress corrosion under operating conditions. Vapour proofing and adhesives shall be compatible with the insulation; under no circumstances shall an adhesive or solvent be used which could attack or dissolve the surface or material of the insulation.

Covering which is subject to abrasion during normal maintenance shall be protected by perforated sheet metal with corners and edges of insulation being returned by formed angles fixed to panel edges inside the casing. Covering which may be splashed with water under operating conditions shall be suitably protected and drained to waste.

Piping, ductwork or equipment shall be clean, dry, free from grease, rust and scale and shall be tested and approved for tightness and workmanship prior to application of insulation. Insulation shall be continuous through sleeves, wall and ceiling openings.

Materials and Finishes

Any insulation material and their finishes used shall resist rotting, fire, decay, fungus growth, attack by vermin or erosion, thermal or acoustic, whichever may occur under operating conditions.

The thickness of insulation, unless otherwise specified, shall conform with the following dimensions for the various normal application :-

THERMAL CONDUCTIVITY W/m°C	APPLICATION:	PIPING		
	TEMP. LIMITS:	4 - 100 °C	4 - 100°C	DIRECT EXPANSION SUCTION
	SIZE:	MAX 80mm dia	80-500 mm dia	
≤ 0,035		25 mm	50 mm	40 mm

Piping Insulation Material shall be as follows:

Piping > than 100mm (Outside Building): Mylar foil covered polystyrene – Bends insulated with fiberglass rope and wool materials, supercoated with a 12mm thick layer of insulpro hardsetting insulation plaster and finished with a gauze reinforced vapour barrier.

Piping > than 100mm (Inside Building) : Mylar foil covered fibreglass – Bends insulated with fiberglass rope and wool materials, supercoated with a 12mm thick layer of insulpro hardsetting insulation plaster and finished with a gauze reinforced vapour barrier.

Piping < than 100mm: Elastrometric Armaflex.

All external (exposed to rain and sunlight) piping and all piping up to 3m high or where shall be cladded in GSM.

Ducting Insulation Material shall be as follows:

External insulation	:	25mm fibreglass
Density	:	16 kg/m;
Conductivity	:	0,045 W/mK
Vapour barrier	:	Foil reinforced Kraft
Fixing	:	Pinned and strapped

Internal insulation	:	Fibreglass with sonic liner
Inside Building	:	25mm
Outside Building	:	50mm
Density	:	16 kg/m;
Fixing	:	Mechanically fixed and pinned.

Where specified thickness of insulation exceeds commercially available sizes, insulation in two or more layers, with all joints staggered, shall be applied. Overlaps shall be at least 50 mm.

To ensure that the correct thickness of insulation and covering has been applied, the Contractor shall, if required to do so, cut one or more section from the finished insulation. If deficiencies are revealed, the Contractor shall, at his own expense, remove the whole and provide and fix the correct insulation.

Fire Hazard Ratings

Satisfactory test results from the National Building Research Institute or test reports from an approved testing laboratory may be required, at the Contractor's expense, to certify the fire hazard ratings for proposed materials for insulation, covering and vapour sealing do not exceed those specified.

Such Building Research Institute of the South African Council for Scientific and Industrial Research, and in accordance with test procedures BS 476.

Insulating materials, finishes, vapour barriers and adhesives shall conform to the fire hazard ratings specified as follows:-

- The fuel contribution index shall not exceed O when compared with asbestos taken as O.

- The smoke contribution index shall not exceed 10 when compared with hardboard taken as 100.

- The spread of flame index shall not exceed 0 when compared with asbestos taken as 0.

Any productions of combustion of said materials shall be completely non-toxic and non-corrosive.

Piping and Fittings

Unless otherwise specified or noted, the following piping need not be insulated :-

Vent, overflow, drain and relief piping; pneumatic control air piping; cold water make-up piping; water treatment piping; condenser water piping.

All cold piping (chilled water, refrigerant suction) and all steam, condensate and hot water circulating piping shall be insulated, using rigid performed sections having a bore to suit the pipe.

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

Covering of insulation which is visible but not readily accessible shall be finished neatly, and painted. Where the covering used, as specified above, is not suitable for the purposes, hard setting compound shall be applied, trowelled true and smooth, and painted.

Insulation in plantrooms and enclosures and insulation which is visible and accessible, i.e. up to 2,5 m above floor level shall, in addition to the covering specified above, be neatly enclosed in metal casings made out of aluminium or galvanised steel of at least 0,8 mm thickness or covered with 12 mm thick minimum hard setting compound, reinforced by galvanised mesh.

Insulation of piping exposed to the weather shall be metal cased as specified above, and this casing shall be lapped so as to be rainproof. Casing shall be painted.

Self-tapping screws, or blind rivets, the application of which could damage the vapour sealing, shall NOT be used for fixing metal casings to vapour sealing.

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.

Alternatively, the Engineer may permit the use of foamed-in-situ insulation inside metal casings applied to such special positions.

Where practically possible, piping shall be supported OUTSIDE the insulation or cradles as specified below. 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. Normally, dry hardwood will be acceptable for this purpose.

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

Ductwork

Unless otherwise specified or noted, the following ductwork need not be insulated:-

Return air ductwork; exhaust air ductwork; supply ventilating systems except when incorporating heating.

Unless otherwise specified or noted, insulation shall be applied to the outside of the duct.

Concealed ductwork shall be insulated with rigid or flexible materials. Flexible materials shall have a density of at least 16kg/m;.

Ductwork which is exposed and visible but not readily accessible shall be insulated with rigid material having a facing of aluminium foil or hard setting cement finished smooth and true, and painted.

Ductwork in plantrooms and ductwork which is exposed, visible and readily accessible, i.e. up to 2,5 m above floor level, shall be insulated with rigid material and protected against mechanical damage either by aluminium sheet of at least 0,8 mm thickness or be reinforced hard setting compound of minimum 12 mm thickness, and painted.

Ductwork insulation exposed to atmospheric conditions shall be covered by galvanised sheetmetal panels soldered and lapped so as to be weatherproof, and painted.

Self-tapping screws, or blind rivets, the application of which could damage vapour sealing, shall NOT be used for fixing metal casings.

Where insulation is fixed to the inside of the ductwork, the surface treatment of such insulation exposed to the air flow shall resist shredding and erosion, and where such insulation is adjacent to humidifiers, air washers or cooling coils; the surface shall have water protection.

The insulation shall cover flanges by means of boxes or by increasing the thickness of insulation to give at least a 6 mm cover at these points.

Fans

Fans handling cooled or heated air, and externally subject to ambient temperatures, shall be insulated on all exposed surfaces with a semi-rigid material cut to shape, covered with

galvanised bird-wire held with welded pins at 300 mm centres each way and hard setting cement of at least 20 mm thickness.

The minimum insulation thickness shall be the same as specified for ducting.

Air Handling Units and Enclosure

Air handling units shall be insulated with rigid material on all exposed areas, held in place by pins and washers at 450 mm centres each way, and covered with sheetmetal panels.

Air handling unit enclosures, either being in metal, concrete or brick and containing cooled or heated air, shall be insulated.

Where possible, such insulation shall be on the inside of the enclosure, suitably retained and protected.

The minimum thickness of insulation shall be as specified above, for ducts.

For such internal insulation the enclosure will act as vapour seal for cooling plant, and the fabric of said enclosure shall therefore be treated as follows :-

a) Metal enclosures: all seams, rivet holes etc. sealed.

b) Masonry enclosures: internally coated with suitable bitumen emulsion.

Cooling Coil Sumps

Sumps shall be mounted on 25 mm thick insulation having a thermal conductivity of not more than 0,04 W/m ℕC.

Alternatively, they may be internally lined with an equivalent thickness of foamed-in-situ plastic, internally moisture proofed.

Vapour Barriers

Insulation used on piping, ducting and plant, operating below ambient temperatures, shall be coated with a vapour barrier to be applied immediately after dry insulation has been fitted.

No chilled water, refrigerant, suction gas or cold air shall pass through insulated piping, ducting or equipment before vapour proofing has been applied.

Where insulation shall be removable, eg. at flanged joints, etc. the main insulation shall be stopped short of the fitting with the vapour barrier sealed to the shell. The removable portion of the insulation shall then be fitted as a separate item with its vapour barrier overlapping and sealed to the main vapour barrier. Attention shall be given that the vapour barrier and the insulation are not pierced or damaged by supports.

At discontinuities and at section ends, the vapour barrier shall be returned to the surface to prevent moisture from entering the insulation at the edges.

Where it is unavoidable to connect hangers, supports or anchors solidly to cold services, such hangers etc. shall be "feathered" with insulation, and vapour sealed, after the main insulation and vapour sealing has been applied, which later shall be carefully sealed onto the metal of the support.

At the point where the support is attached to the building fabric, insulation such as rubber or neoprene pads or bushes shall be provided to prevent invisible condensation and corrosion.

Piping vapour barrier shall be Mylar foil laminate.

10. INSTRUMENTATION

The equipment and/or sub-system supplier/assembler shall provide under the overall responsibility of the air conditioning contractor, all permanently installed instrumentation necessary for logging and monitoring of status and performance of equipment and components.

In addition, a sling psychrometer shall be provided at handover for use by the Employer.

All instruments shall be of such dimensions and mounted in position so that they are easily and accurately readable by an operator standing on the floor.

Test instruments shall be checked for accuracy by the manufacturer or by an approved laboratory with certificates being submitted prior to site tests, showing the degree of accuracy over a life of 15 years.

Temperature Indication

All thermometers and temperature reading devices (direct reading or switched) shall have an accuracy of 0,5 ºC and a range of -10 ºC to 50 ºC, unless otherwise specified, with graduation being in steps of 1 ºC.

Stem thermometers shall be approximately 150 mm long and dial type thermometers approximately 80 mm diameter.

Wells shall be set vertically or at an angle to retain oil. Pipes smaller than 80 mm 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.

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 Pa.

All differential dial pressure gauges shall have an accuracy of 2% and shall not be less than 100 mm 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.

Hygrometers

Hygrometers shall have an accuracy of 5% in the range of 10% to 100% relative humidity.

Flow Meters

Liquid flow shall be measured by means of an in-line orifice, or Venturi tube and differential pressure gauge normally calibrated in litres per second.

11. SAFETY AND AUTOMATIC CONTROL SYSTEM

a) The safety and control equipment for all sub-systems located in plantrooms and enclosures and as shown on the control schematic drawings shall be supplied by the equipment and/or sub-system supplier/assembler under the overall responsibility of the air conditioning contractor.

b) All control equipment for the various sub-systems shall be supplied by a reputable firm properly established in the Republic of South Africa which has a proven track record of at least five years and which can demonstrate the reliability of the control systems offered.

c) The control systems as indicated on the control drawings shall include all controllers and controlling devices, specified or implied, to perform specified functions.

d) The control devices with their control action, performance and safety settings shall be installed and connected to perform the functions and operate in their required sequence as detailed on the control drawings.

e) At the time of equipment submission, the contractor shall provide complete documentation for each component or assembly of components in the sub-systems.

f) The installation in its entirety shall comply with regard to electrical safety and supply interference suppression requirements, with SABS and/or local authorities by-laws, and/or Post Office regulations.

g) The equipment shall be so constructed and components installed and connected and required spares available so that the maximum breakdown interference due to component replacement will be limited to one hour.

h) All items of the installation shall be readily accessible and connected for quick and easy replacement. Adequate space shall be provided around all items for easy removal of parts.

i) Every care shall be taken to protect material, either fixed or unfixed, from damage, ingress of dust and moisture. The entire installation shall be in "as new" condition at handover.

j) Each controller and control device for all sub-systems in plantrooms and enclosures shall be provided with instruments (pressure gauges, volt meters, pilot lights, etc.), to show at the controller or control device location, the condition of the power supply to the controller and control device, and the point within its control range at which the controller or control device is operating.

k) Where indicated for individually mounted controllers or control devices, the instruments may be permanently mounted or, a portable instrument may be supplied for each 12 of such controllers or control devices, but not more than 4 such instruments will be required in one building.

l) For equipment mounted in control panels (refer Part IV Clause 12), individual permanently mounted instruments may be supplied or a single instrument may be mounted on each panel and provided with a suitable switching means to permit connecting the instrument to any controller on the panel. The panel instruments may also be arranged to connect to individually mounted equipment in lieu of portable instruments.

m) At each controller for which portable instruments are to be used, means shall be provided for attaching and disconnecting the instrument without the use of tools (other than for removal of covers) and without breaking control lines.

n) Pressure gauges for individually mounted controllers shall be stem mounted, 40 mm large in diameter, with black finished cases. Individual gauges for panel mounted controllers shall be 50mm in diameter with black or plated finish. Gauges for multiple indication or panel mounted controllers shall be 120 mm in diameter, with black or plated finish.

o) A thermometer pocket shall be installed at or near each insertion thermostat, located so that a calibrated thermometer inserted there will accurately indicate the temperature surrounding the sensing element of the thermostat.

12. CONTROL PANELS

Each sub-system, located either in plantrooms or enclosures, and as defined on the control drawings, shall be provided with their individual control panels. Sub-systems include chillers, master chiller control, cooling towers, air handling units, packaged and rooftop units, etc. but exclude room terminal equipment.

Instruments, operating and adjusting mechanisms specified in Part IV clauses 10 and 11 and as shown on the control drawings, and all controllers, relays, switches, indicators, instruments, voltmeters, ammeters, hourmeters, control push buttons, etc. connected with the sub-system shall be mounted on the panel.

All panels shall be totally enclosed, dust, damp and vermin proof. Panels shall be free standing floor mounted.

The Contractor shall note whether rear access to the board is available. In cases where no rear access is possible the panels shall be designed to enable all connection to be made and for all component parts to be accessible from the front.

All operating mechanisms, switches, etc. shall be mounted on hinged panel doors. Wiring, tubing shall be so disposed at the hinged side of the door to facilitate that opening and closing does not impose stress on wiring.

All small power and control wiring to external circuits shall be wired or tubed to numbered terminals.

Terminal blocks shall be suitable for mounting on standard channels and shall include at least 12 spare terminals for future extensions.

The channels shall be long enough to accommodate wiring and tubing for the said 12 spare terminals.

Each piece of equipment, instruments, etc. on the panel door or in the panel shall be identified by a nameplate in accordance with Part IV Clause 7 and coded as shown on the sub-system operation drawings.

Each panel shall be complete with mimic diagrams of the "sub-system schematic" and "operating sequence" as indicated on the control drawings. The mimic diagrams shall be printed on high quality, non-deteriorating boards and framed behind non-reflective clear perspex. The control drawings shall be printed on non-deteriorating plastic sepias and framed behind non-reflective clear perspex on the writing top.

13. EQUIPMENT SUBMITTAL

The contractor shall compile and submit three (3) booklets of the equipment selection and submittal to the Consulting Engineer within two weeks after appointment for approval.

The equipment submittal booklet shall consist of:

1. Cover page stating the project name, the client, the consulting engineer and the contractor with contact persons and details
2. The index page stating the contents and sections of the submittal with page numbers
3. General: a brief description of the project and the equipment offered
4. Introduction: brief history of the contractor, experience, personnel proposed for the project with brief CV and project photos where the equipment proposed was used.
5. Table of the equipment capacity of all equipment contained in the submittal showing the following:
    i. Design conditions
    ii. Equipment name and designation
    iii. Area served
    iv. Operating capacity
    v. Dimensions (length, width, height and weight)
    vi. Starting current, running current and voltage
    vii. Noise level
    viii. Compliance with specification
6. Detailed of the equipment offered (this section is to be repeated for every single item of equipment offered).
    i. General: name of equipment offered, previous project where equipment was used with reference from the client
    ii. The Equipment: all technical specifications, photos where applicable, service interval and estimated operating life in years of the equipment. The technical specifications as a minimum shall state:
        i. Capacities
        ii. Material of manufacture and type of finishes
        iii. Make
        iv. Model number
        v. Manufacturer details
        vi. Estimated delivery date
        vii. Noise levels
        viii. Operating conditions and performance curves where applicable
        ix. Compliance with specifications
        x. Electrical requirements and loading
        xi. Energy efficiency measures of the equipment offered
        xii. Any special sustainable design and details included in the equipment
        xiii. The completed schedule of information in the tender document
        xiv. Manufacturer’s catalogues
        xv. Control system and electrical schematics for the equipment
        xvi. Any other relevant information
7. Motivation for the proposed equipment

8. Conclusion
9. Approval page for signature and date:
    i. The contractors name and responsible person signature
    ii. The consulting Engineers name and responsible person signature
    iii. The client's signature and responsible person
    iv. Approval stamp by consulting engineer.

14. OPERATION & MAINTENANCE MANUAL

The contractor shall compile and submit one (1) booklet of the operation and maintenance manual to the Consulting Engineer two months prior to practical completion for approval.

On approval by the consulting Engineer, the contractor shall prepare and submit four (4) copies of the approved operation and maintenance manual on practical completion sign off in both hard cop and soft copies.

The Operation and Maintenance booklet shall consist of:

1. Cover page stating the project name, the client, the consulting engineer and the contractor with contact persons and details
2. The index page stating the contents and sections of the submittal with page numbers
3. General information on the project:
    i. Name of project
    ii. Address of project
    iii. Start and completion date
    iv. The professional team and contacts
    v. The contracting team and contacts
    vi. Emergency contact details of the contractor
    vii. Maintenance start and completion date
    viii. Major equipment suppliers and contact details
4. Description of the System
    i. Design conditions and technical specification
    ii. Salient points of the installation
    iii. Detailed description of the systems
    iv. Detailed technical specification and description of all installed equipment and system
5. Table of the equipment capacity of all equipment an system installed on the project showing the following:
    i. Equipment name and designation
    ii. Area served
    iii. Operating capacity
    iv. Dimensions (length, width, height and weight)
    v. Starting current, running current and voltage
    vi. Noise level
    vii. Compliance with specification
6. Supplier details and catalogues/technical manuals for each major equipment installed on the project
7. Operating and maintenance schedules and checklists:
    i. Weekly maintenance
    ii. Monthly
    iii. 3 monthly
    iv. Quarterly
    v. Yearly
    vi. Minor service
    vii. Major service
    viii. Every 5 years
    ix. Every 10 years
    x. Others
8. Commissioning results and details of each equipment
9. Training of end user details and attendance register sign off
10. Recommended spares

11. As built drawings and documentation
12. Equipment submittal approved page
13. Conclusion
14. Approval page for signature and date:
    i. The contractors name and responsible person signature
    ii. The consulting Engineers name and responsible person signature
    iii. The client's signature and responsible person
    iv. Approval stamp by consulting engineer.

15. TRAINING

On completion of the entire contract work, the contractor shall conduct a detailed training on the installation works for the end user/client representatives in respect of the operations, maintenance and all other requirements to maintain a fully functional service to the client.

For the training to commence, the contractor shall compile and submit two (2) copies of the detailed training manual to the Consulting Engineer within three months prior to practical completion for approval by the Engineer and the end user client. The submission will include the agenda for the training, the requirements and qualifications for the training and the duration.

From the consulting engineer, the contractor shall allow a minimum period of two weeks to train the end user in the proper functionality of the system. The training shall consist of both formal class room training and hands on training on the completed project.

The training manual booklet shall consist of:

1. Cover page stating the project name, the client, the consulting engineer and the contractor with contact persons and details
2. The index page stating the contents and sections of the training manual with page numbers
3. General: a brief description of the project and the equipment offered stating the start date and expected completion date
4. Introduction: brief system description of the project, salient training issues and brief of the maintenance checklist
5. Table of the equipment capacity of all equipment installed showing the following:
    i. Design conditions
    ii. Equipment name and designation
    iii. Area served
    iv. Operating capacity
    v. Dimensions (length, width, height and weight)
    vi. Starting current, running current and voltage
    vii. Noise level
    viii. Compliance with specification
6. Detailed training on the equipment offered (this section is to be repeated for every single item and systems installed on the project). The training will include but not limited to:
    i. General: name and description of the system(s)
    ii. Operating conditions and technical specifications including materials of manufacture
    iii. Operating life and operational sequence
    iv. Trouble shooting details
    v. Maintenance checklist
    vi. Spare parts for the system and equipment
    vii. Drawings of the system and equipment
    viii. Commissioning details of the equipment
    ix. Manufacturer's requirements for training and maintenance
    x. Any other relevant information i.e. frequency of training and retraining of end user

7. Training attendance register and certificate of attendance
8. Conclusion
9. Approval page for signature and date:
    i. The contractors name and responsible person signature
    ii. The consulting Engineers name and responsible person signature
    i. The client's signature and responsible person
    ii. Approval stamp by consulting engineer.

16. OPERATING AND MAINTENANCE MANUALS

The contractor shall supply four (4) comprehensively indexed Operating and Maintenance Manuals, bound in loose leaf plastic covers, including as built@ drawings. In additional provide 2 set of manuals and drawings in electronic format

The Operations and Maintenance Manual must describe how the facility will be operated and by whom, as well as the desired level of training and orientation required for the building occupants to understand and use the building systems.

Full testing and commissioning procedures for individual equipment and for the entire systems shall be submitted.

The manuals shall generally be arranged in two parts in accordance with of the ASHRAE HVAC APPLICATIONS HANDBOOK: DOCUMENTATION, or equal.

17. TEMPORARY USE OF EQUIPMENT

No equipment which is part of the permanent installation shall be operated or used, during the course of construction without the written permission of the Architect.

18. TESTING, BALANCING AND COMMISSIONING

Comprehensive pre-commissioning, commissioning as well as quality monitoring shall be done on all the mechanical systems in a systematic manner and in exact accordance with CIBSE Commissioning Codes, as follows:

- CIBSE Code A – Air Distribution;
- CIBSE Code B – Boilers (if applicable)
- CIBSE Code C – Automatic Controls;
- CIBSE Code M – Management;
- CIBSE Code R – Refrigerant Systems (Heat Pumps); and
- CIBSE Code W – Water Distribution

The Commissioning Records must:

- Demonstrate that the services were commissioned in compliance with CIBSE Commissioning Codes for all services;
- Include commissioning dates, records of all functional/commissioning testing undertaken, a list of any future seasonal testing, and a written list of outstanding commissioning issues; and
- Include the outcomes and changes made to the building as a result of the commissioning process, accounting for all of the recommendations;
- Reference appended extracts of commissioning records.

The Mechanical contractor will be required to include:

- Definitive commissioning specifications;
- Requirements for witnessing including full details of tolerances applicable to all parameters;
- A commissioning program, including time for witnessing;
- Health and Safety risk assessment and method statements for the tasks to be completed;
- Commissioning method statements for each system;
- Pre-commissioning checklists for each system;
- Commissioning checklists; and.
- Commissioning certification for each system countersigned by the Engineer and accepting authority including the record sheets provided in each CIBSE code.

Training:

After completion of the contract, the contractor shall be required to provide system knowledge to the building owner/manager by submitting the following documentation:

- Design intent report;
- As-built drawings;
- Operational and Maintenance Manuals;
- Commissioning Records; and
- Commissioning Reports for each system;

In addition, the contractor shall provide training on all the systems to the building owners' building management staff. Training provided must include:

- Information provided in the Design Intent Report (including energy/environmental features);
- Review of controls set up, programming, alarms and troubleshooting;
- Review of O&M manuals;
- Building Operation (start up, normal operation, unoccupied operation, seasonal changeover, shutdown);
- Measures that can be taken to optimize energy efficiency;
- Occupational Health and Safety (OH&S) issues;
- Maintenance requirements and sourcing replacements; and
- Obtaining and addressing occupant satisfaction feedback.

TOLERANCES

The indoor climate factors and air flow rates, heating, cooling and humidifying performances, electrical characteristics and other design data shall be measured at the ventilation system design air flow rate.

Tolerances of the measured values in respect of the selection of the measuring equipment are given in the following table:

PARAMETER	UNCERTAINTY*
Air flow rate, each individual diffuser	± 10%
Air flow rate, each system	-5% +10%
Smoke extract	0 to +20%
Supply air temperature	± 2°C
Relative Humidity [RH]	± 15% RH
Air velocity in occupied zone	± 0,05 m/s
Air temperature in occupied zone	± 1,5°C

	A-weighted sound pressure level in the room	± 3 Dba
	* The uncertainties include the permitted deviations from the design values as well as any measuring error.	

If the performance of the system requires closer uncertainties, this shall be specially defined in the documentation of the system. If product standards, national or local regulations require closer uncertainties, this shall be adhered to. Refer to control diagrams for additional tolerances.

19. QUALITY MANAGEMENT SYSTEMS

The contractor shall ensure that an approved and appropriate quality management system is implemented for the manufacture of equipment and site installation of the systems.

20. INTERNAL NOISE LEVELS

The project is targeting Internal Noise Levels to maintain sound levels below 40dB(A)eq (assuming open plan office) in accordance with SANS 10103:2004 for a minimum of 95% of the Usable Area.

It is the Contractor's responsibility to undertake noise testing for the Usable Area. The Commissioning report shall detail the methodology in which the testing has been carried out and the noise levels achieved within the space.

21. VOLATILE ORGANIC COMPOUNDS

The project is targeting the minimisation of Volatile Organic Compounds (VOC) associated with paints, adhesives and sealants, carpets and flooring.

The Contractor shall select and install materials which comply with the TVOC Content limits specified below. The Contractor is required to submit VOC data sheets for each material type used including the details of the type and quantity of each product with receipt confirmation from the supplier.

Compliance with the TVOC limits is to be determined by:

Providing a manufacturer-supplied datasheet that documents the theoretical calculation method to determine TVOC levels of each specified product (exempt compounds are not to be subtracted from the TVOC content); Or

The datasheets must come from an ISO/IES 17025 registered laboratory quoting the TVOC level of each specified product.

The Contractor is required to obtain approval from the design team or client before substituting the finishes listed. At the end of the construction works, the contractor is to undertake a final audit to ensure that correct products have been used.

22. Paints

Any paint used in an internal application, and applied on site, must meet the TVOC Content Limits outlined in the table below. This includes exterior-grade and solvent based paints should they happen to be used in interior application. Values should reflect the final product as mixed and ready to use, inclusive of tints. Exterior applications and internal car parks are excluded from these requirements.

The calculation for paints is to be based on the whole paint by grams of VOC per litre. The values should reflect the final product as mixed and ready to use inclusive of all additives, tints or the like.

Where the TVOC content of individual components is unknown it is to be determined experimentally using one of the following methods:

- ISO Method 17895 (2005) for a material with presumed VOC content <1%;
- ISO Method 11890 (2006) for a material with presumed VOC content <15%;
- ISO Method 11890-1 (2007) for a material with presumed VOC content >15%; Or
- ASTM D3960.

Table 1: Maximum TVOC Content Limits for Paints, Varnishes and Protective Coatings

PRODUCT TYPE / SUB-CATEGORY	MAX TVOC CONTENT (G/L OF READY TO USE PRODUCT)
Walls and ceiling – interior semi gloss	16
Walls and ceilings – interior low sheen	16
Walls and ceilings – interior flat washable	16
Ceilings – interior flat	14
Trim – gloss, semi gloss, satin, varnishes and wood stains (Application examples: Timber varnishes, timber paints, mild steel, galvanized metal, all metal types)	75
Timber and binding primers	30
Latex primer for galvanised iron and zincalume (Application examples: Mild steel, galvanised iron)	60
Interior latex undercoat	65
Interior sealer	65
One and two pack performance coatings for floors	140
Any solvent-based coatings whose purpose is not covered in table Ieq-13.1 in the GSSA Office V1 Technical Manual	200

23. REFRIGERANT / GASEOUS ODP

All HVAC and refrigeration equipment shall have refrigerants with Ozone Depletion Potential (ODP) of zero.

The contractor shall provide supporting documentation (e.g. manufacturer data sheets, receipts and suppliers' confirmation) detailing:

- Type of equipment;
- The quantity of equipment supplied to the project;
- The type/s of refrigerants used in the equipment and the quantity of refrigerant/s (in mass).

24. ENVIRONMENTAL

The contractor shall take the necessary care to avoid the release of Refrigerant gas into the atmosphere. In the instance of the gas having to be drained, the contractor shall obtain the services of a gas-recovery company who specializes in the removal, storage and re-use of refrigerants.

Any refrigerant must have an ODP of zero.

Any paint/solvent based coatings, which are internally exposed in the building and applied on site, must have a VOC content of less than 200g/l.

25. INSULANT ODP

All thermal insulation for pipes and ducts shall have no ozone-depleting substances (zero-ODP) associated with either the manufacture or composition of the product. Fibre-based woven insulation products (e.g. glass fibre, mineral wool, polyester etc.) and foil insulation which are not manufactured by using blowing agents may be used.

It is the Contractor's responsibility to maintain and submit the following documentation:

- Summary of types and application of all thermal insulants installed on site with supporting confirmation from the supplier;
- Manufacturer's Data Sheets for all insulants installed on site. The MDS is to clearly confirm that the thermal insulants are free of ozone-depleting substances in both the manufacture and composition.

PART V – DETAILED SPECIFICATION

PART V.A.

SCOPE OF THE WORK

1. **GENERAL**

The contract works to be carried-out consists of the engineering, supply, erection, testing, commissioning into service, guarantee and maintenance of an air conditioning and ventilation installation as described herein.

The engineering and quality control equipment selection, shop drawings, testing, balancing, commissioning and preparation of operating, and maintenance manuals, and inspections are to be executed in a systematic manner, once programmed, under the Engineer's general supervision and direction. The preparation and submission for approval by the Engineer for:-

a) Equipment Selection
b) Shop Drawings
c) Testing, Balancing and Commissioning Documentation
d) Operating and Maintenance Manuals
e) Inspection Record Cards/Checklists

shall be in accordance with the project manager procedures defined by the Engineer.

The Contractor shall familiarize himself with these project management procedures and submit the detailed cost breakdown on his engineering and management as listed.

2. **SPECIFICATION AND DRAWINGS**

Engineer's Drawings and Specification

The drawings prepared by the Engineer show general layout of all equipment and distribution systems, complete with schematic arrangements. These, together with the specification, give sufficient information to enable the Contractor to estimate the cost and to determine how the system must be installed, tested, balanced, inspected, operated, serviced and maintained.

These drawings are not dimensioned installation drawings, and cannot be used as construction/shop drawings. Location dimensions shown are only indicative of the routes and zones in which the service must be installed.

2.1 **Installation Drawings**

2.2.1 **Structural Drawings**

The Contractor shall supply to the Engineer marked-up structural drawings or other drawings showing any changes or additional requirements to be made in the structure in order to fit apparatus and materials to be installed by him. However, it will be the Contractor's responsibility to ensure that sufficient installation clearance is provided for positioning the selected equipment into the building space provided.

2.2.2 **Shop Drawings**

Copies of shop drawings of all parts of the contract works shall be submitted to the Engineer for approval. These drawings shall indicate all equipment, distribution systems, testing/inspection/instrumentation positions, access requirements and builder's work requirements.

Drawings shall be produced in Autodesk Revit 2015 or later format and the contractor shall be able to receive and transmit drawings electronically.

Builder's work requirements shall include all work by others (holes in concrete, frames, masonry holes, bases, etc.) as well as the sizes, capacities and positions of service connections.

The Contractor may, if he so desires, purchase Revit electronic drawings of the Engineer's drawings for modification and updating if required. These drawings shall be re-titled in accordance with the Contractor's system and shall thereafter be submitted as the Contractor's shop drawings. No portion of the Contractor's work shall be commenced until the shop drawing has been approved by the Engineer.

"As Built" drawings on plastic foil shall be furnished on completion. These shall comprise the shop drawings as specified above, embodying all modifications made during construction, and further system diagrams indicating the intended functioning, capacity data and control functioning of all systems, as well as an electronic copy of the "As Built" Revit model. (The works shall not be certified as complete unless these drawings and the specified Operating and Maintenance Manuals have been submitted.)

2.2 **Submission**

Submission for approval will consist of the following activities executed by the Contractor and other parties involved:-

The Contractor shall review, stamp, date and sign to signify his approval and submit in the manner required by the Consulting Engineer and with reasonable promptness and in orderly sequence so as to cause no delay in the work, all contractor's drawings and samples required by the Contract documents or subsequently by the Architect. Contractor's drawings and samples shall be properly identified as specified or as the Architect may require.

At the time of submission the Contractor shall inform the Architect in writing of any deviation in the Contractor's drawings or samples from the requirements of the contract documents.

The drawings shall be submitted in a number of copies and along the channels directed by the Architect for approval.

By submitting drawings and samples, the Contractor represents that he has determined and verified all site measurements, site instruction criteria, materials, catalogue numbers and similar data, or will do so, and that he has checked and co-ordinated with the other Contractor's drawings with the requirements of the works.

The Architect will review and approve construction drawings and samples with reasonable promptness so as to cause no delay, but only for conformance with the design concept of

the contract works and with the information given in the contract documents. The Architect's approval of a separate item shall not indicate approval of an assembly in which the item functions.

The Contractor shall make any corrections required by the Architect and shall re-submit the required number of corrected copies of Contractor's drawings or new samples until approved. The Contractor shall direct specified attention in writing on re-submitted drawings to revisions other than the corrections required by the Architect on previous submissions.

No portion of the contract works requiring a Contractor's drawing or sample submission shall be commenced until the submission has been approved by the Architect.

2.3 **Samples**

Samples are any samples required by the Architect or the Engineer. Samples shall be physical examples to illustrate materials, equipment or workmanship, and to establish standards by which the works may be judged. Such samples, after approval, will be retained by the Architect or Engineer for a period sufficient to ascertain that the relevant component is actually provided as per such sample, but will then be returned to the Contractor for incorporation in the works.

3. PROGRAMMING

The Contractor shall submit within accordance to the contract, a practicable work programme in reproducible from. The programme shall be updated and controlled in accordance with these clauses.

The section of the programme covering submission of equipment selection and installation drawings, preparation of Operating & Maintenance Manuals, Testing, Balancing and Commissioning shall be presented in the form of a network analysis in accordance with procedures generally referred to as Programme Evaluation Review Technique (PERT) or Critical Path Method (CPM).

Meetings shall be arranged and attended in accordance with the contract Preliminaries.

4. CONTRACT MANAGEMENT

All activities, information required, approvals, etc. shall be managed by the Contractor's officially appointed Project Manager to ensure completion of the contract at specified completion date and specified quality.

- It shall be the duty and responsibility of this Project Manager to identify any item such as delays, activity time overrun, late information and/or approval at least fortnightly, and describe in his standard report proposed action to overcome the adverse conditions to maintain the planned construction schedule.

- It shall be the duty and responsibility of this Project Manager to prepare a detailed tabulated construction activities breakdown with related earliest and latest dates for information required, approval, area availability and inspection.

Construction activities are:

a) Equipment Selection and Submission
b) Construction Drawings
c) Off site Manufacturing
d) Installation on Site
e) Testing of completed work

- The Project Manager shall monthly, throughout the progress of the contract, amend and update the "tabular list of activities" to ensure that the completion date will be met. He shall particularly note and report on unusual conditions encountered which may (or have) delayed progress of the work related to the contractor's programme.
- The Project Manager shall report in writing only and shall personally sign not only each progress report, but also equipment submissions, drawings and inspection checklists and reports.
- The Project Manager shall be capable of using network diagrams to explain the sequence and actual dates used by him in his tabular form monthly report in order to prove that "cut-off" dates are realistic and factual and not an attempt to formulate claims for delays.
- On the request of the Engineer/Architect and/or Principal Contractor, the contractor shall remove from the works a person acting as Project Manager who only records deviations from the original programme, reports mainly verbally and does not propose remedial action in writing, and replace him with a Project Manager who executes the defined duties and responsibilities in a systematic, diligent manner.

5. ORGANISATION AND STAFF OF CONTRACTOR

In addition to the site Supervisor/Foreman, the Contractor shall employ as many responsible and experienced engineers, programmers and administrators as may be necessary for the purpose for the contract to ensure:-

- Selection and/or engineering or equipment and components into working assemblies all in conformance with the design concept contained herein.
- Equipment and shop drawings submission for approval in accordance with the required procedure.
- Attendance on meetings.
- Conducting of all tests required.
- Expediting of the work.

6. ONE YEAR'S MAINTENANCE AND GUARANTEE

The Contractor shall perform all maintenance on the entire contract works for a period of twelve months after handover. Maintenance shall include systematic examination and adjustment of equipment at least once a month or in accordance with the manufacturers recommendations.

The Contractor shall in the course of such maintenance, or on call during the maintenance period, repair or replace defective parts if required, and shall use only genuine standard parts produced by the manufacturer of the original part.

The Contractor shall respond within 24 hours after receipt of a call-out.

The Contractor shall supply all spare parts, lubricants, refrigerant, chemicals, filters, fuses, etc. during the free maintenance period. Renewals or repairs resulting from misuse by somebody other than the Contractor, however, shall not be made at the expense of the Contractor.

This guarantee shall be in addition to the employers common law rights.

7. GUARANTEE

The Air Conditioning Contractor shall guarantee that the air conditioning and associated systems will be installed and adjusted in such a manner that it will, subject to the capacity limits specified in Part V.D. maintain the dry bulb temperature and humidity levels specified in Part V.C. during operating hours.

Noise levels in rooms caused by the operation of the air conditioning and associated systems, whether generated within the rooms through duct walls or floors, etc. shall not exceed the values given in Part V.C., at any point within the room.

8. TESTING, BALANCING, COMMISSIONING, OPERATING OF PLANT AND BALANCING

Submit full testing, balancing and commissioning procedures for individual equipment and for the entire air conditioning and ventilation systems.

Include the following:-

a) Checking of all safety features of equipment by simulation of overload and abnormal conditions.
b) Setting of protective devices to stop operation of equipment at overload or abnormal conditions.
c) Checking of performance of equipment and systems by simulation through the range of maximum to minimum operating conditions.
d) Method of adjustments to correlate operating point with chosen point of application on the performance curves of equipment.

After physical completion has been reported and all defects made good, "start-up" shall take place and the above check-out procedures shall be carried-out.

Prior to the carrying-out of acceptance tests as defined in Clause 6 of Part IV, the Contractor shall operate the entire system for as long a period as may be required to provide satisfactory performance at all times in the occupied spaces served by that system for up to 24 hours a day continuously.

The Contractor shall provide all labour, supervision and equipment required for testing and operating the plant. "The Employer" may assign operating personnel as observers, but such observation time shall not be counted as instruction time.

The Contractor's operator(s) shall be fully conversant with the operation and experienced in running similar installations. The Contractor shall train the Employer's operator(s) to enable them to be responsible for and capable of operating the plant.

Logging of the plant operation shall commence once plant has been commissioned and the Contractor shall continue logging until the acceptance tests have been carried-out and the plant handed-over.

The Contractor shall also log, as part of his commissioning, outside air, supply air and room temperatures. These shall be recorded by continuous temperature recorders measuring the various temperatures simultaneously. Temperature recordings shall be taken over a minimum period of fourteen days at various positions designated by the Engineer.

All tests shall be recorded in a field test report for insertion in the operating and maintenance manual. Values of operating pressure, temperature and amps shall be marked on gauges and instruments as appropriate.

TOLERANCES

The indoor climate factors and air flow rates, heating, cooling and humidifying performances, electrical characteristics and other design data shall be measured at the ventilation system design air flow rate.

Tolerances of the measured values in respect of the selection of the measuring equipment are given in the following table:

PARAMETER	UNCERTAINTY*
Air flow rate, each individual room	± 10%
Air flow rate, each system	± 10%
Smoke extract	- 10%
Supply air temperature	22.5°C ± 1.5°C
Relative Humidity [RH]	50 ± 15% RH
Air velocity in occupied zone	0.5m/s ± 0,05 m/s
Air temperature in occupied zone	22.5°C ± 1,5°C
* The uncertainties include the permitted deviations from the design values as well as any measuring error.	

If the performance of the system requires closer uncertainties, this shall be specially defined in the documentation of the system. If product standards, national or local regulations require closer uncertainties, this shall be adhered to. Refer to control diagrams for additional tolerances.

9. COMPLETION OF CONTRACTOR WORK

Completion of the works will occur after the following procedure has been certified by the Architect as having been carried-out in accordance with the specification: -

a) Physical completion has been reported to the Architect by the Contractor, and all defects made good and the Architect has given approval for "start-up".
b) "Start-up" has taken place.
c) Commissioning and testing have taken place as specified and witnessed (where required), recorded and approved by the Architect.
d) One set of “as built" drawings, on computer discs have been furnished to the Architect, these shall comprise the "Shop Drawings" as specified in Clause 2.2.2 above, embodying all modifications made during construction, and further system diagrams indicating the intended functioning, capacity data and control functioning of all systems. For these latter drawings, the Contractor may, if he so desired, obtain plastic negatives of the Engineer's System diagrams for updating if required.
e) The specified five copies of indexed loose-leaf manuals containing complete Operating and Maintenance Instructions have been furnished to the Engineer for all mechanical and electrical systems, equipment and controls, and for all other equipment or systems specified under this contract. The Operating and Maintenance Manuals shall be set out as described in Part IV.

PART V.B.

DIVISION OF WORK SCHEDULES

The following related work to the air conditioning and ventilation (HVAC) contract will be provided by others. The HVAC contractor shall be responsible for the detailing, checking and ensuring that the work as listed in the schedules and shown in principle on the drawings is provided as per his detailed builder's work and related services drawings.

Instructions for the HVAC contractor's exact requirements shall be transmitted to the principal contractor and other contractors timeously in the form of builder's and associated services drawings in accordance with an agreed programme. Should these instructions be issued after the completion of relevant areas, then this work will be carried-out at the expense of the HVAC contractor.

- **HVAC Contractor**

  Plant rooms

  Holes in core as per Structural and Architectural drawings.

  Unframed holes through wall (above ceiling) for every shaft to be bricked up or sealed after ducting installation.

  Brick walls or fireproof partitioning around air conditioning plant rooms, and toilet ventilation shaft after completion of ducting installation.

  Concrete plinths.

  External weather louvers.

  Screen wall around the plant room and a roof over the pumps and switchboard.

  Hoisting of equipment, such as ducting, piping, pumps, fans, chillers and air handling units.

  Black steel sleeve supplied by HVAC contractor and to be built in the wall by the contractor at every branch duct from the riser.

- **Plumbing Contractor**

  Condensate drain points in all plant rooms.

  Make-up water points for the chilled water system expansion tanks in the roof plant.

- **Electrical Contractor**

  The following related work to the air conditioning and ventilation contract will be provided by the electrical contractor:

  Power supply (3 Phase, Earth and Neutral) to the live side of the isolator of the distribution board on the roof.

  Fire interlock to potential free contact on relays in all the air conditioning distribution boards.

  Power supply and isolator (3 Phase, Earth and Neutral) with high temperature wiring to the basement ventilation fan high temperature control panels

  Power supply to and including isolators to the fan coil units on the floors will be provided fixed to the nearest cable basket

- **Fire Contractor**

  The following related work to the air conditioning and ventilation contract will be provided by the fire contractor:

  Fire signal to be provided to each panel by the Fire Contractor to be terminated by the HVAC contractor to be interlocked with all Air Handling Units and Fans (smoke/ stair case pressurization, etc).

- **Builders Work**

  The following will inter alia be required as detailed in drawings:

  - Making fire safe of any penetrations exposed to connect outdoor and indoor units with refrigerant piping.

PART V.C.

DESCRIPTION OF THE SYSTEM, DESIGN CRITERIA AND DRAWING INDEX

Contractor is to price “Rates only” BOQ and specifications associated with this document. Contractor is also to price the CLM Data Centre Tender, the SMH Data Centre Tender, the Origin Centre Tender & the Health Sciences Tender. All of these tenders are separate documents. All the tendered prices from these documents are to be added to the tender summary in VI.A1.

Design Criteria and Comfort Levels

The following design criteria apply:

- **Outside Design Conditions**

  The design is based on CSIR report 300 “Climatic and Other Design Data for Evaluating Heating and Cooling requirements in Buildings”.

Probability Level	%	:	5
Summer Outside	ºC db	:	31
	ºC wb	:	20
Winter outside	ºC db	:	2

- **Internal Design Conditions**

Summer dry bulb	:	22.5±1.5°C
Summer humidity	:	Uncontrolled but expect 30-60% RH
Winter dry bulb	:	21±1.5°C
Winter humidity	:	Uncontrolled but expect 20-50% RH

MAINTENANCE AND GUARANTEE: -

The entire HVAC installation and all relevant HVAC equipment need to be guaranteed and serviced for 12 months from handover, not from when the HVAC equipment is set into work and commissioned. The service intervals need to be monthly or as per the manufacturer's recommendations if less than monthly.

Further to the above, the HVAC contractor should allow for a suitably qualified service team with technicians that have undergone the necessary equipment specific training for all relevant equipment, the service team needs to be full-time on site for the duration of the 12-month service and guarantee period.

The contractor should allow for a complete set of new filters to be installed in the week prior to the mall opening, as well as temporary disposable filter media during BO periods.

SUPPLIER TECHNICAL, COMMISSIONING SUPPORT AND TRAINING: -

The equipment suppliers of all major equipment such as fans need to provide full commissioning support and training to the HVAC contractors' technicians and service team

All suppliers need to provide full commissioning support for all major HVAC equipment.

OPERATING AND MAINTENANCE MANUALS: -

The tenderer should allow the office to have their own set of Operating and Maintenance Manuals complete with As-Built drawings and Commissioning Data. 5-off copies need to be provided in both hard copies and soft/electronic format on Beneficial Occupation.

GENERAL: -

The contractor must allow for the following: -

- Labelling to ALL HVAC Equipment
- All frames, supports and brackets external of the building to be hot dipped galvanized
- All fans to be placed on Tico Pads
- The contractor should allow for rigging of all HVAC equipment into the plant room as and when required by the construction programme.

V.D1 EC FAN

1. Supply and install as shown on drawings the EC Circular Duct fans handling the specified air quantities as listed in the schedule.

2. The fan shall be a fully catalogued product and the documentation shall include sound power level spectrums, performance curves and/or tables for the expected range of operational conditions.

3. The fan motor should be an Electronically Commutated (EC) motor.

4. Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.

5. The contractor shall submit at time of equipment submission-

    a) Detailed system resistance calculation for minimum/maximum pressure drops.

    b) Certified detailed selection shown on performance curves and/or tables for the specified conditions.

    c) The service and maintenance instructions.

    d) The estimated total expenditure on replacement of parts during the service life.

    e) Installation, testing, balancing and commissioning instructions and trouble analysis guide.

6. The fan should be 100% speed controllable. Fan selection shall be in the stable part of the curve.

7. The fan shall be engineered and components selected when operated under normal building conditions with optimum servicing and maintenance for a minimum service life of 10 years with 6,000 operating hours per annum.

8. The Engineer reserves the right to call for

    a) Test certificates and reports from the manufacturer's quality control laboratory or independent test laboratory such as SANS, and/or

    b) Site inspections, customer reports/references and user's interviews, and/or

    c) Full engineering, design and component selection details

    to check the correctness of the claimed service life.

9. Fan installation shall comply with local authority by-laws and with Occupational Health and Safety Act of 1993, as amended.

10. Fan shall be complete with wire guard(s) if accessible from either side.

11. Fan shall be installed in accordance with manufacturer's recommendations and shall be maintained in "as new" condition at start-up of installation.

12. Fan and motor shall be weatherproof and shall be protected from wind, rain and insects.

13. Fan shall be quiet in operation and shall be statically and dynamically balanced at the factory.

14. Bearings shall be of the permanently lubricated type.

15. Mounting plates shall not distort under any operating conditions.

16. Fan shall be supplied c/w 7-day programmable timer switch

17. Fan shall be mounted on vibration isolating mounting.

18. Power source to motors shall be through flexible conduit.

19. Fan schedule is located on the drawings.

20. Potentiometer included for ease of commissioning.

21. Mounting brackets should be included.

22. The casing should be manufactured from sheet metal.

23. The terminal box should be IP55 rated.

24. Motor protection should be integrated into the electronics of the motor.

25. Motor conduit box shall be mounted on exterior of fan casing. Lead wires from motor to conduit box shall be protected from the air stream.

26. Silent type fans should have a silencer casing manufactured from Expanded Polypropylene (EEP) or equivalent sound dampening material.

V.D1.06- AIR COOLED SCROLL WATER CHILLER (DUAL SYSTEM)

1. Supply kerb side as listed in the schedule the scroll type air cooled water chiller. The Chiller shall be complete with compressor(s), heat exchanger(s), condenser(s), fan(s), on board primary pumps, controls, refrigerant, and lubrication, including full commissioning and 12 months warranty and

maintenance.

2. Chillers shall be manufactured by: Carrier, Trane, York or CIAT or approved equal (approved before tender submission)

3. The unit shall have capacity control to vary its capacity in response to varying load conditions.

4. The water chiller shall be a standard catalogued product of a reputable manufacturer. The documentation shall include performance curves and selection tables for the expected range of operational conditions.

5. Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.

6. Performance data to be provided at 10% intervals from 10% to 100%.

7. Certified detailed selection shown on these performance curves and tables shall be submitted, including: -

   a) The specified duty.
   b) A 10% overload.
   c) Part unloaded conditions at 35°C and varying ambient conditions.

8. Submit the possible percentage variation of data measured on site with the supplied and/or installed instrumentation compared to the catalogued performance data.

9. The water chiller shall be fully protected and shall be fail-safe. Minimum safety protection shall be provided for the following possible external abnormal and overload conditions: -

7.1 No or reduced chilled water flow.

7.2 Low chilled water temperature.

7.3 High discharge pressure.

7.4 Low suction pressure.

7.5 Low oil differential pressure.

7.6 Voltage drop, phase reversal and power interruption.

7.7 Combined thermal overload and phase failure.

10. Submit checklists of overload and abnormal conditions which will be checked as part of the testing, balancing and commissioning.

11. Submit details of all safety protection devices, including method of setting, marking and recording of the devices to prevent damage to the apparatus under continuous overload and abnormal conditions.

12. Systems in which lubricating oil comes in contact with the refrigerant shall be provided with oil heaters to inhibit refrigerant absorption. The heater circuit shall remain energised when compressor stops.

13. Each compressor shall have proportional capacity control to vary its capacity in

response to varying load conditions from 100% to at least 25% and shall maintain constant leaving chilled water temperature. Dual compressor circuits with two independent refrigeration and electrical circuits shall be provided.

14. The unit shall comply with ARI 550-98

15. The water chiller shall be so constructed and installed, and sufficient spares shall be available to limit the maximum breakdown time to 3 days.

16. Special care shall be taken in transport, delivery, storage on site, and installation to ensure

17. Heat exchangers shall comply with the relevant BS, ASME or DIN standard and shall by hydraulically tested to a pressure of 1000 kPa or 1,5 x maximum working pressure, whichever is greater.

18. Refrigerant shall be non-toxic, non-flammable, odourless and have an Ozone Depletion Potential (ODP) of zero. On completion of the project, the supplier of the equipment shall confirm the type and total volume of refrigerant used in the equipment.

19. The water chiller shall be installed in accordance with manufacturer's instructions.

20. The contractor shall familiarise himself with the proposed location of the water chiller and shall be responsible for ensuring that sufficient access and structural support is available on site to allow the machine to be brought into position and shall ensure sufficient space for air flow is available.

21. The piping system shall be adequately supported so that no strain is imposed on the water chiller.

22. The required unobstructed space shall be left around the installation for maintenance and service of the equipment in accordance with the manufacturer's instructions.

23. The evaporator shell exposed refrigerant circuit piping and auxiliary water piping must be insulated. All thermal insulation used on the project shall have no ozone-depleting substances associated with either the manufacture or composition of the product. Fibre-based woven insulation products (e.g., glass fibre, mineral wool, polyester etc.) and foil insulation are not manufactured using blowing agents and may be used.

    The supplier(s) of equipment shall confirm in writing that all insulants used are free of ozone depleting substances in both manufacture and composition. The supplier(s) shall identify the types and the properties of the insulants used and provide Manufacturers' Data Sheets confirming these.

24. Level adjusting spring isolator shall be used between unit and floor.

25. A control centre shall be provided for each chiller and may be mounted on or adjacent to it and shall not be subject to vibration.

26. The control centre shall contain the control and protection devices and the pressure gauges for: -

a) High discharge pressure.
b) Low suction pressure.

27. All electrical wiring shall be brought to a numbered terminal strip within the panel.

28. The water chiller shall have clearly marked oil sight glass indicating the 'normal' operating level and a sight glass moisture indicator.

29. Piping connection shall be by means of flanged bends to provide access to the tubes without dismantling the piping system. Air vent and drain cocks shall be provided.

30. The water chiller components and particularly the compressor shall be readily accessible for maintenance without major dismantling of other items of equipment.

31. The water chiller shall be of the scroll type complete with accessible semi hermetic liquid refrigerant cooled motor(s), compressor(s), condenser, evaporator, control panel, base frame and items necessary to complete the refrigeration cycle. The chiller shall be shell in tube (copper tubing with steel shell). Condenser coils shall be aluminium fins and copper tubing.

32. Water velocities shall not exceed 2,7 m/s in any part of the water circuit under any operating condition.

33. Minimum evaporator temperature shall not be lower than 1ºC.

34. The unit shall have a baked enamel finish and shall be suitably finished for outside installation and shall be fully weather protected.

35. Fan(s) shall be statically and dynamically balanced and factory tested with the fan installed in the casing.

36. The chiller components shall be so selected that noise generated through the operation of the chiller when measured at the site boundary shall be in accordance with the National Building Regulations.

37. The HVAC contractor shall be responsible for all cranage, rigging and hoisting from kerbside to final location on concrete plinth as per approved shop drawing

38. The chiller shall be fitted with hail-guards.

39. The maintenance shall incorporate the following: -

- Testing of the oil quality on a six-month interval
- Replacing of the oil filters on a six-month interval if necessary
- Replacing of the oil on a twelve-monthly interval (mandatory)
- Recording of all operating parameters and comparing it with the start-up parameters
- Rectification of conditions that are outside the specified ranges.

40. The chillers must come complete with a BACNET compatible controller that controls/monitors the following points:

- Control Chiller Start/Stop Function
- Indicate Chiller General Alarm/Fault Status

- Monitoring of Chiller Inlet and Outlet Temperatures
- Monitoring Status of Chiller water flow
- Control of Chiller set-point
- Monitoring of chiller running amps.

V.D3.01 - PUMP SETS

1. Supply and install as shown on drawings and as listed in the schedule, centrifugal pump sets of the base mounted direct coupled type with the specified duty.

2. Pumps shall be current catalogued products and documentation shall include performance curves or selection table for the expected range of operational conditions.

3. Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.

4. The flow rate at break-off point of the curve for the impeller selected shall be at least 1,5 times the specified flow rate.

5. The head at zero delivery of the curve for the impeller selected shall be at least 1,2 times the operating head.

6. The efficiency of the pump shall not be less than 70% but not more than 3% below the peak of the efficiency curve for the impeller furnished.

7. At the time of equipment submission, submit the following

   a) Certified details selection shown on performance curves or tables.
   b) Operating, testing, balancing and commissioning instructions.
   c) Trouble analysis guide.
   d) Detailed pressure drops and net positive suction head calculations for the system by one or more circulating pumps.
   e) Full details of periodic and annual maintenance and service to be undertaken by the building maintenance staff in accordance with a preventive maintenance programme.
   f) The service and maintenance instruction.
   g) The estimated total expenditure on replacement of parts during the service life.

8. The pump set shall be engineered, and components selected when operated under normal building conditions with optimum servicing and maintenance, for a minimum service life for 15 years with 3000 operating hours per annum.

9. The Engineer reserves the right to call for:

   a) Test certificates and reports from the manufacturer's quality control laboratory or independent test laboratory such as SABS, and/or
   b) Site inspections, customer reports/references and user's interviews, and/or
   c) Full engineering, design and component selection details to check correctness of the claimed service life.

10. Pump installation shall comply with local authority by-laws and with the Occupational Health and Safety Act of 1993, as amended.

11. Pump set shall be installed in accordance with manufacturer's instructions and maintained

in "as new" condition at start-up.

12. Pump set shall be installed on a common vibration isolated steel and concrete base and levelled.

13. Pump and electric motor shall be aligned to within 0,05mm, both radially and directionally to avoid vibration and pumps shall be statically, dynamically and hydraulically balanced within the design operating range.

14. The required unobstructed space shall be left around the installation for maintenance and service of the equipment in accordance with the manufacturer's instructions.

15. Pump set shall be designed and selected for quiet operation with a maximum permissible pump/motor speed of 1440 rpm.

16. Water shall not be spilt over the plantroom floor; condensate and gland leakage shall be piped to nearest drain or gulley and/or a galvanised drip tray shall be provided to each chilled water pump, outlet pipe to drain with galvanised piping.

17. Motor shall be of the totally enclosed fan cooled type.

18. Pump shall be protected by strainer from all damaging and flow restricting debris.

19. A single pressure gauge, snubbed or glycerine filled to prevent pointer vibration, shall, be connected through a three-way valve to read both suction and discharge pressure at each pump. Tapping's shall be either in casing or immediately before suction flange and after delivery flange.

20. Lifting eyes or lugs shall be provided for parts weighing over 25 kg.

21. Complete overhauling of the pump shall be possible without breaking piping or motor connections.

22. A metal lubrication instruction plate shall be attached to each pump in a location where it is clearly visible. The plate shall indicate the recommended lubricant, points of lubrication and the recommended frequency of lubrication.

23. Pump shall be equipped with an air vent cock and a valved drain at lowest point of casing.

24. Motor to pump coupling shall be of an approved flexible type. Coupling shall be rated at not less than 125% of motor rating.

25. The rating of the motor shall not be less than the maximum power required by the pump at any operating point between zero and break-off capacity with maximum size impeller for available casing.

26. Pump casing shall be selected for a minimum of 1 000 kPa or 1,5 times the actual discharge pressure, whichever is greater.

27. The pump shall be complete with bronze impeller and stainless-steel shaft.

28. The pump shall be complete with mechanical seals.

29. The secondary pumps shall be complete with Danfoss variable frequency speed drives.

V.D4.02.03 - WASHABLE AIR FILTERS

1. Supply and install as shown on the drawings and as listed in the schedule, filters passing the air quantity at the specified maximum face velocity, pressure drops, efficiency and dust holding capacity.

2. Air filters shall be a current catalogued product with complete documentation, including tables and graphs listing efficiency, dust hold capacity and pressure drop, for the expected range of operating conditions.

3. Certified detailed selection shown on these performance tables or curves shall be submitted.

4. The filter bank shall be so constructed and installed and necessary access provided to make it possible to change one filter element in five minutes.

5. Filter materials shall be fire resistant.

6. Filters shall be adequately protected against dirt during construction and shall not be operated until system is thoroughly cleaned.

7. Special care shall be taken in transport, delivery, storage on site and installation to ensure that the filters are installed in 'as new' condition

8. After all the adjustments etc., are completed and before the filters are accepted for regular operation, these shall be cleaned.

9. Filters must be put in regular operating conditions before the fans are operated for any purpose such as temporary ventilation or adjusting.

10. The filter frame shall be suitable for standard commercial range of filter media available.

11. An air filter differential pressure gauge shall be installed on each filter bank. The gauge shall be connected to static pressure tips of approved design, so that it will indicate correctly the resistance to the airflow of the filter.

12. Gauges shall be carefully levelled and adjusted.

13. Each filter bank shall be provided with an identification plate mounted in a location readily visible after installation.

14. Plate shall show serial number, model number and all other data necessary for ordering the new media.
15. Filter elements shall be either removable from sides of unit or front of filter bank.

16. Adequate personnel access shall be provided in front of filter bank if filter elements are removed from front.

17. The filter elements and filter frame shall be fully corrosion protected. Construction of filter frame, and method of holding down filter elements shall ensure no passage of unfiltered air through filter bank.

18. One spare set of filters shall be provided for each filter bank.

SCHEDULE

1.	Identification		-	
2.	Service		Fresh air	AHUs
3.	Location		-	-
4.	Thickness of filter media	mm	50	50
6.	Maximum face velocity	m/s	2.5	2.5
7.	Maximum pressure drop when new	Pa	25	75
8.	Maximum pressure drop when dirty	Pa	150	150
9.	Arrestance (grav.) average - ASHRAE 52-76	%	88	88
10.	Efficiency (atmostph) average - ASHRAE 52-76	%	35	35
11.	Dust holding capacity at specified pressure drop when dirty	g/m^2	400	400

V.D4.04.03 – ELECTRIC HEATER BANK

1. Supply and install in the unit, an electric heater bank at rated capacity and specified entering and leaving air temperatures.

2. The heater shall be fully catalogued product and the documentation shall include performances curves of selection tables for the expected range of operational conditions.

3. The electric air heater shall be complete with :-

   a) Auto reset thermal cut-out device set between 60 - 80 NC.
   b) Manual reset thermal cut-out device set between 80 - 100 NC with reset button. Labelled and operable without removing any terminal box cover.
   c) Air flow interlock with the supply air fan, supply air pressure switch, or air flow switch.
   d) Run-down timer to ensure supply air fan operates for a timed period after de-energising of the heater bank to distribute residual heat.

4. Submit checklists of overload and abnormal conditions, which shall be checked as part of the testing, balancing and commissioning.

5. The air heater shall be so constructed and installed that either a sub-component

replacement or total removal and re-installation of the air heater shall not take longer than 1 hour by normal building maintenance staff.

6. The heater and heater components shall be selected for minimum service life of 15 years operating for 3000 hours per annum under normal building operating conditions.

7. The final selection of the electric heating coil shall be coordinated with the control contractor to ensure compatibility with the controls specified and the temperature, load, voltage and other service conditions, which may be encountered.

8. The heater element for each step shall be strung across the entire face of the coil to prevent stratification when operating at less than full capacity.

9. Heaters and its components shall be fully protected against scaling, flaking or other corrosive action.

10. Heaters shall be so installed that there is no by-pass of untreated air.

11. Elements shall have an adequate resistance to earth, with due regard to the possible condensation of moisture during the cooling cycle.

12. A metal plate, showing wiring and control diagrams, complete with ratings of fuses and heat limiters, shall be provided to each heater.

13. Heaters shall be so constructed and installed that routine maintenance, repair or replacement can be undertaken without dis-assembly of the connected components of the air handling unit.

14. Parts used in the construction of the heater shall have adequate strength and the overall construction and installation shall be rigid to ensure satisfactory operation.

15. A terminal box shall be provided in a position readily accessible after installation, and this box shall be the only point of connection between internal and external wiring. A sufficient number of knock-outs shall be provided for the satisfactory bonding of external conduits and/or cable glands.

16. Built-in features in the terminal box shall include contactors, transformers, interlock relay and fuses (one set if total amperage is less than 40 and one set of each step if total amperage is more than 40). All built-in components shall be factory wired.

17. Ventilation and other openings in the external enclosure shall be protected that contact with live internal parts is rendered impossible.

V.D4.05.01 – AUTOMATICALLY CONTROLLED AIR DAMPER

1. Supply and install the dampers of the opposed blade, 100% shut-off type suitable for the capacity listed in the schedule.

2. The damper, complete with frame and linkage, shall be a fully catalogued product of a

manufacturer regularly engaged in the production of high quality dampers.

3. Damper with frame may be made up in one section up to 1200 mm in width and 2400 mm in height. Larger sizes shall be made up in sections for easy handling.

4. Special care shall be taken in transport, delivery, storage on site etc, to ensure that the dampers are installed and maintained in 'as new' condition at start-up of the installation.

5. The damper and damper frame shall be installed level in both directions. There shall be no torsion or twist in the frame to prevent smooth operation of the damper. The blades shall not touch any adjacent material throughout the full travel of the blades, and shall be capable of opening to a full 90 degrees. Linkages shall incorporate a positive 90 degrees opening stop.

6. The drive shaft for the linkages shall be suitable for automatic operation.

7. The dampers and linkage shall be cleaned of any debris or dirt that may cause binding.

8. Damper blades shall rotate on pivot assembly in permanently lubricated oilite bearings.

9. Pressure drop through the damper shall not exceed 50 Pa at 5 m/s velocity over the face area.

10. Damper frame and blades shall be manufactured of galvanised sheet steel.

11. Damper motors shall be of the electric type and shall be sized to suit the damper areas.

12. Size and location as per bill of quantities

V.D4.05.02 - MANUALLY ADJUSTABLE AIR DAMPER

1. Supply and install the dampers of the opposed blade, 100% shut-off type suitable for the capacity listed in the schedule.

2. The damper, complete with frame and linkage, shall be a fully catalogued product of a manufacturer regularly engaged in the production of the high-quality dampers.

3. Damper with frame may be made up in one section up to 1200 mm in width and 2400 mm in height. Larger sizes shall be made up in sections for easy handling.

4. Special care shall be taken in transport, delivery, storage on site etc, to ensure that the dampers are installed and maintained in "as new" condition at start-up of the installation.

5. The damper and damper frame shall be installed level in both directions. There shall be no torsion or twist in the frame to prevent smooth operation of the damper. The blades shall not touch any adjacent material throughout the full travel of the blades and shall be capable of opening to a full 90 degrees.

6. The drive shaft for the linkages shall be suitable for manual operation and shall be lockable.

7. The dampers and linkage shall be cleaned of any debris or dirt that may cause binding. Damper blades shall rotate on pivot assembly in permanently lubricated oilite bearings.

8. The combined pressure drop through the louver and damper shall not exceed 50 Pa at 4m/s velocity over the face area.

9. Damper frame and blades shall be manufactured of galvanised sheet steel.

10. Damper to have a fire rating of 300℃ for 1 hour.

11. Dampers to either be installed immediately behind the intake louvers or an integrated louver damper may be supplied.

12. Size and location as per the bill of quantities.

V.D4.05.04 – NON-RETURN DAMPER

1. Supply and install the dampers, 99% shut-off type.

2. The damper, complete with frame and linkage, shall be a fully catalogued product of a manufacturer regularly engaged in the production of the high-quality dampers.

3. Damper with frame may be made up in one section up to 1200 mm in width and 2400 mm in height. Larger sizes shall be made up in sections for easy handling.

4. Special care shall be taken in transport, delivery, storage on site etc, to ensure that the dampers are installed and maintained in "as new" condition at start-up of the installation.

5. The damper and damper frame shall be installed level in both directions. There shall be no torsion or twist in the frame to prevent smooth operation of the damper. The blades shall not touch any adjacent material throughout the full travel of the blades and shall be capable of opening to a full 90 degrees.

6. The dampers and linkage shall be cleaned of any debris or dirt that may cause binding.

   Damper blades shall rotate on pivot assembly in permanently lubricated oilite bearings.

7. Pressure drop through the damper shall not exceed 50 Pa at 16.5 m/s velocity over the face area.

8. Damper frame and blades shall be manufactured of galvanised sheet steel.

9. Damper to have a fire rating of 300℃ for 1 hour.

10. Size and location as per the bill of quantities.

V.D4.06.02 - VANEAXIAL FAN

1. Supply and install as shown on drawings vaneaxial fans delivering the air quantities as listed in the schedule.

2. The fan pitch shall be manually adjustable.

3. The fan shall be a fully catalogued product and the documentation shall include sound power level spectrum, performance curves and/or tables for the expected range of operational conditions.

4. Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.

5. Submit at time of equipment submission:

   a) Detailed system resistance calculations for minimum/maximum pressure drops.

   b) Certified detailed selection shown on performance curves and/or tables for the specified conditions.

   c) Installation, operating, testing, balancing and commissioning instructions and trouble analysis guide.

   d) The estimated total expenditure on replacement of parts during the service life.

   e) The service and maintenance instructions.

   f) The possible percentage variation of data measured on site by the supplied and/or installed instrumentation compared to the published data.

6. Fan selection shall be in the stable part of the curve.

7. Fans shall be so constructed and installed that any sub-component replacement shall not take longer than 1 day when executed by qualified building maintenance staff.

8. The fan shall be engineered and components selected when operated under normal building conditions with optimum servicing and maintenance for a minimum acceptable service life of 15 years with 3 000 operating hours per annum.

9. The Engineer or his representative reserves the right to call for:-

   a) Test certificates and reports from the manufacturer's quality control laboratory or independent test laboratory such as SABS, and or

b) Site inspections, customer reports/references and user's interviews, and/or

c) Full engineering, design and component selection details to check the correctness of the claimed service life.

10. Fan installation shall comply with local authority by-laws and with Occupational Health & Safety Act of 1993, as amended.

11. Fan shall be factory assembled and shipped with all components - casing, motor, drive, vanes - factory mounted.

12. Fan assembly shall be installed in accordance with manufacturer's recommendations and shall be maintained in "as new" condition at start-up of installation.

13. Fan assembly shall be statically and dynamically balanced at the manufacturer's works within the design operating speed range.

14. Fan assembly shall be isolated from duct and structure by flexible connection and vibration isolation mountings with maximum vibration transmission as specified in Part IV.

15. Fan shall not be operated until connected ducts have been cleaned and specified filters have been put into regular operating condition.

16. Rotation arrow shall be installed.

17. Lubrication shall be possible while fans are in operation without removing any part and without danger of over lubrication.

18. An airtight inspection door sited to allow convenient access to the fan and motor shall be provided; alternatively, fan casing may be arranged to pivot.

19. Fan casing shall not drum, distort or leak at any operating point and shall, if necessary, be externally sound insulated to maintain specified noise level in plantroom or adjacent rooms.

20. Motor rating shall not be less than the maximum power required by the fan at any operating point between zero and break-off capacity for the fan wheel furnished.

21. Motor shall be of the totally enclosed, squirrel cage induction, constant speed, continuous duty, variable torque type.

22. Fan shall be direct connected with motor inside the fan casing.

23. Fan assembly shall be suitable for vertical or horizontal mounting.

24. Power supply to motors shall be flexible.

25. Motor conduit box shall be mounted on exterior of fan casing. Lead wires from motor to conduit box shall be protected from the air stream.

26. All fans to be complete with Danfoss variable frequency speed drives or approved equal, where indicated in the BOQ

27. All smoke extraction fans to be connected via fire rated cables.

V.D4.06.03 – IMPULSE FAN

1. Supply and install as shown on drawings the low-profile high flow induction jet fan for controlling air movement in underground service area

2. The fan pitch shall be manually adjustable set and tested in the factory to provide optimum aerodynamic performance

3. Casing shall be of galvanised sheet metal

4. Fans to have a fire rating of 300˚C for 1 hour.

5. Units shall have 50N or 100N thrust.

6. Size and location as per the bill of quantities.

V.D4.06.04 – IN LINE TUBE FAN

1. Supply and install as shown on drawings in line tube fans delivering the air quantities as listed in the schedule.

2. The fan pitch shall be manually adjustable.

3. The fan shall be a fully catalogued product and the documentation shall include

sound power level spectrum, performance curves and/or tables for the expected range of operational conditions.

4. Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.

5. Submit at time of equipment submission:
   a) Detailed system resistance calculations for minimum/maximum pressure drops.
   b) Certified detailed selection shown on performance curves and/or tables for the specified conditions.
   c) Installation, operating, testing, balancing and commissioning instructions and trouble analysis guide.
   d) The estimated total expenditure on replacement of parts during the service life.
   e) The service and maintenance instructions.
   f) The possible percentage variation of data measured on site by the supplied and/or installed instrumentation compared to the published data.

6. Fan selection shall be in the stable part of the curve.

7. Fans shall be so constructed and installed that any sub-component replacement shall not take longer than 1 day when executed by qualified building maintenance staff.

8. The fan shall be engineered and components selected when operated under normal building conditions with optimum servicing and maintenance for a minimum acceptable service life of 15 years with 3 000 operating hours per annum.

9. The Engineer or his representative reserves the right to call for:-

   a) Test certificates and reports from the manufacturer's quality control laboratory or independent test laboratory such as SANS, and or
   b) Site inspections, customer reports/references and user's interviews, and/or
   c) Full engineering, design and component selection details to check the correctness of the claimed service life.

10. Fan installation shall comply with local authority by-laws and with Occupational Health & Safety Act of 1993, as amended.

11. Fan shall be factory assembled and shipped with all components - casing, motor, drive, vanes - factory mounted.
12. Fan assembly shall be installed in accordance with manufacturer's recommendations and shall be maintained in "as new" condition at start-up of installation.

13. Fan assembly shall be statically and dynamically balanced at the manufacturer's works within the design operating speed range.

14. Fan assembly shall be isolated from duct and structure by flexible connection and vibration isolation mountings with maximum vibration transmission as specified in

Part IV.

15. Fan shall not be operated until connected ducts have been cleaned and specified filters have been put into regular operating condition.

16. Rotation arrow shall be installed.

17. Lubrication shall be possible while fans are in operation without removing any part and without danger of over lubrication.

18. An airtight inspection door sited to allow convenient access to the fan and motor shall be provided; alternatively fan casing may be arranged to pivot.

19. Fan casing shall not drum, distort or leak at any operating point and shall, if necessary, be externally sound insulated to maintain specified noise level in plantroom or adjacent rooms.

20. Motor rating shall not be less than the maximum power required by the fan at any operating point between zero and break-off capacity for the fan wheel furnished.

21. Motor shall be of the totally enclosed, squirrel cage induction, constant speed, continuous duty, variable torque type.

22. Fan shall be direct connected with motor inside the fan casing.

23. Fan assembly shall be suitable for vertical or horizontal mounting.

24. Power supply to motors shall be flexible.

25. Motor conduit box shall be mounted on exterior of fan casing. Lead wires from motor to conduit box shall be protected from the air stream.

V.D5.01 - PROPELLER FAN

1. Supply and install as shown on drawings the propeller fans handling the specified air quantities as listed in the schedule.

2. The fan shall be a fully catalogued product and the documentation shall include sound power level spectrums, performance curves and/or tables for the expected range of operational conditions.

3. Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.

4. The contractor shall submit at time of equipment submission-

   a) Detailed system resistance calculation for minimum/maximum pressure drops.

   b) Certified detailed selection shown on performance curves and/or tables for the specified conditions.

   c) The service and maintenance instructions.

   d) The estimated total expenditure on replacement of parts during the service life.

   e) Installation, testing, balancing and commissioning instructions and trouble analysis guide.

5. Fan selection shall be in the stable part of the curve.

6. The fan shall be engineered and components selected when operated under normal building conditions with optimum servicing and maintenance for a minimum service life of 10 years with 6 000 operating hours per annum.

7. The Engineer reserves the right to call for

   a) Test certificates and reports from the manufacturer's quality control laboratory or independent test laboratory such as SANS, and/or

   b) Site inspections, customer reports/references and user's interviews, and/or

   c) Full engineering, design and component selection details

   to check the correctness of the claimed service life.

8. Fan installation shall comply with local authority by-laws and with Occupational Health and Safety Act of 1993, as amended.

9. Fan shall be complete with wire guard(s) if accessible from either side.

10. Fan shall be installed in accordance with manufacturer's recommendations and shall be maintained in "as new" condition at start-up of installation.

11. Fan and motor shall be weatherproof and shall be protected from wind, rain and insects.

12. Fan shall be quiet in operation and shall be statically and dynamically balanced at the factory.

13. Bearings shall be of the permanently lubricated type.

14. Mounting plates shall not distort under any operating conditions.

15. Fan shall be mounted on vibration isolating mounting.

16. Power source to motors shall be through flexible conduit.

17. Fans shall be complete with an intake louver of suitable size to be mounted on the opposite side of the wall.

V.D6.01 - AIR DISTRIBUTION SYSTEM

1. **GENERAL**

1.1 The Contractor shall supply and install the air distribution, return and exhaust systems as shown on the drawings.

1.2 The entire ducting system, including spigots but excluding flexible connections to air terminals, shall not leak more than 4% of the maximum design air flow at design duct static pressures, as determined in the manner specified.

1.3 Ducts shall be even, and internally smooth with neatly finished joints, shall be free from vibration and drumming under all operating conditions and shall ensure an even flow of air without undue pressure loss.

1.4 The entire ducting system, including flexible ducts, finishes, hangers and supports, dampers and valves, connections, access doors, acoustical treatment and thermal insulation, sealants and sealing gaskets, shall be selected, constructed and installed to give a minimum working life of 20 years under expected building service conditions.

1.5 All exposed duct flanges to be covered with waterproof membrane with top-hat flashing

1.6 Unless otherwise indicated, all ductwork sizes shown on the drawings are clear internal air passage sizes.

1.7 Ductwork in plantrooms and ductwork which is exposed and visible shall be painted in accordance with "Painting and Protection Against Corrosion" Part IV. Any paint/solvent based coating used for internally exposed air-conditioning ductwork and applied on site, must have a VOC content of less than 200g/l.

1.8 Ducting shall be identified for services and direction of flow in accordance with "Identification" Part IV.

1.9 All thermal insulation used on the project shall have no ozone-depleting substances associated with either the manufacture or composition of the product. Fibre-based woven insulation products (e.g. glass fibre, mineral wool, polyester etc.) and foil insulation are not manufactured using blowing agents may be used. The supplier(s) of equipment shall confirm in writing that all insulants used are free

of ozone depleting substances in both manufacture and composition. The supplier(s) shall identify the types and the properties of the insulants used and provide Manufacturers' Data Sheets confirming these. At practical completion, the contractor shall confirm that all insulants installed were as per the engineers' specification.

1.10 The Contractor shall select, construct and install the ducting and other sheetmetal work in accordance with the following classification of conditions in the several sections of the air distribution system:-

CLASSIFICATION	VELOCITY (m/s)	PRESSURE (Pa)
Low Velocity Low Pressure	Up to 10	Up to 500
High Velocity Medium Pressure	Over 10	501 to 1500
High Velocity High Pressure	Over 10	1501 to 2500

2. LOW VELOCITY LOW PRESSURE DUCTWORK

2.1 General

2.1.1 Except as noted, ducts and other sheetmetal work for air distribution shall be constructed and installed in accordance with:-

a) Contract drawings.

b) Latest edition: "Low Velocity and Duct Construction Standards" by SMACNA or SANS 1238- 2005 and 10173- 2003.

2.1.2 Ducting and appurtenances shall be constructed of Galvanised Steel.

2.1.3 Bracing angles shall be compatible with the duct material.

2.1.4 Changes in dimensions, shape and direction of ducting shall be gradual, complying with SANS 1238- 2005, Sections 5.4.

2.1.5 Elbows shall be of the standard radius (R=W) type. Short radius (R=1/3W) and vaned square elbows shall be used only where required to fit restricted space.

2.1.6 Air turns shall be installed in all non-standard radius elbows and shall consist of 'double-thickness' type vanes, arranged to permit the air to make the turns without appreciable turbulence.

2.2 Branches and Take-Offs

Throat velocities in branch connections shall not exceed main duct velocity.

2.3 Sealants

All joints shall be sealed using an approved sealant.

2.4 Installation

Ducts shall be securely attached to building construction in an approved manner.

2.5 Flexible Connections

2.5.1 Ductwork shall be connected to fans, air handling units or other vibration inducing equipment by flexible connections suitable for the pressure at the point of installation. Such flexible connections shall consist of fireproof fabric reinforced airtight material. Flexible connections will also be required at expansion joints in the building structure, unless sufficient flexibility is provided in the adjacent ducting.

2.5.2 Connections shall be attached at both ends by approved metal collars or frames.

2.5.3 The openings being connected shall be of equal size, aligned and parallel.

2.5.4 The flexible material shall be in folds to permit sufficient movement and the unfolded width and width of "gap" in the operating condition shall be as scheduled below.

Largest dimension of opening	600mm	600 - 2000 mm
Unfolded width of connection	80mm	150mm
Average gap	8mm	20mm

2.6 Flexible Ducting

2.6.1 Where indicated ductwork shall be connected to mixing boxes and integrally mounted ceiling diffusers by means of flexible ducting.

2.6.2 Flexible ducting shall consist of aluminium foil faced glass fibre fabric mechanically interlocked by a corrosion resistant metal spiral helix on the outside of the fabric.

2.6.3 Flexible ducting shall comply with local codes, NFPA Bulletin 9OA and SANS fire resistance requirements.

2.6.4 Flexible ducts connected to diffusers of mixing boxes shall, unless otherwise shown or approved, not exceed 1,5m in length nor have more than (the equivalent of) two 90 degree bends. Bends shall be of the maximum possible radius without flattening or distorting the flexible.

2.7 Access Doors and Panels

2.7.1 Access doors and panels shall be installed in casings, plenum chambers and ducts where shown and required for inspection, maintenance and replacement of equipment, instruments and controls in accordance with SANS 1238-2005.

2.8 Site Assembled Casings

2.8.1 Except as indicated, floor under site assembled casings shall serve as bottoms.

2.8.2 Walls and ceilings may only be used as part of the casings with the express approval of the Engineer. These shall be insulated and covered with galvanised sheet metal as directed.

2.8.3 Casing shall not drum vibrate or leak.

2.8.4 Built-up casings shall be of the sandwich panel insulated wall type constructed with prefabricated panels.

2.8.5 Sandwich panel skins shall be constructed of galvanised steel of a gauge to suit operating conditions and finished with a vinyl based baked enamel painted to an approved colour.

2.8.6 Sleeves shall be provided where panels are pierced for the purpose of introducing services. Void and sleeves shall be filled with insulation and mastic compound.

2.8.7 Plenum chambers shall be braced with angles rivetted to sheet at 150 mm centres.

2.8.8 Casings shall be jointed to walls, plinths, floors or ceilings with angles secured with expansion bolts on 300 mm centres.

2.8.9 Doors in insulated casings shall be of double panel construction, panels minimum 1,2 mm thick and filled with insulation to the thickness of the casing insulation.

2.9 Exhaust Hoods

Exhaust hoods shall be of the type as indicated on the drawings, and shall comply with the relevant section of Part V.

2.10 Testing

2.10.1 All duct work shall be leak tested and made airtight before ducts are insulated or concealed.

2.10.2 Calibrated equipment for leak testing shall include rotary blower, orifice section and U-type gauge board complete with cocks, rubber tubing and other appurtenances required for conducting tests, generally as described in the SMACNA "High Velocity Duct Construction Standards".

2.10.3 As installation progresses, suitable and approved sections of ducting including spigots for flexible ducts shall be temporarily sealed for testing.

2.10.4 Test pressure shall be 75 Pa. During the test period, the entire section of ducting tested shall be examined for leaks and noise. Leaks and noisy conditions shall be marked, repaired and re-tested. Noisy leaks shall be repaired under all conditions, even when leakage is within acceptable limits.

2.10.5 Test holes for instruments shall be 25 mm diameter and provided with an effective seal.

2.10.6 Reports on leak testing shall be submitted in a bound folder with all accompanying sketches, and shall indicate that the total of "operating" leakages inferred from tests on all sections of the system does not exceed the specified maximum of 4% of the (maximum) design air quantity for said system. (Note: Actual leakage quantities found in each test may be reduced in the ratio /Pt/Po where Po equals design operation pressure and Pt the test pressure employed, to calculate the "operating" leakage).

2.10.7 The Contractor shall provide all facilities for measuring and testing.

3. HIGH VELOCITY MEDIUM AND HIGH PRESSURE DUCTWORK

3.1 Except as noted ducts and sheetmetal work shall be constructed and installed in accordance with :-

a) Contract drawings.

b) Latest edition "High Velocity Duct Construction Standards" by SMACNA or SANS 1238-2005 and SANS 10173-2003.

3.2 Except where noted ducts and sheetmetal work shall be constructed of galvanised sheet steel.

3.3 Access doors and panels shall comply with "Access Doors and Panels" as specified under low pressure ductwork.

3.4 Leak testing shall be executed as specified for low pressure ductwork but the minimum test pressure shall be as follows:-

High Velocity Medium Pressure Ducting:	1500 Pa
High Velocity High Pressure Ducting:	2500 Pa

3.5 The Contractor shall provide all facilities for measuring and testing.

4. FIRE DAMPERS

4.1 Dampers shall be located as shown on the drawings.

4.2 Dampers shall be designed to close automatically and remain tightly closed upon the operation of an approved fusible link of other heat actuated device, located where readily affected by an abnormal temperature in the duct. Device shall have a temperature rating approximately 20ºC above the maximum temperature that would normally be encountered when the system is in operation or shutdown.

4.3 The open or closed status of the damper shall be indicated outside the casing.

4.4 Dampers shall be sized so that the free air space when open is not less than the connected duct free air space.

4.5 Dampers shall be installed so as to form part of a continuous barrier to passage of fire when in a closed position. Where a fire damper cannot be fitted immediately adjacent to the fire wall, the section of ducting between damper and wall shall be of at least the same metal thickness and fire rating as the damper casing.

Dampers shall be self-supporting in case of duct destruction due to heat. Care shall be exercised that the frame be set so that the closing device will be accessible.

4.6 Suitable hand openings with tightly fitted covers shall be provided to make dampers accessible for inspection and maintenance.

4.7 Dampers shall comply with the requirements of local authorities and NFPA Bulletin 90A and SANS 193.

4.8 Dampers shall be selected for a minimum fire protection rating of two hours.

V.D6.01.01 - SOUND ATTENUATORS

1. **GENERAL**

Sound attenuators shall be manufactured by a reputable manufacturer regularly engaged in the manufacturing and testing of sound attenuators.

The sound attenuators shall be tested to BS 4718 as amended and test data shall be available for both static and dynamic insertion losses in octave frequency bands from 63 to 8000 Hz.

The sound attenuator shall be tested for pressure drops and tables of airflow vs pressure drop shall be available.

Sound attenuator dimensions shall be verified with site measurements where space is constrained, specifically where fitted between structural elements.

Installation methodology in confined spaces shall be submitted for approval by the engineer and contractor

Sound attenuators used for grease laden air shall be lined with a non-absorbent material

The attenuators shall be leak proof.

The attenuators shall have a Class 1 rating for surface spread of flame as measured to BS 476 Part 7.

The casing shall be manufactured from galvanised mild steel.

V.D6.02 - WATER PIPING SYSTEM

1. **GENERAL**

1.1 The Contractor shall supply and install the water piping systems in accordance with the layout as shown.

1.2 All components shall be fully catalogued products and documentation shall include selection tables or pressure drop data for the expected range of operation conditions.

1.3 The water piping shall be designed and engineered in detail in accordance with the design criteria laid down in: -

a) The latest ASHRAE Publication, and/or
b) The latest CIBSE Publication, and/or
c) Carrier - Handbook of Air Conditioning System Design - Water Piping Design.

1.4 Water velocities and pressure drop in any part of the piping system shall not exceed 2,7 m/s and 350 Pa/m length respectively except in or adjacent to control valves where high velocities and the associated high frictions may be needed to obtain stable control.

1.5 Full documentation and calculations shall be submitted for approval showing all detailed pressure loss and velocity calculations for the entire piping system and components both under full load and minimum load conditions.

1.6 The system shall be designed: -

a) To ensure water flow and return to all sections of the installation. The requirements shall be met at full load and part load conditions.
b) To avoid the accumulation of dirt and other foreign matter in the system.
c) For all possible expansion and contraction in all parts of the water piping system.
d) For simple balancing.

1.7 The water piping system shall be designed, selected and installed to ensure no leakage during its operational life.

1.8 The water piping system and components, including thermal insulation, hangers, support and vibration eliminators, shall be designed, selected and installed to ensure a minimum working life of 60 000 hours under actual operating and normal building service conditions.

1.9 Piping shall be designed and installed within the space limitations shown or implied on the drawings.

1.10 The Contractor shall ensure that sufficient access is provided for inspection, testing and servicing.

1.11 The Contractor shall ensure that loads imposed on the building structure are evenly

distributed and shall submit details of all loads imposed by the system on the structure via hangers, supports, bases, etc.

1.12 The minimum gradient for water piping shall be 1:500 up towards venting positions and drainpipes shall be 1:100.

1.13 Square tees shall be used where sweep fittings would cause air to be trapped in the system.

1.14 Eccentric reduction sockets shall be used where necessary on horizontal runs of pipe and concentric reduction sockets on vertical pipes.

1.15 Open or automatic air vents shall be provided at all high points in the system. The latter shall be preceded by stop valves, and the outlet piped to visible discharge over drain point.

1.16 The Contractor shall provide valves and caps or drains at all low points in piping system and at the bottom of each riser section for draining. Due allowance shall be made for venting sections of pipe being drained, both to enable drainage to be complete, and to prevent collapse due to internal vacuum.

1.17 Piping shall be installed so as to allow for expansion and contraction Connections to coils, pumps and other equipment shall be made in such a manner as to eliminate undue strains in piping and equipment. Necessary fittings and bends shall be furnished to avoid springing of pipes during assembly. Flexible connectors shall be provided where indicated, or if found necessary (see Clause 8 Part IV) and may also be required to bridge expansion joints in the structure.

1.18 Piping shall be installed parallel or perpendicular to building construction, while maintaining the required gradients, where applicable.

1.19 System vibration isolation shall be in accordance with "Sound and Vibration Control" - Clause 8 of Part IV.

1.20 Any paint/solvent-based coating used for internally exposed pipes and applied on site, must have a VOC content of less than 200g/l.

1.21 Thermal insulation shall be in accordance with "Insulation" - Clause 9 of Part IV.

1.22 All thermal insulation used on the project shall have no ozone-depleting substances associated with either the manufacture or composition of the product. Fibre-based woven insulation products (e.g., glass fibre, mineral wool, polyester etc.) and foil insulation are not manufactured using blowing agents may be used. The supplier(s) of equipment shall confirm in writing that all insulants used are free of ozone depleting substances in both manufacture and composition. The supplier(s) shall identify the types and the properties of the insulants used and provide Manufacturers' Data Sheets confirming these. At practical completion, the contractor shall confirm that all insulants installed were as per the engineers' specification.

1.23 All necessary pressure gauges, thermometer wells and thermometers shall be installed on the pipelines to check pressures and temperatures for monitoring the functioning of various components including possible blockage of strainers.

1.24 Flow meters and/or connections for portable flow meters shall be provided as shown.

1.25 All piping shall be cleaned and primed in accordance with "Painting and Protection Against

Corrosion" - Clause 6 of Part IV. The specified two coats of paint shall be applied to the primed surface of uninsulated piping and to the vapour barrier on insulated piping.

1.26 Piping shall be complete with all necessary isolating valves to enable repairs to be done to any one section of the system without the necessity of shutting down and draining the remainder.

1.27 Components requiring regular inspections, cleaning and removal shall be isolated by shut-off valves to enable this to be done without draining the entire system.

1.28 Components shall be so connected and installed that removal and re-installation will not take longer than 2 hours by a qualified mechanic.

1.29 Relief valves shall be installed in all closed piping system in easily accessible positions. The discharge of each relief valve shall be visible and piped to drain.

2. STRAINERS

2.1 Strainers shall be installed to ensure that all foreign matter is continuously removed from the system.

2.2 Strainers shall be of at least the same nominal bore as the pipeline in which they are fitted.

2.3 The filter medium shall be removable for cleaning purposes. Bolted end covers shall incorporate drain plug for blow down purposes.

2.4 Strainers shall be of the pot or angle type.

2.5 Strainers of 50 mm bore and smaller shall be taper screwed and shall have bronze, gunmetal or ductile iron bodies.

2.6 Strainers of 65 mm bore and larger shall be flanged and shall have cast iron bodies to BS EN 1561 GR 14, ductile iron to BS EN 1563 or cast steel to BS EN 10213 and its parts.

2.7 Screen shall be bronze, monel metal or stainless steel with perforation as follows: -

Strainer Size	**Perforation**
20 - 50 mm	0,74 mm
65 - 150 mm	l,50 mm
200 - 300 mm	3 mm

2.8 The open area of each screen shall be at least three times the area of the inlet pipe.

2.9 Strainers shall not be fitted in suction pipes feeding pumps unless ample static head (200 kPa minimum) is available in such suction pipes at the position of the strainers.

3. PIPING

3.1 The following materials, grades and methods of construction shall be used for the

applications listed: -

APPLICATION	NOMINAL SIZE/mm	MATERIAL AND GRADE	APPLICABLE STANDARD	JOINTS
Chilled water and closed condenser water	Up to 20	Annealed copper Hard temper copper	SANS 460	Flared compression capillary soldered. Silver soldered.
>=	25 - 65	Medium grade, black steel	SANS 62	Screwed BSP. Socket unions. SANS 62.2.
>=	80 - 200	>= >=	SANS 719	Butt welded. Flanges welded on. Grooved and clamped. SANS 62.
>=	over 150	A @	SANS 679	SANS 719
Open circuit condenser water piping, cold water	Up to 65	Medium grade galvanised mild steel	SANS 62	Screwed BSP. Socket unions. SANS 62.2 Galvanised flanges screwed on. Grooved and galvanised clamps.
>=	Up to 80 mm	=	SANS 62	Galvanised flanges BS 50921
>=	Over 150	Welded steel, galvanised after fabrication	SANS 62	Flanges welded on, galvanised after. Grooved and galvanised clamps.
Drains	Up to 25	Copper	SANS 10147	Brazed SANS 10147.
Drains Hot	A	PVC class 6	SANS 966	Solvent glued. Air welded.
Drains Hot	25 & Over	Medium galvanised mild steel	BS 1387	Screwed BSP socket unions.
Spray water		Annealed copper Hard temper copper	SANS 462	Compression
Hot water closed circuit	Up to 50	Heavy grade black mild steel	BS 1387	Welded. Steam quality socket unions. Flanges.
>=	Over 150	>=	BS 1387	Welded. Flanges.
>=	Over 150	Black steel	BS 534	Welded. Flanges.

4. JOINTING

4.1 No joints shall be made in thickness of walls, floor or ceilings. Pipework shall not be embedded in masonry.

4.2 Detachable joints shall be made to facilitate the maintenance and removal of piping and connected equipment. At least one detachable joint is required in each system of piping, of up to 10 m length.

Such detachable joints shall be as follows for the several types of piping. :-

a) Copper tubing: flared compression joints.

b) Steel piping up to 65 mm nominal bore: socket unions with ground metal-to-metal seating.

c) Steel piping over 65 mm nominal bore: flanges or clamping bands onto grooved

pipe ends (not for hot water).

d) Rigid PVC: PVC socket unions.

4.3 Screwed joints in steel piping shall be taper-to-taper: screwed BSP, with PTFE tape applied to male pipe ends only. Pipes shall be cut and chamfered with approved cutters: hacksawing will not be permitted. Screwed threads shall be machine cut.

4.4 Clamped connections shall be made with approved forged steel or ductile cast iron clamps and resilient sealing rings

Clamp and bolts shall be galvanised or other approved anti-corrosion treatment applied by maker.

Pipe ends shall be machine cut and grooved to the depth recommended by manufacturer.

4.5 Flanged joints shall be made up with one-piece gaskets not more than 1,6 mm thick. "Ring" gaskets, inside the bolts only, are preferred.

Materials for gaskets shall be: -

For hot water piping	:	Compressed asbestos fibre, "Kingerit" or equal approved.
For chilled and cold	:	Rubber insertion water piping
Flanged joints between	:	Dupont "Teflon" or equal dissimilar metals.

Flanged joints between dissimilar metals shall have insulating gaskets, sleeves and washers between flanges, bolts and nuts respectively.

Gaskets shall be suitable for service, temperature and pressure of system and installed in accordance with manufacturer's recommendations.

4.6 Non-detachable joints shall be as follows for the different types of piping:

a)	Copper tubing	:	Capillary soldering
b)	Copper tubing	:	silver soldering
c)	Steel piping	:	Arc welding
d)	Rigid PVC	:	Solvent Gluing and / or hot air welding.

4.7 Arc welding shall be in accordance with SANS 10044.

The Contractor shall allow for one in ten welded pipe joints to be cut for examination purposes. If any of the welds prove unsatisfactory, the Contractor shall be called upon to have all welds examined by X-ray and to have X-ray plates examined by the SABS or other approved authority.

5. FITTINGS

5.1 For piping up to 32 mm nominal bore bending shall be used in preference to fittings, and this shall be done on approved bending machines: loaded if necessary.

5.2 Fittings shall be specifically suited for the material and grade of piping to which they are connected, and have the same, or compatible, surface treatment.

5.3 Rigid PVC pressure piping may be used for drains where indicated. Bends only shall be used, no elbows.

5.4 Copper Fittings: -

Soldering fittings shall be of the capillary type. Below 50mm flared or compression type may be used, as scheduled.

Fitting shall be non-dezinctifiable metal alloy.

5.5 Fittings of inert materials shall be interposed between copper and galvanised steel pipes to prevent electrolytic action.

5.6 Welding Fittings:

Fittings attached by welding shall be specifically suited for this purpose; to SANS 10044 or similar or similar approved.

5.7 Welded-on outlets to heaters shall be suitable reinforced by extra thickness or gusseting in order to obtain the same strength throughout the header.

5.8 Valves made for welding into pipelines shall not be used unless such usage is approved for each individual case.

6. VALVES

6.1 Provide valves as indicated or required for operation of systems and control of apparatus, and as scheduled for the particular duty.

6.2 Wherever possible, valves shall be of same manufacture.

6.3 Valve bodies shall be of copper alloy for valves up to 50mm diameter, and of cast iron and steel for those over 50mm diameter.

6.4 Valves shall conform to the following material specifications:

Bronze : BS EN 1982

Cast Iron : BS EN 1562

6.5 Valve mating flanges shall correspond to valve pressure rating and valve flange diameter.

6.6 Handwheels for valves shall be of a suitable diameter to allow tight closure by hand with the application of reasonable force without additional leverage and without damage to stem, seat and disc. Handwheels operated valves shall close CLOCKWISE.

6.7 Seating surfaces shall be machined and finished to ensure tightness against leakage for service specified and shall seat freely.

6.8 All screwed valves shall be so designed that when the screwed connections are properly made, no interference with, nor damage to the working parts of the valve, can occur.

6.9 Gate valves shall have rising stems and split or solid wedge gates and shall have back seats to facilitate repacking under pressure and shall be drop tight closing.

6.10 Copper alloy gate valves shall comply with BS 5154 and BS EN 1288. Cast iron gate valves shall be to SANS 664, and BS EN 1171.

6.11 Butterfly valves with flanged bodes, or of the "wafer" type, for fitting between flanges fixed to adjacent piping, may be used to isolating valves. These valves shall close drop tight against the prevailing pressure and be lever geared handwheel, electrical or pneumatically operated. Indicators showing "open", "closed" and "intermediate" positions shall be provided. The valve disc shall be hydrodynamically stable and seated against renewable resilient seats. The spindle seal shall be drop tight and renewable under pressure.

6.12 Diaphragm valves such as "Saunders" or equal approved or butterfly valves shall be used in lieu of gate valves, for isolating purposes, specifically in positions where the risk of leakage cannot be accepted (e.g., in false ceilings and computer room access floors).

6.13 "Sphere" or "ball" valves shall have a polished spherical metal closing element with renewable sealing rings incorporated in the body. The port shall have the same bore as the body. The operating spindle seal shall be renewable under pressure and drop tight.

Such valves shall normally be lever- or key operated and may be used as stop- and balancing valves by means of an adjustable top to the operating mechanism.

6.14 Globe valves shall conform to BS5154, or equivalent.

6.15 Globe valves shall have characterised plug discs. The discs shall be free to rotate, readily removable from the valve stem and renewable.

6.16 Valves shall permit control of flow rate from full flow to complete shut-off and suitable for repacking of stem gland under pressure.

6.17 Lubricated plug cocks shall be designed to prevent lubricant entering into the valve port opening. The port area shall be equal to 100% of the area of the pipe to which the valve is connected.

6.18 Check valves shall conform to BS BS 5154 or BS EN 13789 and shall be non-slamming, fully guided, spring closed type and silent operating.

6.19 Float valves up to 50 mm nominal bore shall confirm to BS 1212, of the "Portsmouth" type for high pressure duty; floats shall be of copper to SANS 752.

Above 50 mm nominal bore, balanced pressure float valves with flanged cast iron bodies, as VOSA Fig 730054 shall be used. These valves shall have a stilling pipe fitted to the outlet, with anti-syphoning hole above overflow level.

6.20 Drain cocks shall be of the screw and/or bolted down tapered plugs plug type. Plugs shall be tapered and ground into the body to form a tight seal under pressure. They shall be

suitable for hose connection at outlet.

6.21 Gauge cocks on chilled and condenser cooling water shall be of the straight pattern, ground plug type with a lever handle.

6.22 Pressure relief valves shall be of the totally enclosed spring loaded type with padlock and easing lever. The outlet shall be piped to the visible position where discharge will not cause damage or injury.

6.23 Schedule of Valve Applications

TYPE OF VALVE	SIZE LIMIT	ISOLATION	BALANCING	POWER OPERATION	POSITION INDICATION	SPECIAL PURPOSE
Copper alloy gate valve	Up to 50mm	Yes	No	No	Rising stem type only	
Cast Iron gate valve	Over 50mm	Yes	No	Yes	Rising stem type only	
Diaphragm		Yes	No	On-Off	Yes	Drip
Butterfly		Yes	No	On-Off	Yes	Drip free
Sphere		Yes	Yes	On-Off		Combined stop and balance
Globe		Yes	Yes		Rising stem only	
Lubricated plug cock		Yes	No	Requires high torque	Yes	Gas tight
Special globe or plug valve		Yes	Yes	Yes	Yes	Combined/Stop balance (and measure)
Special globe or plug valve		No	No		Yes	Proportional control
Special sleeve valve		No	No	Yes	Yes	Proportional control
Ball valves	Up to 65	Yes	No	No	No	No

7. HANGER AND SUPPORTS

7.1 Hangers for steel pipes shall conform to [obsolete – not replaced] BS 6700 or BS EN 806-2 where applicable.

7.2 Provide anchors and guides for all horizontal and vertical piping for proper control of thermal movement to prevent undue strain on branches and equipment and to provide proper performance of expansion joints and loops.

Provide all additional steel framing required for proper support, handling, anchoring and guiding of piping.

7.3 Hangers and supports shall be designed to support the full weight of piping, coverings and fluid conveyed.

7.4 All flexibly supported piping shall be sway-braced without interfering with thermal movement of piping.

7.5 Hangers and supports shall allow adequate adjustment.

7.6 Pipes of small and medium bore shall be supported by means of compatible clamps, clips, holder bats or hangers in the manner and at the maximum spacing laid down in BS 6700.

For larger piping, the proposed methods of supports shall be shown on the Contractor's drawings, for approval.

7.7 Provide additional hanger supports at vertical or horizontal changes in direction of piping, and at locations of concentrated loads due to valves, strainers, separators meters and other accessories.

Pipe hangers shall be of the springlex - positionable type.

7.8 Contact of dissimilar metals shall be avoided. Mild steel piping shall have steel contacts, galvanised piping shall have galvanised contact and copper piping shall have copper, plastic or copper alloy contacts.

7.9 Multiple pipe supports for pipes of differing sizes shall be spaced at intervals to the requirements of the smallest pipe.

7.10 Branches from risers shall not be used as a means of support for the riser, and shall be sufficiently flexible to absorb thermal movement.

7.11 All insulated piping shall be supported outside insulation at hangers as follows:-

Up to 50 mm bore	:	1,25 galvanised steel shield 120 ° arc, minimum 0,3m long.
65 to 150 mm bore	:	2 mm galvanised steel shield 120 ° arc, minimum 6 diameters long.

8. FLEXIBLE CONNECTIONS

8.1 Flexible connections shall be of a reinforced rubber type with flanged ends suitable for the maximum working pressure and shall be selected for a 15 year life span.

8.2 Hoses shall be resistant to water treatment chemicals and seating, pressure shock and sweating.

8.3 Hoses shall be factory tested to 2.5 times the working pressure.

8.4 Holes shall be stainless steel reinforced.

8.5 Suppliers shall guarantee hoses for at least 5 years.

8.6 Hoses shall be insulated with Armourflex.

9. SLEEVES AND PLATES

9.1 These shall be provided for building in by Principal Contractor for pipes passing through walls, partitioning and building structure.

9.2 Sleeves shall be not less than 5mm larger than the piping and its covering, if any.

9.3 Sleeves shall extend through the full depth of construction including final finishes.

9.4 Sleeves and packings through fire walls shall be in accordance with NFPA requirements and all authorities having jurisdiction, and shall have a fire rating at least equal to that of the structure in which they occur.

9.5 Sleeves in concrete work shall be flanged at the bottom or provided with temporary centring cap and securely nailed or screwed to shuttering.

9.6 Such sleeves will be placed by others, but the Contractor shall satisfy himself that all sleeves are correctly positioned and rigidly fixed, before concrete is poured.

9.7 Sleeves shall be of zinc-coated steel not less than 1,5mm thick, or of pitch fibre, asbestos cement, or heavy duty PVC piping.

9.8 Sleeves through exterior walls shall have "puddle" flanges, and the gap between sleeve and pipe shall be waterproofed by means of hemp and lead, or epoxy resin.

9.9 Exposed vertical pipes passing through floor shall be provided with floor plates and where ceiling is finished with ceiling plates. Pipes through waterproof floors shall be `flashed' as specified below, for pipes through roofs.

9.10 Horizontal exposed pipes passing through finished walls shall be provided with wall plates.

9.11 Wall and ceiling plates may be split, and shall be securely fastened to the pipes or to the sleeves.

9.12 Sleeves in fire walls shall be packed with asbestos cotton, fibrous glass, or other approved incombustible material.

9.13 Pipes passing through roofs shall be "flashed" by a cowl fixed to the pipe overlapping and waterproof sleeve the top of which is at least 50 mm above top of roof covering.

10. INSTALLATION

10.1 The Contractor shall properly cap all open ends during installation so as to prevent the entrance of sand, dirt, etc.

10.2 The Contractor shall ensure that piping is clean, straight and free of defects before welding,

insulation or painting.

10.3 Pipes shall be reamed after cutting and shall be free from burrs, rust and scale.

10.4 System components which do not function properly because of insufficient cleaning of the water piping system shall be replaced.

10.5 Pipes shall be cut accurately to measurements established on site and worked into place without springing or forcing, except that expansion of hot pipes may be (partly) allowed for by pre-calculated "cold springing" during installation.

11. **PRESSURE TESTS**

11.1 The system shall be filled and air vented at least 24 hours before the actual test pressure is applied. The piping system shall be tested to a hydrostatic pressure of at least 1,5 times the maximum operating pressure but not less than 700 kPa.

11.2 The system shall maintain the test pressure for a minimum period of 2 hours without pumping.

11.3 A satisfactory pressure test will not absolve the Contractor from responsibility for leaks, which develop when the piping is operating under its normal working conditions, and also under any abnormal conditions, which may reasonably be expected to occur.

V.D6.03 REFRIGERANT PIPING

1. During the welding of refrigerant copper piping, a small amount of nitrogen must be passed through the pipes to avoid flaking of the inside of the piping.

2. Brazed joints shall be used instead of screwed or flared joints. The number of joints shall be minimized.

3. All refrigerant piping shall be well saddled and secured to minimize vibration of piping.

4. All pipes shall be de-burred and cleaned after being cut. Only circular pipe cutters shall be used, no sawing of pipes shall be allowed.

5. Pipe benders, flaring and swaging tools shall be used.

6. Sizing of refrigerant piping shall be done according to air-conditioning unit manufacturer's requirements, taking into account equivalent pipe length and height difference between evaporator and condenser.

7. Refrigerant piping shall be supplied by a reputable supplier and approved by the engineer

8. **All refrigerant piping must be pressure tested** at 20% above operating pressure, using nitrogen and the refrigerant that will be used in the system. The system

pressure must be observed, and any reduction in pressure means that there is a leak in the system. An approved leak testing method must be used to find leaks. After leak repair, the pressure test must be repeated.

9. **All refrigerant piping system are to be evacuated with a vacuum pump,** to a pressure of 40 to 45 microns (electronic vacuum gauge). A two-stage vacuum pump must be used specially designed for this purpose.

The manifold valves shall be closed off and vacuum observed for at least 2 hours. If there are no movement on the gauge, then there are no leaks or moisture in the system. Gauges will indicate between -80 and -100 kPa.

If the vacuum reading moved above 45 microns in 2 hours, the system must be checked for leaks or further vacuum pumped to remove moisture.

10. **Records** of pressure testing and evacuation of each refrigerant piping systems must be kept and submitted to the mechanical engineer.

11. All thermal insulation used on the project shall have no ozone-depleting substances associated with either the manufacture or composition of the product. Fibre-based woven insulation products (e.g. glass fibre, mineral wool, polyester etc.) and foil insulation are not manufactured using blowing agents may be used. The supplier(s) of equipment shall confirm in writing that all insulants used are free of ozone depleting substances in both manufacture and composition. The supplier(s) shall identify the types and the properties of the insulants used and provide Manufacturers' Data Sheets confirming these. At practical completion, the contractor shall confirm that all insulants installed were as per the engineers' specification.

V.D7.01.03 HVAC AUTOMATIC CONTROL SYSTEM (BMS)

1. GENERAL

1.1 The contractor is not expected to install new CBMS related equipment. but must ensure that new HVAC equipment installed is compatible with the specification below. This does not make part of the scope of work and is for information purposes only.

1.2 The Heating, Ventilation and Air Conditioning system shall be controlled and monitored by a server based automatic control system having a network distributed intelligence structure.

1.3 There shall be 1 automatic control system with 1 license. The 3 tower users will require access to their own systems (3 in total). Access to each of the 3 different systems to be password protected

1.4 The client shall employ a reputable automatic control contractor who is well established in South Africa and or Eswatini, and be responsible for the design, engineering, documentation, supply, installation, commissioning, and maintenance of an automatic control system to implement the sequence of operation as shown on the control schematic drawings.

1.5 All control equipment (actuators and sensors) shall be supplied and installed by one firm and shall be Tridium or equal approved.

2. COMPLIANCE WITH REGULATIONS AND STANDARDS

2.1 The complete installation shall comply with all relevant statutory regulations and amendments thereto in particular the following:

2.2

2.3 SANS Codes of Practice for Wiring of Premises.

2.4 The Occupational Health and Safety Act of 1993, as amended.

2.5 National Building Regulations Specifications and Codes of Practice issued by the SANS and British Standard Institute.

2.6 All wiring, including conduiting shall form part of this contract.

2.7 Submit details of all power requirements as part of the tender.

2.8 All communications cables shall be screened and earthed. The system shall be earthed from a single point.

2.9 All equipment shall be protected against lightning.

2.10 All controllers must be BACNET compatible and BTL certified.

3. SYSTEM STRUCTURE

3.1 The system structure shall include:

3.1.1 There shall be one PC based operator terminal workstation which links to the server based automatic control system, which provides means to control the HVAC in accordance with the control schematic

3.1.2 Supervise the system performance and status in the form of dynamic graphics and point status lists.

3.1.2.1 Prepare status reports, log sheets and provide a hard copy thereof on a separate printer. Functionality to manually and/or automatically generate and send email-based reports.

3.1.2.2 Execute integrated software package to manage the system with regard to operation, maintenance, etc. The software package shall be able to run from a virtual PC allocated on a remote server, this requirement includes both functionality and licensing.

3.1.2.3 Implement, install and adapt all software packages including standard packages as indicated in the specification. The software shall be the latest available version at handover and during the maintenance period.

3.1.2.4 To change set points and read the local set points of sub-system controllers and to communicate with outstations.

3.1.2.5 To acknowledge and prioritize alarms and route messages.

3.1.2.6 To interface and communicate with other systems via MODBUS RTU, IP or LONWORKS.

3.1.2.7 Have the facilities for remote HTML connection to the BMS.

3.1.2.8 Schedule stop/start, set point changes and form of running.

3.1.2.9 An optimal start algorithm based on the schedules, previous day ambient temperature profile, day of the week and month.

3.1.2.10 Programmable load shedding incorporating time of day scheduling.

3.1.2.11 Perform software calculations on real time data monitored by the BMS.

3.1.2.12 Record run-time totalization on monitored plant equipment.

3.1.2.13 The system should also allow escalation trees with the ability to provide both SMS and email reporting as required.

3.1.2.14 Have the option to lockout nuisance alarms.

3.1.2.15 Store, simulate, change and download all DDC strategies to the outstations.

3.1.3 Intelligent stand-alone controllers serving each sub-system (AHU's, chiller system, etc.) that will:

3.1.3.1 Perform the control function in such a manner as to achieve the HVAC design conditions for the building,

3.1.3.2 Provide means to change set points.

3.2 **Password Protection**

3.2.1 Access to the BMS system must be restricted through a password protection facility.

3.2.2 A minimum of 10 alpha-numeric passwords of up to 10 digits shall be provided. Each password shall be assignable to any of 10 levels of authority.

3.2.3 The system shall have the ability to track sessions to determine when each user was logged into the system, and changes each user made.

3.3 System Addressing

3.3.1 System point addressing shall be by English language text identifiers and operating selectors.

3.3.2 Multiple point addressing by plant, location or other set attribute shall be possible both as methods of interrogation and control.

4. OPERATOR INTERFACE

4.1 Operator Interface Hardware

The BMS contractor shall verify that the existing system is suitable to efficiently operate the system.

4.2 Operator Interface Software

4.2.1 The operator software shall be a true multitasking package running on an allocated server under Windows 7 or higher with full Windows compatibility.

4.2.2 The operating software will be required to run on a dual server system, with a test and a production server.

4.2.3 The operating system shall be mouse driven with a full graphical user interface.

4.3 Outstation Controllers

4.3.1 A human machine interface (HMI) plug-in connection on each outstation controller shall provide local display of point conditions on all outstations.

4.3.2 The human machine interface shall be a portable, password protected, plug-in type device, with local alarm notification and acknowledge capability.

4.3.3 Local setpoint adjustment and manual override shall be possible, but any setpoint changes shall be protected by a password system.

4.4 Graphics Screens

4.4.1 Each piece of plant equipment such as chiller, air handling units, fan coil units, chilled water plant, pumps, fans, etc. shall have dedicated graphics screen which indicates control and monitoring parameters, such as scheduling, stop/start, status, sensor readings, etc.

4.4.2 Each plant room shall have a dedicated graphic screen.

4.4.3 Each equipment family will have the appropriate number of overview pages.

4.4.4 Each floor shall have a graphics screen, with appropriate links to the aforementioned equipment screens. All links shall be two-way links.

4.5 Energy Metering Interfaces

4.5.1 There shall be a dedicated graphics screen/s for the water/energy meters.

4.5.2 The BMS is to record chilled water flow rates and supply/return temperatures at each floor branch as to calculate the energy consumption (kWh), calculated as percentage of the related chiller plant's actual power consumption for billing of utilities.

4.5.3 Where multiple tenants share a wing and floor the consumption measured by the applicable meter is to be pro-rated to those tenants.

4.6 **Alarm Monitoring**

4.6.1 The BMS shall have alarm viewing functionality and be able to map the alarm to a particular building The BMS shall graphically show the building and applicable plant, together with the alarm and other relevant information.

4.7 **Off-site Remote Interface**

4.7.1 The system shall have remote login capability and the remote interface shall be based on an HTML interface.

5. INSTALLATION

5.1 Extra-low voltage BMS cables shall be screened twisted pair cables.

5.2 Wiring shall be run in conduit or trunking and protected as agreed with the engineer to suit the various environmental and mechanical conditions.

5.3 Cable specifications shall meet the manufacturer's requirements, particularly respecting over-all resistance and capacitance limits.

5.4 Generally, no joints shall be allowed in cables. Where joints prove necessary up to one joint per run will be accepted, the cables shall be jointed using an approved housing which shall be securely fixed complete with cables securing clamps. The wiring connections shall be soldered with heat shrink. Any such connecting boxes shall be shown on the record drawings.

5.5 No BMS data cable shall be installed in the same conduit as any power cable nor affixed within 25mm if surface/tray/ladder mounted. Where BMS data cables are run in trunking or with other wiring on a tray, the data cables shall be identified either by colour or labels every 2m.

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

5.7 Each BMS field device shall be identified and labeled (space temperature and humidity sensors shall be labeled inside their removable covers) with a common code used on interconnection and wiring schedules, parts lists, control strategy drawings and installation diagrams/drawings.

5.8 All BMS cables shall be suitably identified with sleeves at their terminations. The identification codes shall be recorded on the installation diagrams and wiring schedules.

5.9 Sensors, actuators, switches and all field devices shall be mounted according to the manufacturer's instructions. Field devices shall be installed with ample clearance to allow for servicing. Conduit connections to field devices shall be easily removable to allow for easy replacement of components.

5.10 Where outstations switch circuits having potentially different mains voltage supply feeds, extra low voltage relay circuits shall be employed. A notice shall be fixed inside the outstation detailing how all mains feeding into it can be isolated.

5.11 An additional loop of control cable shall be installed in each riser cupboard and plant room fitted with network cables, but not equipped with an outstation. The cable loop shall be of adequate length to allow future outstations to be fitted and connected to the control cables.

5.12 The network system shall be designed to cater for future expansion.

5.13 The LAN will use Category 6 cable and the minimum port throughput will be 100 Mbps. No 10 Mbps ports will be provided.

6. COMMISSIONING

6.1 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.

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

6.3 Sensors shall be checked to ascertain accuracy within limits.

6.4 Pressure switches checked to switch points and hysteresis.

6.5 All the necessary test equipment and material used in commissioning shall be supplied by the BMS specialists.

6.6 All test equipment shall have valid test certificates.

6.7 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.

7. SERVICE CONTRACT, BUILDING TUNING AND RE-COMMISSIONING

7.1 This tender shall include for a 12 month service contract, which shall maintain the system for a period of 12 months after handover.

7.2 The service contract shall include monthly visits to site, calibration of all instrumentation and checking the functionality of all components of the system.

7.3 A report shall be prepared and submitted to the building manager on a monthly basis.

8. EQUIPMENT CONTROLLED / MONITORED BY THE BMS

8.1 Main Chiller Plantroom

8.1.1 The intelligent stand-alone controllers located within the Plant rooms will provide the control for the A/C plant as shown on the control schematics.

8.1.2 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 chilled water temperature and return chilled water temperature.

8.1.3 The running load amps, percentage output of each chiller, cooling output of each chiller and COP of each chiller shall be monitored; further to this the total cooling of the chilled water plant, total electrical load and total plant COP shall be indicated on the BMS.

8.1.4 The chiller will either have a BACNET MSTP or BACNET IP communication interface.

8.2 **Air Handling Units**

De-centralized variable air volume and constant volume chilled water air handling units are located throughout the building. Individual, stand-alone controllers will provide the control as indicated on control schematics.

CO_2 monitoring and control is allowed for via fresh air fans with VSDs or actuated dampers on the AHUs.

8.3 **Ventilation Systems**

The BMS shall provide stop/start signal and monitor the status and alarm condition of all ventilation fans.

8.4 **Basement Extraction**

The BMS shall provide stop/start signal and monitor the status and alarm condition of all ventilation fans. In addition it will provide the monitoring of CO levels throughout the basement and the control of the extract fans speeds based on the CO levels.

8.5 **Points List**

The following point's lists shall be read in conjunction with this document.

8.6 **Bill of Quantities**

The points list constitutes the bill of quantities

V.D7.02 - ELECTRICAL SYSTEMS

1. **GENERAL REQUIREMENTS**

The installation in its entirety shall be designed, engineered, installed and rendered serviceable in complete accordance with the following: -

a) South African Bureau of Standards, Code of Practice 10142-2006 for the Wiring of Premises.
b) All by-laws and ordinances of the relevant supply authorities.
c) Any particular requirements of this specification and drawings attached hereto.
d) The performance of the equipment offered shall be suitable for operation under the parameters detailed for :

i. Site Connections
ii. System Details

Any deviation from this specification shall be conditional upon the written approval of the Architect or his appointed representative.

The Contractor shall employ the services of an electrical specialist who shall be responsible for the application, engineering, documentation, supply, installation, commissioning and maintenance of the electrical system.

The installation in its entirety shall be in full conformity with the requirements of the local by-laws, supply authorities and with the requirements of all further authorities having jurisdiction.

Material and apparatus shall be in accordance with the relevant SANS or BS Standards. The former shall have precedence over the latter when both bodies have issued conflicting specifications or Coded of Practice.

The Contractor shall secure approval of all authorities as required for materials, equipment and installation.

The Architect or his representative reserves the right to call for test certificates and characteristic curves of every item of equipment to prove compliance with the standard to which it is built and to prove compliance with the specification regarding performance.

Test certificates shall be issued by a recognised testing authority and shall be submitted at the time called for.

Every care shall be taken to protect material, either fixed or unfixed, from damage.

All items shall be protected against the ingress of dust and moisture, so that no damage results to items and systems. All large items, requiring removal and exceeding 25 kg in weight, shall be fitted with lifting lugs or eyes.

All items of equipment mounted outdoors, equipment in air handling units and equipment mounted in a wet or possibly wet environment, shall be weatherproof.

Supply and installation shall include all equipment detailed on the approved shop drawings and wiring diagrams.

Commissioning shall include the validation of the systems as detailed on the shop drawings and wiring diagrams, and demonstrating that the electrical system does in fact provide the sequence of operation, control and safety operation as detailed on the approved wiring diagrams.

In addition, commissioning will involve the close co-operation of the electrical specialist contractor with the Contractor and operation and automatic control system contractor in adjusting the electrical system to provide the results intended.

The equipment, such as the starters, contactors, relays, etc., used in the electrical installation shall; be fully catalogued products and documentation shall include installation, testing, maintenance instructions and performance curves or selection tables for the expected range of operational conditions.

Methods of recording and presentation shall be suitable for incorporation in the Operating and Maintenance Manual, and for display in the plantrooms.

All items of the electrical installation shall be readily accessible for quick and easy replacement.

Adequate space shall be provided around all items for easy removal or parts.

2. CABLING

Particular care shall be taken with the selection and installation of cables to ensure that all parameters such as environment fault level, voltage drop and group de-rating factors are given full consideration.

Precaution shall be taken to prevent the ingress of water into cables.

Weather exposed cabling to be in bosal conduit

Bending radii for cables shall be as large as possible. No radius shall in any event, during installation or when permanently installed, be less than the following: -

11 000 V grade	:	minimum	12 x Outside diameter
3 300 V grade	:	minimum	8 x Outside diameter
600/1 000 V grade	:	minimum	8 x Outside diameter
250 V grade	:	minimum	6 x Outside diameter

Where cables are clamped, cleated, strapped or bound to racks, the Contractor shall ensure that no sagging occurs, and that the pressure exerted by these fixing devices is not detrimental to the cable performance. Cables shall be clamped, cleated, strapped or bound to racks when in a vertical disposition at intervals not exceeding 0,5 metres whilst horizontally disposed cables shall be secured at intervals not exceeding 3 metres.

Care shall be exercised in the laying of the cables to prevent excessive crossing.

All cables shall be adequately supported during their installation to prevent undue internal stresses, particularly in the vertical configurations.

Each and every cable shall have permanently attached to it, at each end and at every 10 metres throughout its length, a label to exclusively identify the cable. The label shall be of the light gauge alloy, adhesive backed, "Dyna" type.

The characters embossed upon these labels shall be of a minimum of 3 mm high and shall correlate to the relevant cable number as depicted on the cable schedules.

2.1 Terminations

All terminations shall be carried out in a neat and orderly manner, particular care being taken to ensure that armourings form an effective earth path with all gland lock nuts, etc., being adequately tightened. Gland shrouds shall be fitted. All control cable cores shall be effectively identified by means of ferrules, the number correlating to the relevant inter-connection on the wiring diagram.

Where control connections are collectively marshalled in a common box, particular care shall be taken to ensure neat and orderly wiring looms with no undue crossing at the "crutch" points. Conductors shall be fitted with a "crimp type spade ferrule, before being inserted in the terminal box. The Contractor shall check that marshalling box identification labels correlate to the relevant diagrams.

Cable Testing

Upon completion of the installation of the cables, prior to actual termination, each and every cable shall be effectively tested for insulation breakdown and core continuity.

All cables shall be effectively tested for insulation breakdown with a 2 kV "Megger". Core and earth continuity tests shall be carried out.

Where control and power cables are terminated within equipment, every precaution shall be taken to ensure that the conductors are correctly terminated, to obviate cross connections of the power and control circuits.

All power connections to motors shall be checked, prior to dry running of machines, to ensure that the directional requirements of the equipment are correct.

All lugs fitted to cables shall be selected to ensure a good joint. Oversized holes and crimp tubes shall not be acceptable.

Lug barrels shall be sleeved where it is apparent that loose connections on motor/equipment studs could come into contact with each other or 'earth'.

The specialist Contractor shall ensure that all 'lock nuts' on equipment terminals are replaced and tightened.

Where it is apparent that vibration of equipment will occur, a loop of sufficient length shall be left between the static cable side and the equipment connection point.

3. MOTORS

Motors shall be liberally rated for the duty with due allowance made for temperature, altitude and possible variations in voltage. Motor ratings shall however, not exceed 120% of the required capacity.

Motor ratings shall not only be based on the full load requirements but motor capacity and starting characteristics shall be compatible with the requirements of the driven equipment. Motors shall be current catalogued products, preferably of South African Origin, and documentation shall include performance curves for expected range of operational conditions.

Motors shall comply with SABS 948, BS 2613 and/or BS 170 or other applicable standards of their country of manufacture.

Motors shall be protected against:-

a) Overloads - provide adjustable thermal overload protection in all three phase legs capable of positive tripping at full load.
b) Single phasing - provide single phasing protection operative down to 45% of motor rating, independent of overload setting.
c) Short circuit - provide HRC fused switch or MCCB for starter back-up protection and motor short circuit protection.
d) Motors in excess of 200 kW rating shall embody a device which directly monitors the winding temperature for the class of insulation employed.

The power factor of motors, with capacities of 20 kW or more, shall not be less than 0,9 lagging under the operating conditions.

Motors shall normally be of the totally enclosed fan cooled type.

All motors of the air conditioning installation shall be of the same make or of the same interchangeable frame type. Variation in type and size shall be limited, wherever possible, to avoid duplication of spares.

In case of imported motors on equipment not kept in stock in South Africa, one spare motor for each 10 of the same type and size of motor shall be supplied to the building owner.

4. SWITCHGEAR

4.1 Definition

Fault level - The specified design fault level shall be deemed to be the symmetrical fault power available under short circuit conditions to the incoming terminals of the switchgear and subsequent interruptors, conductors, current transformers and the line side of the limiting device.

Fault duration - Shall be considered as the maximum period for which the equipment will be subject to the abovementioned fault condition. For the purpose of this specification, the period of fault duration shall be assumed to be equal to one second.

4.2 Design

Whilst all equipment shall be designed and manufactured in accordance with the aforementioned standards and accepted codes of practice, the following practices may be adopted providing that the vendor submits full details of his proposals.

Each section of centre fed busbars shall be rated at half the nominal requirements with loads distributed equally over each half of the bus-run.

Fuses of MCCB's shall be provided for the purpose of 'back-up' protection.

Where fuses are employed, starters up to 80 kW will be fitted with safety holders to BSS 88 whilst fuses in excess of 80 kW will be the bolted link type.

A control bus capable of being open circuited via an emergency stop operated relay shall be employed where an isolator is employed as an incoming device. This system shall be fail safe.

Where circuit breakers are employed, the 'Emergency Stop' shall cause a shunt trip mechanism to function.

5. SWITCHBOARDS

5.1 Construction Details

General - The switchboards shall be of a folded type cubicle construction to render a robust arrangement with a pleasant appearance.

Each cubicle shall be self contained and hold only the equipment for one circuit. Cubicles shall be capable of being isolated and the equipment therein being worked on without interfering with other equipment.

Particular attention shall be paid to the mounting of internal sub-assemblies with reference to their ability to withstand the dynamic stresses arising from the passage of fault currents at the anticipated levels.

Dust and vermin proofing - Where doors or removable covers are employed, dust proofing shall be achieved by means of gaskets of a suitable material and section.

This material shall be resistant to deterioration from the effects of heat, chemicals and moisture etc. it is preferred that these gaskets be of a minimum thickness of 10 mm compressible to half the original thickness.

The abovementioned gaskets shall be affixed by a suitable adhesive to the door or cover.

Suitable arrangements shall prevent the ingress of insects or vermin to any part of the switchgear.

Ventilation - Should the manufacturer's particular design necessitate ventilation to prevent the accumulation of ionised air, the manufacturer shall provide the necessary louvered openings.

Panel fixing and accessories - All door handles, catches and locks, etc., employed for the purpose of fastening doors or the fixing of removable covers shall be cadmium or chromium plated.

"Nelbar" type square key latching devices shall be utilised to secure doors or lift-off panels. Half turn knurled bolt arrangements will NOT be acceptable.

Where part of any device such as the abovementioned catches, pushbuttons or indication lights etc., pass through a door or panel, felt or neoprene washers shall prevent the contact of the devices with the panel paintwork.

Concealed hinge arrangements are preferred. However, plated projecting hinges are acceptable. All hinges shall be adjustable.

General Fixings - Under no circumstances will the use of self-tapping screws be acceptable other than for the purpose of affixing labels.

"Hank Nuts" washers and spring washers shall be suitably treated against oxidisation. Untreated mild steel bolts etc. will NOT be acceptable.

Lifting and loading facilities - The units shall be manufactured in such a manner that the maximum length of any section does not exceed 3 metres.

The manufacturer shall provide a lifting/loading diagram.

Each section shall be provided with ample lifting facilities so arranged that stresses, incidental to shipping, create no distortion to any part of the section.

Painting and finishing - All metal work shall be eradicated of grease, rust and 'millscale' before the application of self-etching zinc chromate primer.

The primer shall be followed as soon as possible by two coats of the best quality air drying enamel paint to BSS 381C. Paint shall be to an approved colour. The interior finish shall be semi-matt white.

A suitable quantity of exterior and interior paint shall be supplied for the purpose of final touching-up on site after erection.

5.2 Electrical Details

Incoming/Outgoing connections - Adequate space shall be allocated by the manufacturer for the satisfactory entry and termination of all cables.

For cables entering from trenches or ducts, the manufacturer may assume that a depth of 500 mm has been allowed for the transposition of all cables.

Gland plates shall be 16 swg 'blank' sectioned type and the manufacturer shall supply chassis punches to cover all sizes of glands (No. 0-5). The punches shall be guaranteed to cut the requisite number of holes. Collector bars or suitable connection flange shall be employed where the cables are of non-flexible type or more than one cable is to be terminated. Where single core cables are brought through a gland plate, special care shall be taken with respect of "Eddy currents". The glandplates shall be magnetically split by means of a suitable non-ferrous material.

Power terminals shall be grouped in the lower section of each cubicle and shall be the bar and bolt type, with the exception of termination of under 16 mm sq., which shall be of the conductor clamping type.

Control wiring shall be done in multi-stranded wiring (min. 1,5mm) 1100 V PVC. Any wire shall be identified at both ends by means of a "Critchley" type ferrule and shall be correlated to the relevant schematic/wiring diagram. Colour of wire shall match the phase from which it originates.

Where several sets of control wires terminate in one area, the terminal block shall be numbered with the corresponding wire number.

All wiring shall be neatly done and finished; either with the aid of approved wiring channel or laced with best quality lacing material at suitable intervals.

Sufficient slack of wire shall be allowed at all outlet points to enable the use of clip-on ammeters, etc. and such slack wire shall be neatly disposed.

The wiring shall be so disposed at the hinged side of the door to ensure that opening and closing does not impose stress on the wiring.

All small power and control wiring to external circuits shall be wired to a numbered terminal strip with not more than two wires being fixed to any one terminal.

Terminal blocks shall be suitable for mounting on standard channels and shall include at least 12 spare terminals for future extensions.

Multiple ratio current transformers shall be wired to a terminal block accessible from the front of the switchboard. The terminal block shall have provision for selecting the ratio required and for short circuiting windings not required.

Where multi-core cables are brought into the board, they shall be properly finished-off at the entry point and the cores terminated at an enclosed terminal strip for connection to the board wiring.

Incoming Circuit Breakers - Where incoming supplies are controlled via a circuit breaker, these shall be of the air withdrawable pattern.

Shutters shall be provided on the fixed section to screen automatically any inadvertent contact with live contacts.

Closing mechanisms of the abovementioned circuit breakers shall be of the hand-charged spring release type.

Tripping shall be caused by all three of the following functions:

a) Local manual
b) O/C and E/F D M T units
c) 220 V A.C shunt trip

Incoming circuit breaker cubicles shall be fitted with a busbar connected, selective phase to phase and phase to neutral reading voltmeter along with a selective line and out of balance reading ammeter.

Paralleling of supplies onto a common busbar shall be prevented by the employment of suitable interlocks, i.e. the fitting of the aforementioned circuit breakers with Ronis type locks, interchangeable with the bus-section switch.

Bus-section switches shall be of the load break/fault make type isolator.

Isolators employed as incoming switching devices shall be of the load break/fault make type.

Busbars shall be contained in separate chambers and shall be effectively screened against accidental contact and the ingress of undesirable materials.

All busbars and associated connections shall be adequately rated with due regard to temperature rise, altitude, proximity effects, and fault capacity. Phase to phase, and phase to earth clearances shall be measured by the taut string method and shall be in excess of those stipulated in BSS 162 for this class of equipment.

It is preferred that the major axis for any busbar be in the vertical plane, support arrangements shall obviate the possibilities of contact under short circuit conditions.

All busbar joints and taps shall be so constructed as to restrict temperature increase to acceptable limits as detailed in BSS 159.

High-tension bolts shall be employed for all electrical connections

Where dissimilar materials are jointed, consideration shall be given to any electrolytic or chemical reactions.

Oxidization of joint surfaces shall be prevented by means of a suitable compound or tinning process.

Service feeder circuits, where required, shall be equipped with suitably rated MCB'S or C.F.S. units.

Outgoing power connections shall be achieved by means of rear connections studs.

The configuration of these circuits shall facilitate easy connections of the cables.

5.3 Motor Starting Circuits

All line components associated with motor starting circuits shall have a rating at least 10% higher than the maximum imposed loads and in addition shall be rated for:

a) Overcurrents anticipated during the operating time of its own overload tripping device.

b) Fault currents (left through) by the circuit back-up protection device with due regard to the clearance time.

In starters employing more than one stage the changeover from initial to subsequent stages shall be automatic. Contactors shall be interlocked to prevent starting in the incorrect stage.

All motor starting contactors shall be fitted with thermal overload tripping devices with single phasing or differential characteristics.

Protective tripping device shall be of the manual reset type and shall provide for protection under all conditions of motor operation. The overload tripping device shall be adjustable within a range of 75 to 125% of motor rating. Alternative protection by electronic means incorporated overload trips and single phase protection will be considered subject to approval.

Starters and contactors shall be current catalogued products and documentation shall include full performance data.

The following equipment or approved equal shall be used:

Sprecher and Schuh

Siemens

Telemecanique

Klockner Moeller

Allenwest

MTE

Cutler Hammer

Merlin and Gerin

Starters mounted separately shall be of the duct, damp, vermin proof and totally enclosed metal clad type.

Each starter or contactor shall be complete with 3 current transformers for the ammeters in the integrated control panel. The ammeter shall be sized for the motor rating which shall not exceed 75% of the scale and be less than 25% of the scale. The ammeter shall be suitable to withstand the starting current and any fault current. Unless otherwise indicated, motors of 20 kW or more shall have Star Delta rating.

Starter and contactors shall have auxiliary contacts for remote fault condition, and status indication and interlocking required for the sequence of operation as specified.

The starter or contactor shall be so constructed and installed that either a sub-component replacement or total removal and re-installation of the entire starter or contactor will not take longer than one hour by a skilled electrician.

Wherever technically possible, all starters or contactors or relays shall be of the same make or type and size to reduce the number of spares.

The Electrical Contractor shall supply one spare contactor and relay for each 5 items of the same type and size.

Earthing - A continuous copper earth bar shall run the whole length of any switchboards. The cross sectional area of this bar shall be sufficient to carry the anticipated asymmetrical fault currents for the specified time.

In any event the abovementioned earth bar shall not be less than 25 x 6 mm H.D.C.

Adequate arrangements shall facilitate the connection of a fourth core of any motor cable to this earth bar.

Suitable section brass studs and lugs shall be supplied at both ends of the switchboard for incorporation into the earthing system.

6. STANDARDS

The following equipment shall comply with the relevant South African Bureau of Standards (where available) and/or the British equivalent:

		SABS	BSS
Switchgear in general	:	-	162
Circuit Breakers	:	156	4752
Isolators	:	152	5419
Busbars	:	784 & 1195	158 & 159
Fuses	:	172	88
Contactors	:	1092	5424
Motor Starters	:	-	587
Indicating Instruments	:	-	89
Current Transformers	:	-	3938

7. GENERAL

7.1 Labels

Main designation labels shall be fitted to the centre of each complete MCC or distribution board.

Each cell or compartment shall have its function or reference indicated by a label. A circuit breaker supplying power for secondary services shall be separately labelled, and all power circuits shall be labelled with their relevant references.

Control circuit breakers, indication lamps and pushbuttons and other similar control devices shall be labelled in accordance with their respective functions.

Labels shall be of the engraved white on black Traffolyte type, and shall be affixed by self-tapping screws or a suitable adhesive.

Character sizes for the various labels will be as follows :

Main Labels	:	25 mm
Cell, Circuit or Compartment labels	:	12 mm
All other labels	:	4 mm

7.2 Plenum Lights

Lights consisting of watertight bulkhead type fittings shall be provided in each section of the air handling plenum including the air washers.

The light shall be controlled by a switch on the outside of the plenum and on/off position indicated by a pilot light.

7.3 Information and Drawings

The specialist Contractor shall produce, in triplicate within two weeks of receipt of the contract, or in accordance with the agreed programme, the following data:

a) Final arrangement drawings
b) Fully detailed section drawings
c) Schematic and line diagrams
d) Descriptive literature and pamphlets of all electrical components employed in the manufacture of this switchgear
e) Test certificates
f) Comprehensive and schedule of spares

7.4 Factory Inspection and Tests

It shall be possible at any stage for a representative of the employer to inspect the work in progress.

On completion of the contract, the following tests and inspections will be conducted by the manufacturer and witnessed by the employer's representative.

a) Compliance with the specification
b) A full series of primary injection tests
c) A full series of pressure tests on all wiring
d) Functional tests on all circuits and associated equipment

8. ELECTRICITY SUPPLY SCHEDULE

Supply voltage	: 400V
Fault rating	: 50kA

V.D7.03 - WATER CONDITIONING SYSTEM

The Contractor shall employ the services of a reputable water treatment firm who shall be responsible for the application, engineering, documentation, supply, installation, commissioning and maintenance of the water conditioning system, to control corrosion, algae and sludge for each building.

All equipment for the installation shall be supplied and installed by a firm properly established in the Republic of South Africa which is regularly engaged in the installation, maintenance and administration and monitoring of these types of water conditioning programmes.

A detailed standard maintenance, service, administering and monitoring contract shall be submitted to the air conditioning Contractor by the water treatment firm for this particular installation stating rates of charges and total year costs. This contract may be taken over by the Employer of the installation after the contractor's one-year guarantee period has elapsed.

The water conditioning programme shall be for the open and closed water systems and shall commence with the start-up of the refrigeration and air conditioning equipment.

Chemicals used for water conditioning and the methods to feed the chemicals shall comply with local by-laws.

Sufficient chemicals shall be provided for both normal and abnormal operating conditions of the water conditioning system during the one-year free maintenance and guarantee maintenance and guarantee period.

Chemicals used for the water conditioning shall not have detrimental effect on non-metallic materials, such as rubber or wood used in the system.

The system shall include side-stream filtration

The maintenance and service contract shall provide: -

a) A complete analysis of the water to be used for make-up in the systems.
b) Details of the chemical compounds used.
c) Concentrations of chemicals to be maintained in the condenser water, chilled water, hot water and spray water systems.
d) Type and frequency of service.

The water treatment programme shall provide the following:

Corrosion Control

Corrosion control shall be provided for all water circuits by using suitable corrosion inhibitors and pH control.

Corrosion shall be judged under control when the overall corrosion rate does not exceed 5 micron per year for steel and 1 micron per 1 year for copper on any section of the circuit in continuous contact with the conditioned water.

Overall corrosion and pitting rates shall be measured by the use of suitable corrosion test coupons representing the metals in the circuit.

If overall corrosion and/or pitting exceeds the maximum allowable rate, an immediate re-test shall be made.

If the results of the re-test are within the maximum allowable rate, corrosion shall be considered to be under control.

Scale Control

Formation of adherent mineral deposits which cannot be flushed from heat transfer surfaces shall be prevented.

A continuous bleed-off shall be specified for the cooling towers and spray section of air handling units.

Internal chemical treatment of water in the circuit and/or external treatment of the make-up water shall be provided when bleed-off is uneconomical because of excessive use of corrosion inhibitors.

The electrical conductivity of the re-circulated water shall be used to control amount of chemical feed.

Algae and Slime Control

Algae and slime growth shall be prevented in all circuits by using suitable algaecides. Algaecides, which may cause damage to equipment, shall not be used.

Chemical Feeding

Chemicals shall be fed to circuits requiring continuous make-up by automatic proportional feeding devices.

Acid feeders when used shall be controlled by an electronic pH controller.

Service Procedure

The water conditioning company shall provide manual instructions and suitable kits for operating personnel for the maintenance and control of the water conditioning programme.

Periodic service of water analysis and corrosion control tests will be made at intervals as necessary to ensure proper control of corrosion, scale, algae and slime.

Reports of service call, water analyses, corrosion tests, etc. shall be submitted by the water conditioning company, in accordance with a pre-arranged schedule.

V.D10.01.04 SPLIT TYPE AIR-CONDITIONING UNIT COMPLETE WITH REMOTE AIR-COOLED CONDENSER

1. Supply, install and commission the inverter type air-conditioning units as shown on the drawings and with performance as listed in the schedule.

2. Controls and protective devices shall be factory wired and located in a readily accessible location. Control box shall be removable from front of unit.

3. The performance of the unit shall be fully documented and certified by a certifying authority in control of manufacture and/or ARI standard instrumentation ± 5%

and/or SABS and CSIR for South African manufactured products. The documentation shall include:

a) Sound power data for the octave band mid frequencies of 63 to 8000Hz, measured in enclosure and outside the enclosure as indicated on the arrangement drawing.
b) The performance curves or tables stating Total and Sensible Cooling capacities with power absorbed, all at the altitude shown in the design conditions, for the following range of operating conditions:

Entering Air Dry Bulb to evaporator 20 to 25 ºC.

Entering Air Wet Bulb to evaporator 14 to 19 ºC.

c) The possible percentage variations of data measured on site (with calibrated and certified instrumentation) compared to the catalogued performance data.

4. The unit shall be fully protected and shall be fail-safe. Minimum safety protection, caused by possible external abnormal conditions, shall be provided for the following and require manual reset after fault occurrence:

a) High discharge pressure.
b) Low suction pressure.
c) Thermal overload for single phase motors.
d) Combined thermal overload and phase-failure for three phase motors.
e) Over/under voltage protection.

5. The unit capacity shall be controlled by a control switch and adjustable thermostat. Thermostat shall switch on the compressor automatically in accordance with the load. Appearance, finish and colour of exposed thermostats shall be to Architects approval. All controller set points shall be adjustable over a small range to enable fine-tuning to take place in the field.

6. Controllers shall be hard-wired and wall mounted if option is available. The HVAC contractor shall co-ordinate his requirements and the positions of controllers with the electrical contractor.

7. Each unit shall be equipped with the necessary interface to enable it to be linked to a central controller which in turn shall be linked to a third-party web based controller which will be used for scheduling, temperature and air flow rate set points and limitations, logging of historic trend data and group control of various areas and services, as specified under part V.D.7.01.03.

8. In addition to 3 above the Contractor shall submit the following: -

a) Installation and operating manual with check-out and start-up procedures;
b) Normal and emergency operating instructions;
c) Trouble analysis guide;
d) Number and details of periodic services for recommended preventative maintenance programme;
e) Warranty policy - Minimum requirement shall be one year for entire unit and 5 years for refrigeration equipment and accessories.

NOTE: Warranty shall commence with the beneficial use of the equipment when set in operation.

9. The minimum selected service life for which the unit has been engineered and components selected when operated under normal building conditions with optimum servicing and maintenance, shall be 15 years with 5000 operating hours and 1000 stop and starts per annum.

10. The Engineer reserves the right to call for:

a) Test certificates and reports from the Supplier's quality control laboratory and independent test laboratory such as SABS, and/or.
b) Site inspections, customer reports, references and user's interviews, and/or.
c) Full engineering, design and components selection details.

11. The units shall comply with regard to electrical safety and supply interference suppression requirements of SABS and/or local authorities by-laws. The units shall also comply with safety codes for mechanical refrigeration ASA-B9. l.

12. Special care shall be taken in crating, transport, delivery and instruction for storage on site to ensure that the units can be installed in "as new" condition.

13. The overall unit dimensions including mounting details shall not exceed those shown on the drawing. The Contractor shall check the proposed enclosure and ducting details and ensure that all necessary provisions are made for the servicing and maintaining of the units in accordance with the supplier’s service and maintenance instructions.

14. The unit shall be of the air-cooled, split type complete with inverter compressor(s), fan(s), filters, coils (remote condenser) electrics and safety controls.

15. The unit shall not drum, vibrate or leak under any operating conditions. Parts used in the construction of the units shall have adequate strength and the overall construction and installation shall ensure satisfactory operation under normal service conditions.

16. The air discharge of the air-conditioning units shall be as shown on the drawing.

17. Evaporator fan shall be of the direct-drive centrifugal type.

18. Units shall be furnished with washable filters, filtering the evaporator air. Mounting arrangements for filter shall obviate bypass of untreated air. Filters shall be easily removable from units.

19. Units shall be equipped with a hot dipped galvanized drain pan of sufficient size to trap condensate.

20. All electrical components of the unit shall be suitable for power supply of 380/220V with a variation of +- 10% without any modification to the basic unit.

21. The Contractor shall submit, based on the unit manufacturer's noise criteria curves, certified sound insulation calculations from a noise expert for the enclosure including detailed construction and acoustic insulation drawings. The noise expert shall guarantee a noise level not exceeding the design values listed in Part VC for the enclosure for the specified maximum operating conditions.

22. Refrigerant shall be R410a, shall be non-toxic, non-flammable and odourless, with a zero-ozone depletion potential and low global warming potential. R-22 gas will not be accepted. In the event the contractor was to recommend the use of a different refrigerant, approval shall be obtained from the Mechanical Engineer.

23. All condenser coils shall be protected from possible damage by hail by hail-guards.

24. Units shall be capable of operating safely (at reduced capacity) without tripping at an ambient temperature of 40ºC.

25. Units shall be reverse cycle to provide heating (heat pump). A defrost cycle shall automatically be activated.

26. Units shall be equipped with variable speed (Inverter) type compressors.

27. Fan motors shall be of the EC (Electronically Commutated) type.

28. Each indoor unit shall have the ability to be connected to an absence detection sensor which will switch the unit off after a period of time that no occupancy is sensed inside the space. The sensor shall be provided by the electrician.

29. The units shall be equipped with the following features:

    a) Rotation and Back up functions
    b) Temperature Range Restriction
    c) Operation lock
    d) Auto Changeover
    e) High performance Groove piping used in Heat Exchangers

PERFORMANCE SCHEDULE

<u>Note:</u> The unit schedule shown in the BoQ indicates actual design capacities, and therefore unit selections must be de-rated for the following, and selected to satisfy both sensible and total capacity:

- **Altitude = 1400m**
- **Indoor conditions – 22.5^{O}C DB, 50%RH**
- **Summer (on-coil) = 25.1^{O}C DB, 17.1^{O}C WB**
- **Outdoor conditions = 35^{O}C DB**

- **Piping length and height**

Refer to the BoQ for identification.

V.D11.01- CHILLED WATER FAN COIL UNIT

1. Supply and install the fan coil units of the type and duty listed in the schedule and as shown on the drawings.

2. Fan coil units shall be complete with hard wired controller, BACNET P.C interface card, supply and return plenums with hinges return air grille with filter, chilled water connections, motorised 2-way control valves (3-way for end-of-runs). Connection by HVAC contractor to adjacent isolator provided by others. CHW coil & electric heating.

3. The performance of the unit shall be fully documented and certified by a verifying authority in country of manufacture and/or AIR standard instrumentation + - 5% and/or SABS and CSIR for South African manufactured products. The documentation shall include: -

4.1 Performance curves or tables stating Total and Sensible and Cooling capacities with required chilled water quantity with entering and leaving conditions and at the altitude shown in the schedule.

4.2 Sound power data for the octave band mid frequencies of 63 to 8000 Hz, measured 1 m from the unit.

4.3 The possible percentage variation of data measured on site (with calibrated and certified instrumentation) compared to the catalogued performance data.

4. The unit shall be fully protected and shall fail-safe. Minimum safety protection, caused by possible external abnormal conditions, shall be provided for the following, and require manual reset after fault occurrence: -

    i. Thermal overloads for single-phase motors.

    ii. Heater high temperature cut-out - sensor shall sense over the full width of the heater.

    iii. The heater shall be interlocked with the fan.

5. The units shall be capable of operating at the external static pressure required and deliver the stated air quantity and capacity.

6. Controls and protective devices shall be factory wired and located in a readily accessible location.

7. The equipment shall be selected for a minimum service life of 10 years, operating 24 hours per day under full and part load conditions.

8. The units shall comply with regard to electrical safety and supply interference suppression requirements of SABS and/or local authorities by-laws and/or regulations.

9. Special care shall be taken in crating, transport, delivery, and instructions for storage on site to ensure that the units can be installed in "as new" conditions.

10. The overall unit dimensions including mounting details shall not exceed those shown on the drawing. The contractor shall check the proposed access and installation details and ensure that all necessary provisions (including possible breakdown in sections) are made for the installation, servicing, and maintenance of the units.

11. The unit shall not drum, vibrate or leak under any operating conditions. Parts used in the construction and installation shall ensure satisfactory operation under normal service conditions.

12. The filter carrier shall be suitable for standard commercial range of filter elements and filter media available and shall permit easy removal of the filters.

13. The filter media shall be of the washable type.

14. Fans may be either modular direct drive or V-belt drive with lifetime lubricated self-aligning ball bearings, all dynamically balanced.

15. Noise levels in the conditioned space shall not exceed the specified levels.

16. Condensate shall not come into contract with the fan.A hot dipped galvanised or stainless-steel condensate tray with drain connection shall be provided.

17. Coils shall be copper tubing with aluminium fins.

18. The unit shall be complete with a 2m flexible electrical cord and shall be wired into the isolator provided.

19. Casings (where required) shall be epoxy powder coated to an approved colour and shall be removable without tools.

20. Units shall be complete with internally insulated discharge and return plenums, spigots for insulated flexible connections, internally insulated ceiling drop in plenum box with hinged aluminium grille with filter.

PERFORMANCE SCHEDULE

Chilled water entering temperature : 8°C

Chilled water leaving temperature : 14.0°C

Altitude : 1750 m

Select on high static medium speed

V.D12.01 - FACTORY FABRICATED VAV AIR HANDLING UNITS

1. Supply, install and commission, as shown on drawings factory assembled central station air handling units of sectional construction.

2. The unit shall have the following main components: -

2.1 Weatherproof Casings with access doors
2.2 Air filters (washable)
2.3 Chilled water-cooling coil assembly
2.4 Centrifugal fan
2.5 Electric heater bank
2.6 Motor control centre
2.7 Indoor lights in filter and fan plenums

3. The unit and its components shall be a fully catalogued product and the documentation shall include performance curve, or selection tables for the expected range of operating conditions.

4. Submit at the time of equipment submissions, for all the components (except the casing).

4.1 Certified selection shown on these performance curves or tables.

4.2 Full installation, operating, testing, balancing and commissioning instructions and trouble analysis guide.

4.3 Service and maintenance instructions.

5. The unit shall be fully protected and fail safe.

6. The unit shall be engineered, and components selected for a minimum service life of 15 years with 3000 operating hours per annum.

7. The units shall comply with all authorities and by-laws.

8. Special care shall be taken in transport, delivery, storage on site and installation to ensure that the units are installed and maintained in "as new" condition at start-up.

9. Noise levels in the conditioned space through operation of the unit at any operating point shall not exceed the specified room noise level.

10. The overall unit dimensions including mounting details shall not exceed those shown on the arrangement drawing. The supplier shall check the proposed access and installation details and ensure that all necessary provisions (including possible breakdown in sections) are made for the installation, servicing and maintenance of the units in accordance with his service and maintenance instructions and contract.

11. CASING

11.1 Casing shall be of rigid and durable construction and shall be selected for an average life of 15 years under normal building operating conditions.

11.2 The required unobstructed space shall be left around the casing for maintenance and service of the unit components.

11.3 Casing shall not leak, vibrate or drum under operating conditions.

11.4 Water shall not condense or leak onto the floor of the casing.

11.5 Casing panels shall be easily removable for access to the interior.

11.6 Casings shall be:-

a) Sectional construction rigidly braced and bolted.
b) Single skin insulated in accordance with Clause 9 of Part IV.
c) All parts shall be hot dipped galvanised - epoxy coated to an approved colour.

11.7 Sleeves shall be provided where panels are pierced for the purpose of introducing services. Void and sleeves shall be filled with insulation.

11.8 Where units are exposed to the weather casing shall be fully protected and waterproofed. Plastic locking mechanisms will not be accepted, and container door type mechanisms are preferred or equal approved

11.9 Plenum Lights

Lights consisting of watertight bulkhead type fittings shall be provided in each section of the air handling plenum including the air washers.

The light shall be controlled by a switch on the outside of the plenum and on/off position indicated by a pilot light.

11.10 The roof mounted units shall be all weather, waterproof units. The roof shall be sloped, or an independent, removable and replaceable sloping roof shall be provided for each unit.

12. WASHABLE AIR FILTERS

12.1 The filter bank shall be so constructed and installed, and necessary access provided to make it possible to change one filter element in five minutes.

12.2 Filter material shall be fire resistant.

12.3 Filters shall be adequately protected against dirt during construction and shall not be operated until system is thoroughly cleaned.

12.4 After all the adjustments, etc. are completed and before the filters are accepted for regular operation, these shall be cleaned.

12.5 Filters must be put in regular operating conditions before the fans are operated for any purpose such as temporary ventilation or adjusting.

12.6 The filter frame shall be suitable for standard commercial range of filter media available.

12.7 Filter elements shall be removable from the front of the unit.

12.8 Adequate personnel access shall be provided in front of filter bank.

12.9 The filter elements and filter frame shall be fully corrosion protected. Construction of filter frame, and method of holding down filter elements shall ensure no passage of unfiltered air through filter bank.

12.10 Include space in the filter frames for secondary filters for a combined EU7 rating

13. CHILLED WATER-COOLING COIL ASSEMBLY

13.1 The coil bank shall be so constructed and installed that hosing down or cleaning of the coils shall not take longer than 15 minutes when executed by one maintenance person with one helper, while removal and replacement of individual coils shall not take longer than 1 day.

13.2 Complete coil including headers, connections and tubes shall be tested to 2000 kPa and shall be rated for operating at 1700 kPa.

13.3 Coils having loose or damaged fins and distorted tubing, or dents will be rejected and must be replaced with new coils.

13.4 The bottom condensate tray shall be installed on 25 mm thick insulation with thermal conductivity of not more than 0,04 W/mºC.

13.5 Insulation shall be resistant to decay and mildew and shall be water impervious.

13.6 The installation details of the coil shall be such that any coil can be installed from the side.

13.7 No moisture shall be carried beyond the sump under any operating condition.

13.8 Condensate trays shall be hot dipped galvanised with drain connections.

13.9 Coil shall consist of copper tubes with aluminium fins. Coil supports shall be copper or stainless steel.

13.10 The maximum fin spacing shall not be more than 4 fins per 10 mm.

13.11 Coils shall be of the plate fin extended surface type.

13.12 Coils shall be arranged for counter flow of air to cooling medium and no by-pass of untreated air shall occur.

13.13 Suitable baffling shall be provided, if required, to ensure uniform coil velocity.

13.14 Coils shall not distort or vibrate in operation.

14. CENTRIFUGAL FAN

14.1 Air quantity shall be manually adjustable or automatically adjustable with variable speed drive as indicated. The fan shall be fully catalogued product and the documentation shall include sound power level spectrum, performance curves and/or tables for the operational condition.

14.2 All variable volume units shall be fitted with DANFOSS speed controls or equal and approved.

14.3 Fan shall be so constructed and installed that any sub-component replacement shall not take longer than 1 day when executed by qualified building maintenance staff.

14.4 Fan shall be installed in accordance with Manufacturer's recommendations and shall be maintained in "as new" condition start-up of installation.

14.5 Fan shall be statically and dynamically balanced at the manufacturer's works within the design operating speed range.

14.6 Fan and motor assembly shall be installed on vibration isolating mounting.

14.7 Fan shall not be operated until connected ducts have been cleaned and specified filters have been put into regular operating conditions.

14.8 Rotation arrow shall be installed.

14.9 Lubrication shall be possible while fans are in operation without removing any part and without danger of over lubrication.

14.10 All parts of the fan shall be readily accessible for ease of inspection, maintenance, and service.

14.11 Fan casing shall not drum, distort or leak at any operating point and shall, if necessary, be externally sound insulated to maintain specified noise level in plantroom or adjacent room.

14.12 Belts shall be of the oil resistant type and shall be selected for a minimum of 1,2 times the motor rating, 1 start per day and slip-free starting.

14.13 Motor rating shall not be less than the maximum power required by the fan at any operating point between zero and break-off capacity for the impeller furnished.

14.14 The fan impeller shall be of the double inlet or forward curved type.

14.15 Power supply to motors shall be flexible.

14.16 Fan shall be belt driven with adjustable sheave and shall have readily adjustable base to provide variation in centre distance.

14.17 The motor shall be of the totally enclosed fan type. The motor starter, motor and drive shall be selected to ensure slip-free starting without the causing of unacceptable voltage drop.

14.18 The motor shall be of a high efficiency type, IE2, EC or approved equal

15. ELECTRIC HEATER

15.1 The electric air heater shall be complete with: -

a) Auto reset thermal cut-out device set between 60-80ºC.
b) Manual reset thermal cut-out device set between 80 - 100ºC with reset button, labelled and operable without removing any terminal box cover, or fusible current interrupter with radiation shield, to melt at 100ºC replaceable through terminal box without removing entire heater.
c) Air flow interlock by means of either: -
Supply air pressure switch, or airflow switch.
d) Run-down timer on fan to ensure that elements have sufficiently cooled before fan switched off on shutdown.

15.2 The heater shall be so constructed and installed that either a sub-component replacement or total removal and re-installation of the air duct heater shall not take longer than 1 hour by normal building maintenance staff.

15.3 The duct heater shall be so constructed and installed that routine maintenance repair or replacement can be undertaken without disassembly of the connected ducting.

15.4 Parts used in the construction of the heater shall have adequate strength and the overall construction and installation shall be rigid to ensure satisfactory operation during its service life and the normal expected service conditions.

15.5 Heaters shall be so installed that there is no by-pass of unheated air.

15.6 Elements shall have an adequate resistance to earth, with due regard to the possible condensation of moisture during the cooling cycle.

15.7 The heater element for each step shall be strung across the entire face of the coil to prevent stratification when operating at less than full capacity.

15.8 Ventilation and other openings in the external enclosure shall be so protected that contact with live internal parts is rendered impossible without the use of tools.

15.9 Heaters shall be triac type heaters such that a gradual control and delivery of heating is provided.

16. MOTOR CONTROL CENTRE

16.1 The MCC shall be surface mounted inside the plenum at approximately 1,2m affl

16.2 The wiring of to the fan shall be installed in the factory as per relevant electrical specification

16.3 The cable entry into the air handling unit shall be sealed after cable has been installed

16.4 The controls shall be mounted inside this MCC

17. WEATHER LOUVER

17.1 The weather louver shall be sized for 100% supply air

17.2 The face velocity shall be 1.5m/s or lower at 50% free area

18. AUTOMATICALLY CONTROLLED AIR DAMPER

18.1 Supply and install the dampers of the opposed blade, 100% shut-off type suitable for the capacity listed in the schedule.

18.2 The damper, complete with frame and linkage, shall be a fully catalogued product of a manufacturer regularly engaged in the production of high-quality dampers.

18.3 Damper with frame may be made up in one section up to 1200 mm in width and 2400 mm in height. Larger sizes shall be made up in sections for easy handling.

18.4 Special care shall be taken in transport, delivery, storage on site etc, to ensure that the dampers are installed and maintained in 'as new' condition at start-up of the installation.

18.5 The damper and damper frame shall be installed level in both directions. There shall be no torsion or twist in the frame to prevent smooth operation of the damper. The blades shall not touch any adjacent material throughout the full travel of the blades and shall be capable of opening to a full 90 degrees. Linkages shall incorporate a positive 90 degrees opening stop.

18.6 The drive shaft for the linkages shall be suitable for automatic operation.

18.7 The dampers and linkage shall be cleaned of any debris or dirt that may cause binding.

18.8 Damper blades shall rotate on pivot assembly in permanently lubricated oilite bearings.

18.9 Pressure drop through the damper shall not exceed 50 Pa at 5 m/s velocity over the face area.

18.10 Damper frame and blades shall be manufactured of galvanised sheet steel.

18.11 Damper motors shall be of the electric type and shall be sized to suit the damper areas.

Detailed Schedule

- General Notes applicable to all AHUs
    - Heater banks to be in 3 steps
    - Bacnet Compatible
    - Filtration requirements G4: F7
    - Magnahelic filter gauge over filters and coil
    - Coils shall be selected on 8/14°C water in/out temperatures

V.D14.06 - VARIABLE VOLUME SIDEWALL AIR TERMINAL WITH ELECTRICAL RE-HEATER

1. Supply and install as shown on the drawings and as listed in the schedule, VAV terminals delivering the maximum and minimum air quantity at the stated duct static pressure, throws and maximum sound power level.

2. The air terminals shall be complete with factory calibrated balancing devices to adjust the specified air volumes.

3. The air terminal shall be a fully catalogued product and the documentation shall include performance curves or selection tables for the specified range of operational conditions.

4. Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.

5. Submit at the time of equipment submission:

   a) Certified detailed selection shown on these performance curves or table.
   b) The possible percentage variation of data measured on site by the specified testing instrumentation compared to the catalogued performance data.
   c) Installation, operating, testing, balancing and commissioning instructions and trouble analysis guide.
   d) Full details of :-
      i) The service and maintenance instruction
      ii) The estimated total expenditure on replacement of parts during the service life.

6. The air terminal shall be so constructed and installed that either a sub-component replacement or total removal and re-installation of the air terminal shall not take longer than 1 hour by normal building maintenance staff.

7. The minimum selected service life for which the equipment has been engineered and components selected when operated under normal building conditions with optimum servicing and maintenance shall be 15 years with 3000 operating hours per annum and 400 control cycles per annum.

8. The Engineer or his representative reserves the right to call for :

   a) Test certificates and reports from the manufacturer's quality control laboratory or independent test laboratory such as SANS, and/or

   b) Site inspections, customer reports/references and user's interviews, and/or
   c) Full engineering, design and component selection details.

9. Special care shall be taken in transport, delivery, storage on site, and installation to ensure that the terminals are installed and maintained in "as new" condition at start-up of the installation.

10. The grilles shall be finished in anodised aluminium.

11. Supply the portable air measuring device, specified and calibrated by the air terminal manufacturer, to check the operation and air delivery of the air terminals. The air measuring device shall work in conjunction with a commercially available meter.

    The combined assembly shall permit the operator to use the device and meter from floor level without the need for a ladder for terminals up to 4m above floor level.

12. Ensure that no other services or building elements shall affect the accessibility and easy removal of any of the unit components.

13. The removal and installation of the moving parts shall not require special tools or skills for assembly and re-assembly.

14. It shall be possible to check the proper operation of the air terminal through the terminal outlet.

15. Parts used in the construction of the terminals shall have adequate strength and the overall construction and installation shall be rigid to ensure satisfactory operation under normal expected service conditions.

16. Ensure that a minimum of 5% spares for each size operating mechanism will be available.

17. Air quantity shall be controlled by an adjustable electric or electronic thermostat.

18. Each terminal shall be complete with an electric heater.

19. The heater shall be complete with :-

    a) Auto reset thermal cut-out device set between 50 and 60° C.
    b) Manual reset thermal cut-out device set between 60 and 70 °C.
    c) Interlock with the supply air fan to ensure that the heater can only be energised when the supply fan is in operation.

20. The air terminal and heater shall be SANS approved for the entire assembly.

21. Heater element shall be installed so that there is no by-pass of unheated air (at terminal minimum or flow conditions).

22. The normal operating temperature of the heater shall not exceed 80 °C with a room temperature of 20 °C.

23. A metal plate, showing the capacity and voltage shall be permanently attached to each air terminal.

V.D14.09 - VARIABLE VOLUME SQUARE OR ROUND CEILING AIR TERMINAL

1. Supply and install as shown on the drawings and as listed in the schedule, VAV terminals delivering the maximum and minimum air quantity at the stated duct static pressure, throws

and maximum sound power level.

2. The air terminal shall be complete with factory calibrated balancing devices to adjust the specified air volumes.

3. The air terminal shall be a fully catalogued product and the documentation shall include performance curves or selection tables for the specified range of operational conditions.

4. Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.

5. Submit at the time of equipment submission:

   a) Certified detailed selection shown on these performance curves or tables.
   b) The possible percentage variation of data measured on site by the specified testing instrumentation compared to the catalogued performance data.
   c) Installation, operating, testing, balancing and commissioning instructions and trouble analysis guide.
   d) Full details of :-
      i) The service and maintenance instruction
      ii) The estimated total expenditure on replacement of parts during the service life.

6. The air terminal shall be so constructed and installed that either a sub-component replacement or total removal and reinstallation of the air terminal shall not take longer than 1 hour by normal building maintenance staff.

7. The minimum selected service life for which the equipment has been engineered and components selected when operated under normal building conditions with optimum servicing and maintenance shall be 15 years with 3000 operating hours per annum.

8. The Engineer or his representative reserves the right to call for:

   a) Test certificates and reports from the manufacturer's quality control laboratory or independent test laboratory such as SABS, and/or
   b) Site inspections, customer reports/references and user's interviews, and/or
   c) Full engineering, design and component selection details.

9. Special care shall be taken in transport, delivery, storage on site, and installation to ensure that the terminals are installed and maintained in "as new" condition at start-up of the installation.

10. The diffuser shall be finished in baked enamel to an approved colour.

11. Supply the portable air measuring device, specified and calibrated by the air terminal manufacturer, to check the operation and air delivery of the air terminals. The air measuring device shall work in conjunction with a commercially available meter.

    The combined assembly shall permit the operator to use the device and meter from floor level without the need for a ladder for terminals up to 4m above floor level.

12. Ensure that no other services or building elements shall affect the accessibility and easy removal of any of the unit components.

13. The removal and installation of the moving parts shall not require special tools or skills for assembly and re-assembly.

14. It shall be possible to check the proper operation of the air terminal through the terminal outlet.

15. Parts used in the construction of the terminals shall have adequate strength and the overall construction and installation shall be rigid to ensure satisfactory operation under normal expected service conditions.

16. Ensure that a minimum of 5% spares for each size operating mechanism will be available.

17. Air quantity shall be controlled by an adjustable electric or electronic thermostat.

V.D14.10 - VARIABLE VOLUME SQUARE OR ROUND CEILING AIR TERMINAL WITH RE-HEATER

1. Supply and install as shown, VAV terminals as supplied by Rickard air diffusion, delivering the maximum and minimum air quantity at the stated duct static pressure, throws and maximum sound power level.

2. The air terminal shall be complete with MLM VAV diffuser controls, including onboard diffuser mounted controller/sensor, Master Control Units (MCU) and Power Supply Units (PSU)

3. The air terminal shall be a fully catalogued product and the documentation shall include performance curves or selection tables for the specified range of operational conditions.

4. Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.

5. Submit at the time of equipment submission:

   a) Certified detailed selection shown on these performance curves or tables.
   b) The possible percentage variation of data measured on site by the specified testing instrumentation compared to the catalogued performance data.
   c) Installation, operating, testing, balancing, and commissioning instructions and trouble analysis guide.
   d) Full details of:-
      - The service and maintenance instruction
      - The estimated total expenditure on replacement of parts during the service life.

6. The air terminal shall be so constructed and installed that either a sub-component replacement or total removal and reinstallation of the air terminal shall not take longer than 1 hour by normal building maintenance staff.

7. The minimum selected service life for which the equipment has been engineered and components selected when operated under normal building conditions with optimum servicing and maintenance shall be 15 years with 3000 operating hours per annum.

8. The Engineer or his representative reserves the right to call for:

a) Test certificates and reports from the manufacturer's quality control laboratory or independent test laboratory such as SABS, and/or
b) Site inspections, customer reports/references and user's interviews, and/or
c) Full engineering, design and component selection details.

9. Special care shall be taken in transport, delivery, storage on site, and installation to ensure that the terminals are installed and maintained in "as new" condition at start-up of the installation.

10. The diffuser shall be made of pressed Sheetmetal finished in baked enamel or epoxy powder coated to an approved colour.

11. Supply the portable air measuring device, specified, and calibrated by the air terminal manufacturer, to check the operation and air delivery of the air terminals. The air measuring device shall work in conjunction with a commercially available meter.

The combined assembly shall permit the operator to use the device and meter from floor level without the need for a ladder for terminals up to 4m above floor level.

12. Ensure that no other services or building elements shall affect the accessibility and easy removal of any of the unit components.

13. The removal and installation of the moving parts shall not require special tools or skills for assembly and re-assembly.

14. It shall be possible to check the proper operation of the air terminal through the terminal outlet.

15. Parts used in the construction of the terminals shall have adequate strength and the overall construction and installation shall be rigid to ensure satisfactory operation under normal expected service conditions.

16. Ensure that a minimum of 5% spares for each size operating mechanism will be available.

17. Air quantity shall be controlled by the Rickard Multi Loop Modular (MLM) Control system

18. The units shall be complete with electric heater where specified.

19. The heater shall be complete with: -

19.1 Auto reset thermal cut-out device set between 65ºC ± 10 ºC.

19.2 Power reset thermal cut-out device set between 85ºC ± 10 ºC.

19.3 Interlock with the supply air fans to ensure that the heater can only be energised when the supply fans are in operation.

19.4 15A shaved earth pin plug top and 3m flexible cord

20. The normal operating temperature of the heater shall not exceed 80ºC with a room

temperature of 20ºC.

21. All VAV diffusers shall be complete with supply air and on-board heating sensors for compensation of the on-board room temperature sensing device.

22. Reversing action change over functionality shall be provided for all master diffusers with an on-board supply air sensor.

23. Provide calibration to determine maximum and minimum air flows to enable setting of minimum and maximum air flow quantities.

24. Heaters shall switch off under no flow conditions.

25. Diffusers shall be capable of a minimum air flow of not more than 5% of the maximum flow at the design pressure.

26. The diffusers shall be capable of accepting an integrated motion detector to shut down the diffuser after a time dely.

27. The status shall be communicated to the BMS via the MCUs.

28. Diffusers with on board sensor must be upgradeable to have remote infra-red set point adjustments.

29. Include 1 spigot per diffuser and 2m of flexible ducting (average per diffuser) including clamps and fixing.

V.D15.02 - THERMOSTATIC CONTROL OF FAN AIR TERMINALS AND FAN HEATERS

The thermostatic control of fan air terminals and fan heaters shall be in accordance with the control schematic and shall incorporate the following interdependent but separate components.

1.1 Room thermostat/controller with integral thermostat sensor and adjustable set point mounted on the standard ceiling tile and capable of directly controlling up to 6 fan air terminals coupled in series. It shall also control an optional heater relay.

1.2 Connection to power feed shall be by means of a 4,0m long flexible lead terminating in a 3 pin 13A flat earth pin plug.

1.3 The actual sensor shall protrude not more than 20mm below the ceiling tile, colour grey or beige, and with a maximum diameter of 10mm.

1.4 The controller shall control the fan air terminal air volume from 0% to 100% stepless and linear, without pulsation noises, when room temperature varies through a maximum of 3,5ºC When fan heaters run, fan air terminals shall be off.

1.5 The method of fan air terminal speed control shall be approved by the fan air terminal motor manufacturer and shall be certified not to affect the guaranteed fan service life.

1.6 The method of control shall conform to SANS and electrical supply authorities' requirements and shall cause no television or radio interference.

1.7 Socket outlets for fan air terminal and heater relay shall be of the "Bulgin" type with retainer clips to prevent accidental removal.

2.1 Ceiling or slab mounted heater relay capable of controlling up to fan heaters.

2.2 Connection to power feed shall be by means of a 4,0m long flexible lead terminating in a 3 pin 13A flat earth pin plug.

2.3 Connection to thermostat/controller shall be by means of a 4,0m long flexible lead terminating in a "Bulgin" type plug.

2.4 Socket outlet for fan heaters shall be of the "Bulgin" type with retainer clips to prevent accidental removal.

3. All wiring between thermostat/controller, fan air terminals, fan heaters, heater relay and power outlets shall be by means of authorities approved insulation material for the particular plenum application and with lockable plug connector terminations.

V.D16.01- CONSTANT VOLUME SIDE WALL AIR TERMINAL

1. Supply and install air terminals delivering the air quantities as shown on the drawings.

2. Unless otherwise indicated, the air terminal shall be complete with air quantity adjustment device accessible from the terminal face.

3. The air terminals shall be a fully catalogued product and the documentation shall include performance curves or selection tables.

4. Submit certified detailed selection shown on these performance curves or tables.

5. Special care shall be taken in transport, delivery, storage on site and installation to ensure that the air terminals are installed and maintained in "as new" condition at start-up of the installation.

6. The air terminal grille shall be epoxy powder coated or anodised aluminium, to an approved colour.

7. The Contractor shall supply a portable air measuring device, specified and calibrated by the air terminal manufacturer, to check the air delivery of the air terminals. The air measuring device shall work in conjunction with a commercially available meter. The combined assembly shall permit the operator to use the device and meter from floor level without the need for a ladder for terminals up to 4m above floor level.

8. Grille shall be of single/double deflection construction as shown on the drawings.

V.D16.02 - CONSTANT VOLUME SQUARE OR ROUND CEILING AIR TERMINAL

1. Supply and install as shown on the drawings, VAV terminals delivering the maximum and minimum air quantity at the stated duct static pressure, throws and maximum sound power level.

2. The diffusers must be Rickard, TROX or approved and equal. The tender must be based on the specified system with alternatives offered under a covering letter.

3. The air terminal shall be a fully catalogued product and the documentation shall include performance curves or selection tables for the specified range of operational conditions.

4. The diffusers shall be epoxy powder coated to an approved colour.

5. Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.

6. Submit at the time of equipment submission:

7. Certified detailed selection shown on these performance curves or tables.

8. The possible percentage variation of data measured on site by the specified testing instrumentation compared to the catalogued performance data.

9. Installation, operating, testing, balancing and commissioning instructions and trouble analysis guide.

10. Full details of:

    - The service and maintenance instruction
    - The estimated total expenditure on replacement of parts during the service life.
    - The air terminal shall be so constructed and installed that either a sub-component replacement or total removal or reinstallation of the air terminal shall not take longer than 1 hour by normal building maintenance staff.
    - The minimum selected service life for which the equipment has been engineered and components selected when operated under normal building conditions with optimum servicing and maintenance shall be 15 years with 3000 operating hours per annum.

11. The Engineer or his representative reserves the right to call for:
    - Test certificates and reports from the manufacturer's quality control laboratory or independent test laboratory, and/or
    - Site inspections, customer reports/references and user's interviews, and/or
    - Full engineering, design and component selection details.

12. Special care shall be taken in transport, delivery, storage on site, and installation to ensure that the terminals are installed and maintained in "as new" condition at start-up of the installation.

13. The diffuser shall be finished in baked enamel to an approved colour.

14. Supply the portable air measuring device, specified and calibrated by the air terminal manufacturer, to check the operation and air delivery of the air terminals. The air measuring device shall work in conjunction with a commercially available meter.

15. The combined assembly shall permit the operator to use the device and meter from floor level without the need for a ladder for terminals up to 4m above floor level.

16. Ensure that no other services or building elements shall affect the accessibility and easy removal of any of the unit components.

17. The removal and installation of the moving parts shall not require special tools or skills for assembly and re-assembly.

18. It shall be possible to check the proper operation of the air terminal through the terminal outlet.

19. Parts used in the construction of the terminals shall have adequate strength and the overall construction and installation shall be rigid to ensure satisfactory operation under normal expected service conditions.

20. Ensure that a minimum of 5% spares for each size operating mechanism will be available.

21. Air quantity shall be controlled by an adjustable electric or electronic thermostat.

V.D16.04 – EXTRACT / RETURN / TRANSFER AIR GRILLE

1. Supply and install air grilles extracting/transferring the air quantities as shown on the drawings.

2. Unless otherwise indicated, the grille shall be complete with an air quantity adjustment device.

3. The grille shall be a fully catalogued product and the documentation shall include selection tables.

4. Submit certified detailed selection shown on these tables.

5. Special care shall be taken in transport, delivery, storage on site and installation to ensure that the grilles are installed and maintained in "as new" condition at start-up of the installation.

6. The grille shall be epoxy powder coated to an approved colour.

V.D16.05 - DOOR GRILLE

1. Supply and install as indicated, door grilles transferring the air quantities stated as shown on the drawings.

2. The door grille shall be a fully catalogued product and the documentation shall include selection tables.

3. Submit certified detailed selection on these tables

4. Special care shall be taken in transport, delivery and storage on site to ensure that the door grilles are installed and maintained in "as new" condition at start-up of the installation.

5. The door grille shall be of the "no sight core" type and shall be finished in an epoxy powder coating to an approved colour.

V.D16.06 - INTAKE/EXHAUST AIR WEATHER LOUVRE

1. Supply and install as shown on drawings, outside air/exhaust air louvres for the air quantity at the static pressures.

2. The outside air/exhaust air louvres shall be fully catalogued product and the documentation shall include performance curves or selection tables.

3. Certified detailed selection shown on these performance curves or tables shall be submitted.

4. Special care shall be taken in transport, delivery, storage on site and installation to ensure that the outside air/exhaust air louvres are in "as new" condition at start-up of the installation.

5. The outside air/exhaust air louvres shall be installed as shown in principle on the drawings.

6. The louvres shall be finished in baked enamel to an approved colour or epoxy powder coated.

7. All outside air/exhaust air louvres shall be complete with mounting frames suitable to be built into the brick walls by the builder. All outside air/exhaust air louvres shall be vermin proofed.

V.D17.04 - ELECTRIC AIR DUCT HEATER

1. Supply and install as shown on drawings and as listed in the schedule, electric duct heaters at rated capacities and specified entering and leaving air temperatures.

2. The heater shall be a fully catalogued product and the documentation shall include performance curves or selection tables for the expected range of operational conditions.

3. Submit at time of equipment submission: -

   a) Certified selection shown on these performance curves or tables
   b) Full installation, operating, testing, balancing, and commissioning instruction and trouble analysis guide.
   c) Checklists of overload and abnormal conditions, which shall be checked as part of the testing, balancing, and commissioning.
   d) The service and maintenance instructions.
   e) The estimated total expenditure on replacement of parts during the service life.

4. The electric air duct heater shall be complete with: -

   a) Auto reset thermal cut-out device set between 60-80ºC.
   b) Manual reset thermal cut-out device set between 80-100ºC with reset button, labelled and operable without removing any terminal box cover, or fusible current interrupter with radiation shield, to melt at 100ºC replaceable through terminal box without removing entire heater.
   c) Air flow interlock by means of either: -
      Supply air pressure switch, or airflow switch.

5. The air duct heater shall be so constructed and installed that either a sub-component replacement or total removal and re-installation of the air duct heater shall not take longer than 1 hour by normal building maintenance staff.

6. The equipment shall be engineered, and components selected; when operated under normal building conditions with optimum servicing and maintenance; for a minimum acceptable service life of 15 years with 3000 operating hours and 10 000 on/off cycles per annum.

7. The air duct heater shall be SANS or UL approved for the entire assembly.

8. Special care shall be taken in transport, delivery, storage on site, etc. to ensure that the air duct heaters are installed in "as new" condition at start-up of the installation.

9. The air duct heaters shall be installed as shown in principle on drawing.

10. A terminal box shall be provided in a position readily accessible after installation, and this box shall be the only point of connection between internal and external wiring. A sufficient number of knockouts shall be provided for a satisfactory bonding of external conduits and/or cable glands. A metal plate showing wiring and control diagram complete with rating of fuses and heater limited shall be provided inside the cover plate.

11. The electric air duct heater casing shall be flanged.

12. The air duct heater shall be so constructed and installed that routine maintenance repair or replacement can be undertaken without disassembly of the connected ducting.

13. Parts used in the construction of the heater shall have adequate strength and the overall construction and installation shall be rigid to ensure satisfactory operation during its service life and the normal expected service conditions.

14. Heaters shall be so installed that there is no by-pass of unheated air.

15. Elements shall have an adequate resistance to earth, with due regard to the possible condensation of moisture during the cooling cycle.

16. The heater element for each step shall be strung across the entire face of the coil to prevent stratification when operating at less than full capacity.

17. Ventilation and other openings in the external enclosure shall be so protected that contact with live internal parts is rendered impossible without the use of tools.

V.D21.01 – VARIABLE SPEED DRIVE

1. General

1.1 The VSD shall be suitable for controlling the speed of standard three phase 380V - 415V induction motors.

1.2 The VSD is required to operate continuously at full load rating of the driven motor with variations of ±10% of the supply voltage and ±2% of the supply frequency.

1.3 The VSD is required to operate continuously at full load in an ambient temperature of 380C.

1.4 The VSD is required to operate continuously at full load at the stated altitude for the project. Where a de-rating factor is required by the Manufacturer this is to be applied to the VSD and not to the driven motor.

1.5 The VSD is to be manufactured to quality standards according to ISO 9001.

1.6 Unless stated elsewhere to the contrary it is to be assumed that the VSD is to be installed and operated in a high-tech commercial building with multiple tenants with an assortment of computers and sensitive electronic, radio, television and telecommunication equipment. The VSD is therefore required to operate without interference to this equipment.

2. Quadratic Torque Loads

2.1 The VSD unit is to be designed and built specifically for centrifugal fan and pump operation.

2.2 Maximum advantage is to be obtained in terms of energy saving by using an output voltage to frequency ratio allowing only sufficient magnetisation energy at the required motor speed.

2.3 The fans and pumps are expected to operate for extended periods at 50% of rated speeds and a running torque requirement of 25% of the rated value. At this 50% speed reduction the power consumption is to reduce to 12,5% of the rated full load value

3. Operating Parameters

3.1 Operating and set up parameters shall be selected and set by means of a programming keypad and associated display.

3.2 The VSD shall be suitable to respond to speed commands from 0 - 10Vdc and 0 - 20mA control signals and their respective inverted signals.

3.3 The VSD shall provide comprehensive information on the controller and motor condition. The following are minimum requirements:

- Reference % of control signal.
- Frequency Hz
- Current A
- Torque %
- Power kW
- Output voltage V
- Motor RPM

3.4 The VSD shall be suitable for catching a rotating motor. Under certain conditions, the fan or pump may be rotating in its opposite direction and the VSD shall be capable of achieving a clean start under these conditions.

4. Electrical Safety

4.1 The VSD is to have all necessary WARNING or CAUTION notices permanently fixed to the VSD and VSD enclosure.

4.2 The VSD shall be suitable for service in mechanical plant rooms where dust, moisture and water is present. A minimum enclosure protection to IP54 rating is required. The VSD is to be mounted in a ventilated area allowing the dissipation of heat energy.

4.3 The VSD shall be suitable for switching on the output side. Motor reactors limiting the rise time of the current are a minimum requirement and are to be integral with the VSD.

4.4 Isolation of the mains supply to the VSD and from the VSD to motor is a requirement to allow for safe maintenance, repair and to prevent motor operation during set up procedures.

4.5 In the event that the VSD is mounted exposed to ambient condition the VSD shall have a minimum enclosure protection to IP54 rating and shall have a weather canopy mounted over VSD to protect it from direct sunlight and rain.

5. Galvanic Isolation

5.1 The VSD is to provide isolation between the control and power circuits to ensure dangerous voltages cannot be transmitted to control signals. This isolation shall be integral with the VSD and shall be capable of withstanding a test voltage of 2.5KV for 1 second.

6. **Main Disturbance**

6.1 The VSD is to be protected against transients on the main supply caused by short circuit faults, lightning strikes and the switching of power factor correction capacitors

7. **Mains Supply**

7.1 The VSD to incorporate all necessary chokes filters capacitors and motor coils to reduce and limit radio frequency interference and harmonics to a level which does not interfere with other equipment on the same power supply.

7.2 The VSD is to incorporate harmonic reactors in the d.c. link circuit as an integral part of the VSD.

8. **System Protection**

8.1 The VSD system is to provide protection from:

8.1.1 Over current and overvoltage
8.1.2 Under voltage
8.1.3 Overload
8.1.4 Over heating

And to include facilities for:

8.1.5 Current limiting setting
8.1.6 Auto restart following trip or power supply recovery
8.1.7 Soft stall function
8.1.8 Reactivation function following a momentary power interrupt

9. **VSD Overload Protection**

9.1 The VSD is to be protected on the power outlet against short circuits or earth faults on the motor terminals. The three phases of the supply to be continuously monitored and the system to shut down on a missing phase or thermal overload.

9.2 The VSD shall provide storage of all faults. Last fault memory in the event of power failure is required.

10. **Motor Overload Protection**

10.1 The VSD is to provide electronic thermal overload protection of the motor at all operating speeds. This protection is to allow for the cooling conditions experienced with the speed control. The VSD is to allow for a built in motor thermistor should the motor size be 22kW or more.

10.2 The VSD is to incorporate line reactors as necessary to achieve a power factor of the driven motor of not less than 0.9 at any given speed.

11. **Inverter Waveform**

11.1 The VSD is to have manufacturers installed protection devices on the outgoing supply to the motor to suppress the effects of the inverter wave form.

11.2 The VSD shall be of the type utilising digital PWM technology which will enable the full output voltage to be reached without waveform distortion. Derating of the specified motor KW is not permitted.

11.3 The VSD is to provide slip regulation by means of vector control of the output voltage and frequency to maintain a constant motor speed

12. **Radio Frequency/Interference/Radiated and Conducted Interference**

12.1 The VSD is to have manufacturers built in filters to suppress RFI, radiated and conducted interference.

12.2 The VSD shall comply with EMC/EMI standards for immunity IEC 802-805.

12.3 The VSD is to be contained in a metal enclosure to suppress radiated RFI. The earthing of this enclosure to be taken direct to earth.

13. **Motor Noise**

13.1 Electromagnetic noise generated by the VSD and motor is not to exceed a 10% increase over that of a standard motor on a commercial power supply when operating over the specified duty range.

13.2 The additional vibration generated by the motor when operated at reduced speed shall be attenuated by stiffness of base and selection of anti-vibration mountings. The resultant vibration transmitted to building structure must be no more than that of a standard motor on a commercial power supply.

V.D22 Efficiency Air-Cooled Scroll Chiller

1. Supply, deliver and commission air-cooled scroll chillers as indicated on the drawings and schedules. The unit shall be complete with scroll compressor(s), air-cooled condenser coil(s), evaporator, refrigerant circuits, controls, refrigerant charge, lubrication system, and all accessories necessary for proper operation.

2. The chiller shall have automatic capacity control to vary its output in response to varying load conditions and to maintain the specified leaving chilled water temperature.

3. The chiller shall be a standard catalogue product of a reputable manufacturer. The documentation shall include performance curves and selection tables for the expected range of operational conditions.

4. The manufacturer shall submit technical documentation including certified performance data, selection tables, and performance curves covering the expected operating range.

5. Performance curves and selection tables shall be based on reproducible and certified tests conducted in an approved laboratory and in accordance with recognised industry standards.

6. Certified detailed selections shall be submitted for the following conditions:
    - Specified duty point;
    - 10% overload condition, where applicable;
    - Part-load operating conditions.

7. The manufacturer shall state the expected percentage variation between catalogued performance data and site-measured performance using installed instrumentation.

8. The unit shall be fully protected and fail-safe. Minimum safety and protective functions shall be provided for the following abnormal or overload conditions:

    - No or reduced chilled water flow;
    - Low leaving chilled water temperature;
    - High condensing pressure;
    - Low suction pressure;
    - Compressor motor overload;
    - Voltage imbalance, phase reversal, under-voltage and power interruption;
    - Sensor failure and controller fault conditions.

9. Checklists of safety trips, overload conditions, and abnormal operating conditions to be verified during testing, commissioning and handover shall be submitted.

10. Major components shall be selected for a design life of not less than 110,000 operating hours under normal operating and maintenance conditions.

11. Full details shall be submitted for all safety protection devices, including set points, operating logic, indication, and recording features used to protect the equipment under overload and abnormal conditions.

12. Where applicable to the manufacturer’s design, suitable crankcase heaters shall be provided to minimise refrigerant migration during shutdown periods. The heater circuit shall remain energised when the compressor is off.

13. Each refrigeration circuit shall have stepped or modulating capacity control through staging of multiple scroll compressors, coordinated by the unit controller to maintain stable leaving chilled water temperature through PID control logic.

14. The unit shall comply with ANSI/ASHRAE 15 for safety in refrigeration systems, or equivalent applicable international standard.

15. The chiller shall comply with AHRI certification requirements, Eurovent certification, or equivalent recognised certification applicable to the offered unit.

16. The unit shall comply with the Occupational Health and Safety Act, Act 85 of 1993, as amended, and with applicable local authority by-laws. All required pressure vessel and compliance certificates shall be submitted prior to delivery.

17. The chiller shall be constructed and supported by local service capability such that the maximum breakdown period is minimised, with critical spares availability and service response appropriate to the project requirements.

18. Special care shall be taken during transport, offloading, storage, lifting and installation to prevent damage to the unit and its components.

19. The evaporator shall be of the manufacturer's standard type suitable for the offered chiller model and shall be designed and tested in accordance with the relevant BS, ASME, PED, or equivalent standard.

20. The refrigerant shall be a non-ozone depleting refrigerant suitable for the offered chiller. Acceptable refrigerants shall include the manufacturer's standard refrigerant for the selected unit, subject to compliance with applicable safety and environmental requirements.

21. The evaporator, exposed refrigerant piping, and auxiliary water piping shall be insulated with minimum 19 mm closed-cell insulation. No external condensation shall occur on insulated surfaces under design operating conditions.

22. The chiller shall be installed strictly in accordance with the manufacturer's written instructions.

23. The contractor shall familiarise himself with the proposed location of the chiller and shall ensure that:
    - Adequate access is available for delivery, rigging and replacement;
    - Structural support is sufficient for the operating weight of the unit;
    - Manufacturer-recommended clearances are provided for airflow, maintenance and service access;
    - There is no obstruction to condenser airflow or fan discharge.

24. Pipework shall be adequately supported and arranged so that no strain is imposed on the chiller evaporator connections.

25. The required unobstructed service space around the unit shall be provided in accordance with the manufacturer's recommendations.

26. All external insulation exposed to weather or ultraviolet radiation shall be suitably finished or protected against UV degradation and weathering.

27. The unit shall be mounted on suitable anti-vibration supports or spring isolators where required by the project acoustic and structural design.

28. A factory-mounted or adjacent control panel shall be provided for each chiller and shall be designed for outdoor duty where exposed.

29. The control panel shall include all necessary control, monitoring and protection devices, and shall display or make available as a minimum:

    - High condensing/discharge pressure;
    - Low suction pressure;
    - Leaving and entering chilled water temperatures;
    - Compressor status;
    - Refrigeration circuit status;
    - Alarm and fault indication.

30. All control wiring shall be neatly terminated and identified within the control panel.

31. The chiller shall be provided with suitable refrigerant circuit monitoring devices, including sight glass/moisture indication where applicable to the manufacturer's standard design.

32. Chilled water connections shall be arranged to permit maintenance access to the evaporator and associated components. Air vents and drain points shall be provided as required.

33. Chiller components, particularly compressors, control components, fans, and coils, shall be readily accessible for maintenance without major dismantling of adjacent equipment.

34. The air-cooled chiller shall be a packaged scroll type, complete with hermetic scroll compressor(s), air-cooled condenser coil(s), evaporator, control panel, base frame, and all accessories necessary to complete the refrigeration cycle. The unit shall have multiple refrigeration circuits where required by the scheduled capacity.

35. Heat exchanger components shall be suitable for the manufacturer's standard design and arranged for reliable serviceability.

36. Chilled water velocities through the evaporator shall not exceed the manufacturer's recommended limits under any operating condition.

37. The minimum evaporator leaving water temperature shall not be lower than 1°C, unless specifically selected and approved for lower temperature duty by the manufacturer.

38. The unit casing and frame shall be corrosion resistant and finished for outdoor installation. The complete unit shall be fully weather protected.

39. Condenser fans shall be statically and dynamically balanced and factory tested with the fans installed.

40. The chiller shall be selected such that operational noise levels comply with applicable project acoustic criteria and the National Building Regulations at the site boundary where required.

41. The condenser coils shall be protected against mechanical damage by suitable coil guards, including hail protection where required for the installation location.

42. The unit shall be supplied with the manufacturer's standard factory-mounted electrical and starter arrangement suitable for the offered model, complete with all required motor protection and controls.

43. Maintenance requirements shall, as a minimum, include:
    - Periodic inspection of compressor and refrigeration circuit condition;
    - Inspection and cleaning of condenser coils;
    - Verification of refrigerant operating pressures and temperatures;
    - Recording of operating parameters and comparison with commissioning baseline data;
    - Rectification of conditions operating outside the specified range.

44. The chiller shall be supplied complete with a BACnet-compatible controller capable of monitoring and/or controlling at least the following:

- Chiller start/stop;
- General alarm/fault status;
- Chilled water entering and leaving temperatures;
- Chilled water flow status;
- Active set point;
- Compressor running status;
- Chiller electrical load or running current, where supported by the controller;
- Available capacity and operating mode, where supported by the controller.

V.D24 PHEX SPEC

Scope

Provide, install, test, commission, and hand over a complete **plate heat exchanger (PHE)** for **HVAC chilled water service**, as indicated on the drawings and equipment schedules.

The plate heat exchanger shall be suitable for the transfer of cooling between two closed water circuits, including but not limited to hydraulic decoupling,

The works shall include all necessary accessories, supports, sensor sockets, identification, and commissioning services required for a complete and operable installation.

Applicable Standards

The plate heat exchanger and associated components shall comply with the latest applicable editions of the following, unless more stringent local regulations apply:

- **AHRI 400** – Liquid to Liquid Heat Exchangers
- **ASME BPVC Section VIII**, where applicable
- Recognized pressure equipment regulations as applicable to the jurisdiction
- **ISO 9001** quality management systems
- Applicable mechanical services, pressure piping, and building regulations
- Manufacturer's standard factory testing and quality assurance procedures

Service Description

The heat exchanger shall be designed for **chilled water duty** in a closed-loop HVAC system. The unit shall transfer the scheduled cooling load between the primary and secondary circuits while maintaining:

- required supply and return temperatures,
- acceptable approach temperatures,
- low pumping energy,
- pressure drops within design limits,
- reliable and stable operation at full and part load.

The heat exchanger shall be selected with due consideration to system diversity, variable flow conditions where applicable, and long-term operating efficiency.

Type

Unless otherwise indicated on the schedule, the plate heat exchanger shall be:

Preferred Type

Gasketed plate heat exchanger, bolted frame construction, fully serviceable, suitable for chilled water duty, and capable of disassembly for inspection, maintenance, and cleaning.

Alternative Type

Brazed plate heat exchanger may only be used where:

- the duty is relatively small,
- both circuits are clean, closed-loop systems,
- no future plate expansion is required,
- maintenance access is limited but cleaning requirements are low,
- specifically approved by the Engineer.

Design Requirements

The plate heat exchanger shall be selected to meet the scheduled design conditions.

Thermal and Hydraulic Design Data

The following information shall be submitted as part of the submittals to the consultant for approval:

- Cooling duty
- Primary chilled water flow rate
- Secondary chilled water flow rate
- Primary entering water temperature
- Primary leaving water temperature
- Secondary entering water temperature
- Secondary leaving water temperature
- Maximum pressure drop on primary side
- Maximum pressure drop on secondary side
- Design pressure
- Design temperature range
- Minimum fouling allowance
- Capacity margin

Performance Requirements

The unit shall:

- achieve the scheduled duty at the stated design entering and leaving temperatures,

- not exceed the scheduled pressure drops on either side,
- be selected for counterflow operation,
- maintain performance under expected variable flow conditions where applicable,
- be suitable for chilled water temperature differentials shown in the design.

Selection shall not be based solely on nozzle size or nominal plate size.

Materials of Construction

Plates

Heat transfer plates shall be:

- **AISI 304 stainless steel** as standard for chilled water duty, unless otherwise required by water chemistry.

Plate thickness shall be suitable for the pressure and temperature conditions and in accordance with the manufacturer's standard proven design.

Gaskets

For gasketed plate heat exchangers, gaskets shall be:

- removable and replaceable,
- mechanically clipped or securely retained,
- suitable for chilled water temperatures and any glycol concentration where applicable.

Unless otherwise required by the fluid characteristics, gasket material shall be:

- **EPDM** for chilled water service.

Where glycol or other additives are used, gasket compatibility shall be verified by the manufacturer.

Frame

Frame components for gasketed units shall comprise:

- fixed frame plate,
- movable pressure plate,
- carrying bar,
- guide bar,
- tightening bolts,
- support feet/base.

Frame shall be carbon steel with corrosion-resistant factory coating, or stainless steel where specified for corrosive plantroom environments.

Brazing Material

For brazed units, brazing material shall be copper or nickel as required by service compatibility and manufacturer's standard construction.

Connections

Connections shall be of the size and type indicated on the drawings and schedules and may be flanged, grooved, threaded, or union type as approved for the duty and pressure class.

The heat exchanger shall be arranged to permit:

- easy isolation,
- venting at high points,
- draining at low points,
- access for maintenance,
- removal or opening of the unit without major alteration to adjacent pipework.

All nozzles and ports shall be clearly identified by service and flow direction.

Pressure Drop and Hydraulic Performance

The plate heat exchanger shall be selected to minimize system pumping penalties while achieving the required thermal duty.

Maximum pressure drop shall not exceed the scheduled values on either side. Unless otherwise stated, target pressure drop should generally be optimized for lifecycle cost rather than minimum first cost.

Where variable flow systems are used, the supplier shall confirm suitability of the plate arrangement under part-load conditions and provide expected performance across the operating range.

Condensation and Insulation Requirements

Because the unit will operate at chilled water temperatures below ambient dew point, the plate heat exchanger, headers, and associated chilled water pipework shall be insulated and vapour sealed to prevent condensation.

Insulation shall:

- be closed-cell or otherwise suitable for chilled water application,
- include complete vapour barrier protection,
- be neatly finished around connections and supports,
- not obstruct access to vents, drains, pressure tappings, or maintenance points,
- be removable where required for servicing.

All insulation works shall comply with the project chilled water insulation specification.

Water Quality

The chilled water system shall be thoroughly flushed, cleaned, and chemically treated prior to operation.

The contractor shall ensure:

- both circuits are free of debris, scale, and construction residue,
- water treatment chemicals are compatible with plate and gasket materials,
- dirt separators or strainers are installed where specified,
- strainers are cleaned prior to commissioning and handover.

The heat exchanger shall not be placed into service until the system cleanliness has been verified.

Accessories

Provide the following accessories as part of the heat exchanger installation:

- isolation valves on all connections, (priced separately)
- thermometer pockets and temperature sensors on entering and leaving lines, (priced separately)
- pressure gauge tappings on both circuits,
- manual air vents,
- drain valves,
- Y-strainers upstream where required by the engineer,
- balancing valves where specified,
- flexible connectors where required,
- mounting frame or support brackets,
- drip tray where condensation risk exists during maintenance or insulation removal.

For larger units, provide adequate lifting provisions.

Controls and BMS Interface

Where the plate heat exchanger is part of a controlled chilled water interface, the installation shall include provision for:

- temperature sensors on primary supply and return,
- temperature sensors on secondary supply and return,
- pressure sensors or differential pressure monitoring where specified,
- flow measurement or flow proving where scheduled,
- modulating control valve on the primary side where capacity control is required,
- BMS monitoring points for temperatures, alarms, and operating status where applicable.

Control strategy shall be coordinated with the chilled water system design, including variable flow sequencing and pump control philosophy.

Installation

Install the plate heat exchanger strictly in accordance with the manufacturer’s recommendations and approved technical submittals.

Installation requirements shall include:

- correct orientation,
- stable support and anchorage,
- no undue stress on connections from pipework,
- allowance for thermal expansion and maintenance access,
- sufficient clearance for plate pack opening on gasketed units,

- accessibility for inspection, gasket replacement, and cleaning.

The contractor shall verify plantroom access, delivery route, and lifting requirements before ordering the equipment.

Testing

Factory Testing

Each unit shall be factory pressure tested and inspected in accordance with the manufacturer's standard quality procedures and relevant standards.

Provide test certificates confirming:

- model and serial number,
- design pressure,
- test pressure,
- materials of construction,
- compliance with specified duty.

Site Testing

After installation, the complete assembly shall be:

- pressure tested with associated pipework,
- flushed and vented,
- checked for leaks,
- verified for correct flow direction,
- inspected for proper installation and accessibility.

Commissioning

Commission the heat exchanger as part of the chilled water system commissioning process.

Commissioning shall include:

1. verification of approved installation,
2. confirmation of clean and treated system water,
3. filling and venting of both circuits,
4. gradual pressurization,
5. balancing of flow rates,
6. recording of entering and leaving temperatures,
7. verification of pressure drops,
8. confirmation of achieved thermal duty,
9. adjustment of associated control valves and sensors,
10. inspection for leaks, vibration, and abnormal noise.

Submit a commissioning report indicating:

- actual flow rates,

- inlet and outlet temperatures,
- operating pressures,
- measured pressure drops,
- observed cooling duty,
- deficiencies identified and corrective actions taken.

Submittals

Submit the following prior to procurement:

- manufacturer’s data sheets,
- certified selection/performance printout,
- general arrangement drawings,
- nozzle sizes and connection details,
- materials of construction,
- pressure and temperature ratings,
- weight and dimensional data,
- maintenance clearance requirements,
- insulation interface details,
- factory test certificates,
- O&M manuals,
- warranty documentation.

Identification

Provide a permanent manufacturer’s nameplate showing:

- manufacturer,
- model,
- serial number,
- year of manufacture,
- design pressure,
- design temperature,
- test pressure,
- plate material,
- gasket material where applicable,
- rated duty.

Mark each connection to indicate:

- primary in,
- primary out,
- secondary in,
- secondary out.

Warranty

Provide a minimum warranty of **12 months from handover** whichever expires first, covering defects in materials, workmanship, and performance under normal chilled water operating conditions.

Warranty exclusions shall include failure resulting from:

- inadequate flushing,
- poor water treatment,
- freezing,
- operation outside design limits,
- installation-induced pipe stress,
- physical damage after handover.

V.D25 – MIXED FLOW FAN

1. Supply and install as shown on drawings the propeller fans handling the specified air quantities as listed in the schedule.

2. The fan shall be a fully catalogued product and the documentation shall include sound power level spectrums, performance curves and/or tables for the expected range of operational conditions.

3. Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.

4. The contractor shall submit at time of equipment submission-

    a) Detailed system resistance calculation for minimum/maximum pressure drops.
    b) Certified detailed selection shown on performance curves and/or tables for the specified conditions.
    c) The service and maintenance instructions.
    d) The estimated total expenditure on replacement of parts during the service life.
    e) Installation, testing, balancing and commissioning instructions and trouble analysis guide.

5. Fan selection shall be in the stable part of the curve.

6. The fan shall be engineered and components selected when operated under normal building conditions with optimum servicing and maintenance for a minimum service life of 10 years with 6,000 operating hours per annum.

7. The Engineer reserves the right to call for

    a) Test certificates and reports from the manufacturer's quality control

laboratory or independent test laboratory such as SANS, and/or
b) Site inspections, customer reports/references and user's interviews, and/or
c) Full engineering, design and component selection details
to check the correctness of the claimed service life.

8. Fan installation shall comply with local authority by-laws and with Occupational Health and Safety Act of 1993, as amended.

9. Fan shall be complete with wire guard(s) if accessible from either side.

10. Fan shall be installed in accordance with manufacturer's recommendations and shall be maintained in "as new" condition at start-up of installation.

11. Fan and motor shall be weatherproof and shall be protected from wind, rain and insects.

12. Fan shall be quiet in operation and shall be statically and dynamically balanced at the factory.

13. Bearings shall be of the permanently lubricated type.

14. Mounting plates shall not distort under any operating conditions.

15. Fan shall be supplied c/w 7-day programmable timer switch

16. Fan shall be mounted on vibration isolating mounting.

17. Power source to motors shall be through flexible conduit.

18. Fan schedule is located on the drawings.

19. Motor conduit box shall be mounted on exterior of fan casing. Lead wires from motor to conduit box shall be protected from the air stream.

REFER TO EQUIPMENT SCHEDULE

V.D26 SELF-CONTAINED AIR-COOLED PACKAGE UNIT

1. Supply and install as shown on drawings and as listed in the schedule an air-cooled, self-contained Heatpump ac package unit complete with compressor(s), fan(s), filter(s), safety controls, refrigerant and lubrication.

2. The unit shall have capacity control to vary its capacity in response to varying load conditions.

3. The unit shall be a fully catalogued product and the documentation shall include sound power level spectrum, performance curves and selection tables for the expected range of operational conditions. The unit shall be able to continuously operate at 15% of the specified capacity with a condenser air inlet temperature of 15ºC. and shall be able to operate without tripping, with a condenser air inlet temperature of 5ºC higher than the outside summer design dry bulb temperature as specified in Clause V.C.

4. Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.

5. Certified detailed selection shown on these performance curves and tables shall be submitted.

6. The unit shall be fully protected and fail safe.

7. Minimum safety protection shall be provided for the following, and require manual reset after fault occurrence.

   a) High discharge pressure.
   b) Low suction pressure.
   c) Low oil pressure differential.
   d) Combined thermal overload and phase failure for three phase motors.
   e) Thermal overload for single phase motors.

8. Submit checklist for step-by-step simulation of overload and abnormal conditions, which will be checked as part of the testing, balancing and commissioning.

9. Submit details of all safety protection devices, including method of setting, marking and recording of the devices, to prevent damage to the apparatus under continuous overload and abnormal conditions.

10. The unit shall be so constructed and installed and sufficient spares be available to limit the:-

    a) Maximum routine service to 1 hour.
    b) Maximum annual service to 4 hours.
    c) Maximum breakdown to 1 day.

11. The unit shall be selected for a minimum service life of 10 years, operating for 3000 hours per annum under normal building operating conditions.

12. The unit shall comply with "Safety Code for Mechanical Refrigeration", ASA-B9.1.

13. The unit shall comply with the Occupational Health and Safety Act of 1993, as amended, and with local authorities by-laws.

14. Special care shall be taken in transport, delivery, storage on site and installation to ensure that the unit is installed and maintained in "as new" condition at start-up of

the installation.

15. The discharge and return air arrangement of the unit shall be as shown on the drawings. The contractor shall make due allowance if alternative discharge/return arrangements are necessary. Indicated plantroom space and height shall not be exceeded.

16. Sufficient space shall be provided for installation and service of the unit in accordance with manufacturer's instructions.

17. The unit shall be baked enamel or epoxy powder coated finish to an approved colour.

18. The casing shall not drum, vibrate or leak under any operating conditions.

19. The refrigerant piping system shall be adequately supported so that no strain is imposed on the components.

20. Noise level in the conditioned space through the operation of the unit at any operation point shall not exceed the specified internal, NC level with an 8 db room attenuation factor in each octave band. Due allowance shall be made for all attenuators required to meet the specified noise levels whether shown on the drawings or not. Operating of the unit shall not cause noise levels in the surrounding areas to be more than 7 db, in each frequency, above ambient noise levels at any boundary of the site.

21. The refrigerant shall be non-toxic, non-flammable and odourless.

22. A control and instrument panel shall be provided for each unit. The panel shall be internally mounted and factory wired. Gauges as shown on the drawings shall be incorporated in the panel.

23. All electrical wiring shall be brought to a numbered terminal strip within the panel.

24. The panel shall include the safety controls and cut-outs, as specified in Clause 7.

25. The removal and re-installation of the components shall not require special tools or skills.

26. The unit shall have readily removable front hinged panels or access doors with all serviceable components accessible and removable for maintenance.

27. The unit shall be of robust construction, completely insulated and of double skin construction to prevent condensation of moisture.

28. Exposed condenser coils shall be complete with hail guards.

29. The compressor shall be hermetically factory sealed against moisture and dirt. The unit shall have at least two compressors and two independent refrigeration circuits. Coils shall have copper tubes and aluminium fins. Fin spacing shall be more than 2,5 mm.

30. Filters shall be fire resistant, dry media washable type.

31. The evaporator fan shall be of the centrifugal type and shall be complete with automatically controlled vortex dampers linkage connected (or variable speed control on the motors).

32. Condenser air fans shall be of the centrifugal type.

33. Supply fan(s) shall be belt driven and shall have readily adjustable motor base(s) to provide variation to centre distance.

34. Belts shall be of the oil resistant type and shall be selected for a minimum of 1,2 times the rated kW of motor.

35. Fans shall be statically and dynamically balanced and factory tested with the fan installed in the casing to ISO standards.

36. The unit shall be complete with fresh air, return air and relief air dampers to provide modulating economiser cycle control.

37. Dampers shall be of the opposed blade type, 100% shut-off and shall open to a full 90 Degrees.

38. Damper blades shall rotate on pivot assembly in permanently lubricated oilite bearings.

39. Pressure drop through the damper shall not exceed 50 Pa at 5m/s velocity over the face area.

40. Damper frames and blades shall be manufactured of galvanised sheet steel.

41. Damper motors shall be of the electrical type and shall be sized to suit the damper areas.

42. Unit shall include CO_2 sensors, with automatic control of outside and return motorised OBDs.

43. Unit shall have a motorised OBD on the return air and another on the fresh air.

44. Condensate piping shall include an S-trap and routed as per the wet-service engineer's instructions.

45. Unit shall include a fully functional controller c/w wall mounted controller.

46. Unit shall include a fire signal interface.

47. Unit to be placed outdoor. See clause D4.01 for specifications on the casing of the unit.

PERFORMANCE SCHEDULE

Note: The unit schedule shown in the BoQ indicates actual design capacities, and therefore unit selections must be de-rated for the following, and selected to satisfy both sensible and total capacity:

- **Altitude = 1753m**
- **Indoor conditions = 22.5^{O}C ±1.5°C DB, 30-60% RH can be expected (RH not controlled)**
- **Outdoor conditions = 32^{O}C DB**
- **Piping length and height**

PART VI - BOQ PREAMBLES -HVAC SERVICES

The Model Preambles for Trades 2017 as published by the Association of South African Quantity Surveyors shall be deemed to be incorporated in the Bill of Quantities and no claims arising from brevity of description of items fully described in the said Model Preambles will be entertained.

Supplementary preambles are incorporated in the Scope to satisfy the requirements of this project. Such supplementary preambles shall take precedence over the provisions of the Model Preambles.

All supplementary preambles, as detailed below are, applicable to all Model Projects except where otherwise stated.

1.1. Pricing Assumptions and Guidance

1.1.1. The Contractor's prices for all items throughout the Bill of Quantities shall take account of and include for all the obligations, requirements and specifications given in the said Model Preambles and in any supplementary preambles and in the Scope.

1.1.2. The items in Bill of Quantities utilise abbreviated descriptions. It is the intention that the abbreviated descriptions when read in conjunction with the Scope, shall represent the full descriptions. However, should the full intent and meaning of any description not be clear, the Contractor shall, before submission of his tender, call for a written directive failing which it shall be assumed that the Contractor has allowed in his pricing for materials and workmanship as per the Scope.

1.1.3. All item rates and extensions must be priced in detail before submission of Tenders.

1.1.4. Tenderers are advised to check their item extensions and total additions, as no claim for arithmetical errors will be considered.

1.1.5. The offered total of the Prices in the Form of Offer and Acceptance shall constitute the Model Projects Total of the Prices (contract sum) of the successful tenderer.

1.1.6. The priced Bill of Quantities of the successful tenderer will be checked, and the Engineer reserves the right to call for reasonable adjustments to any individual price and to rectify any discrepancy whilst the total tender price, as submitted, remains unaltered. This is to be resolved before award of the contract.

1.1.7. Unless separate rates for the supply and for the installation of any item is specifically called for, the supply and installation costs of any item shall be fully included in the unit price.

The description and pricing of each item shall, unless otherwise stated herein, be held to include making, conveying and delivering, unloading, unpacking, setting, fitting and fixing in position cutting and waste, patterns, templates, plant, return of packings, profit and all other obligations arising out of the conditions of contract, excluding preliminaries.

Hangers, supports, splices, joining drilling etc. shall form part of unit rate

1.1.8. Price adjustment for inflation: the Model Projects tendered rates to be fixed up to the base date as per the Contract Data in ECC4 and rates to be adjusted thereafter as per the contract conditions.

1.1.9. Rate of exchange adjustments as per the Z clause in the Contract Data in the ECC4.

1.1.10. The items in the Bill of Quantities to be priced based on the Scope and the description in the Bill of Quantities.

1.1.11. The Prices and rates in the Bill of Quantities are treated as being fully inclusive of all work, risk, liabilities, obligations, overheads, profit, equipment, staff and everything necessary as incurred or required by the Contractor to Provide the Works.

1.2. Sundry costs

The rates in the Bill of Quantities to include all sundry costs not included at Preliminaries and general.

The sundry costs to include as a minimum the following:

- Transport, delivery to and removal off site - services and Equipment.
- Temporary electrical connections
- Small tools
- Welfare facilities
- Transport of staff, etc.
- Staff organisation (People employed directly by the Contractor, and normal place of working is on site i.e. contract's manager, site agent, foremen, supervisory staff, support staff, equipment operators, material handling gang, cleaners, security guard, etc.)
- Office administration (People employed directly by the Contractor, and normal place of working is not on site i.e. project director, cost controller, administrative staff)
- Equipment (items provided and used by the Contractor to Provide the Works and which the Scope does not require the Contractor to include in the works)
- Telecommunications
- Access to working areas: ID cards, parking permits, etc. (refer to Annexure 4)
- Management of the contract
- Quality management
- Contractor's liability insurance
- Professional indemnity insurance
- General and commercial liability insurance
- Programming of the work
- Programme and Programme updates
- Progress measurements

- Attendance for progress measurements
- Samples
- Tests and inspections
- Protection and cleaning of plant during installation
- Cleaning site and remove rubble
- Contract drawings (Workshop drawings)
- As-built drawings
- Testing, balancing and commissioning
- Spares
- Labelling of equipment (Plant) including general safety labelling
- Standard rigging or hoisting of HVAC equipment (Plant) for off-loading, moving Plant into position up to one storey high including necessary protection and OHS regulations.
- Standard scaffolding for own requirements / use in accordance with OHS regulations.
- Storage
- Certificate of Compliance for HVAC installation including HVAC electrical installation
- Training end user/ client representatives
- Operation and maintenance manuals

1.3. Measurement of quantities

1.3.1. The responsibility for the accuracy of the quantities written into the Bill of Quantities remains with the party who prepared the Bill of Quantities. The tenderer shall be relieved of responsibility of measuring quantities at the tender stage, and tender sum submitted shall be in respect of the quantities set-out in the Bill of Quantities, although he will be required to make his assessment of items such as fixings, etc. from details stated in the Bill of Quantities and shall include the item prices for such small installation materials as are required for the complete installation in accordance with the specification.

1.3.2. All measurements are nett, unless otherwise stated, and wastage must be allowed for in the rates.

1.3.3. The quantities in the Bill of Quantities are measured provisionally. All work executed in accordance with the workshop drawings approved by the Project Manager shall be remeasured by the Engineer who measured the original Bill of Quantities and priced at rates contained in, or based on, the priced Bill of Quantities.

1.3.4. All quantities are remeasure able.

1.3.5. The quantities in Bill of Quantities are not to be used for ordering purposes.

1.4. Payment assumptions

1.4.1. The Contractor and the Project Manager may agree that the total of any bill or bills, including any changes by way of additions thereto or deductions therefrom, represents a fair and accurate quantification of the items set-out in the Bill of Quantities and the parties may agree final payment on that basis. In the event of any dispute as to the quantities, then the disputed item or items shall be adjusted where necessary.

1.4.2. Variations in the Scope and extent of the work included in the Bill of Quantities shall be allowed to meet the Client's requirements and shall be measured and costed at rates entered in the Bill of Quantities, where appropriate, and shall form an addition to or deduction from the total of the Bill of Quantities. Any items or variation for which rates have not been included in the Bill of Quantities shall be agreed and priced in accordance with the provisions of the contract.

1.5. General

1.5.1. Where the Scope on a drawing, specification or other document referred to therein, refers to the words Principal Agent, Architect and Engineer these shall be interpreted as:

- Supervisor, where the context clearly refers to a testing or inspection activity in terms of the Supervisor's role as deemed in the ECC.
- Project Manager, in all other cases.

1.5.2. No alterations, erasure or addition is to be made in the text of the Bill of Quantities. Should any alteration, erasure or addition be made, it will not be recognised, and the original wording of the Bill of Quantities will be adhered to.

1.5.3. Equipment (Plant) in terms of quality shall be as per the Scope.

1.5.4. All Materials or equipment (Plant) specified under a trade name, catalogue or reference number shall, for competitive tender pricing, be exactly as described in this tender.

1.5.5. All specialists' finishes, materials, proprietary name products, etc.: preparation, installation, etc. to be as per manufacturer's specifications.

1.5.6. Equipment, Plant and Materials: purchasing, delivery to and removal from Working Areas, providing and removing packaging, samples and tests as per the Scope are deemed to be included in the rates in the Bill of Quantities.

2. SUPPLEMENTARY PREAMBLES FOR METHOD OF MEASUREMENT

The applicable method of measurement is The Standard System of Measuring Building Work (Seventh Edition) as published by the Association of South African Quantity Surveyors.

All supplementary preambles for method of measurement, as detailed below are, applicable to all Model Projects except where otherwise stated. These supplementary preambles shall take precedence over the provisions of the Standard System of Measuring Building Work.

2.1. Rectangular Ductwork

Rectangular ductwork, including bends and fittings will be measured along the centre lines and is billed in square metres according to size in the five categories based on the SARACCA classification (See Table A for SARACCA Classification).

Where an in-line reduction in size of ducting occurs, the larger size is measured over the full length of the fitting.

Bends are measured along perpendicular centre lines and is billed as extra over to allow for the additional labour, vanes, etc. based on number on the SARACCA classification. All bends in a particular category are grouped together, irrespective of the change in direction.

A T-piece is made-up of two bends; one in each direction of the split. A T-piece is measured as two bends, each based on its branch duct size.

Special fittings, such as trouser pieces, off-centre off-sets and square to rounds are individually with detailed descriptions as extra over to allow for the additional labour to manufacture and erect.

The tenderer may opt to offer a composite rate per square meter that includes the extra over rate for bends and special fittings. The extra over rate is not applicable in this instance.

The rate for ductwork includes all necessary jointing materials such as drive-slips, slip joints, angle section flanges, gaskets, nuts, bolts, duct sealer, etc. and shall allow for offcuts and wastage.

Duct supports are measured in the duct rate and shall include fixing to concrete slabs, roof trusses and purlins as required.

Distinction is made between ductwork fixed vertically or horizontally and between ductwork fixed to different elements and at different heights.

Special ductwork, such as high-pressure ductwork and kitchen canopy exhaust ductwork, are billed separately.

2.2. Round Ductwork

Straight round ducts are listed in metres.

Round fittings are listed separately by type and size.

The rate for ductwork includes all necessary jointing material such as slip joints, angle section flanges, gaskets, nuts, bolts, duct sealer, etc. and shall allow for off-cuts and wastage.

Duct supports are measured in the duct rate and shall include fixing to concrete slabs, roof trusses and purlins as required.

Flexible ductwork are billed in metres and number of lengths based on a length of 1½m (expanded) per section. The rate shall include for two clamps per 1½ section.

2.3. Duct Insulation

Internal insulation is listed in square metres based on the nett metal surface area of the duct to which the insulation is applied based on the measurement method for Rectangular ductwork.

External insulation is listed in square metres based on the outside surface area of the insulation.

Rates for insulation include glue for fixing and pins as per specification.

Areas for different types of insulation and different thicknesses are listed separately.

2.4. Fans and Attenuators

Prices for fan assemblies include support from structure, connection to ductwork and vibration isolation mountings.

Sound attenuators, venturi discharges, flexible connections and inspection doors are billed separately.

2.5. Diffusers, Grilles, Louvres, Dampers, etc.

Diffusers, grilles, louvres, dampers, fire dampers, filters, etc. are given in number for the different sizes.

Master and slave variable volume diffusers are billed separately.

2.6. Supports

Rates for pipework, ductwork and fans allow for “normal” supports.

2.7. Spares and Replacements

Any are billed separately in detail.

Water treatment chemicals are to be included for the full maintenance period.

3. SUPPLEMENTARY PREAMBLES FOR PRELIMINARIES AND GENERAL

Preliminaries and General definition: All costs to Provide the Works, **NOT** priced at the rates in the Bill of Quantities.

Preliminaries and General will be priced per Package Order as per the Package Order requirements based on the Framework Preliminaries Schedule of Rates and Model Projects Preliminaries.

3.1. Fixed preliminaries

Fixed preliminaries definition: All Preliminaries and General costs which are not time-related and not priced in the Bill of Quantities rates.

Fixed preliminaries to include as a minimum the following:

3.1.1. Health and safety: Plan, File, and basic Mandatories (refer to Annexure 5)
3.1.2. Non-standard rigging on the Client’s property: hire of all terrain mobile cranes including establishment, de-establishment, operator, OHS requirements, etc. complete
3.1.3. Non-standard rigging outside the Client’s property: hire of all terrain mobile cranes including establishment, de-establishment, operator, OHS requirements, traffic accommodation, permits, local authority costs, etc. complete. To be priced and agreed per Package Order
3.1.4. Non-standard scaffolding: scaffolding required for a specific Package order project related to HVAC and Builderswork not priced at the rates in the Bill of Quantities
3.1.5. One year’s maintenance and guarantee (refer to Annexure 2) to be priced and agreed per Package Order

3.2. Monthly preliminaries

Monthly preliminaries definition: All Preliminaries and General costs which are time related (i.e. monthly expenses) and not priced in the Bill of Quantities rates.

Monthly preliminaries to include as a minimum the following:

3.2.1. Health and safety compliance services (refer to Annexure 5) including part-time Safety Officer (see below).

Part-time Health and Safety Officer

Part-time Health and Safety officer is required to carry out weekly or daily (as per the requirements) audits/inspections and issue weekly reports.

High-risk factors are deemed to include work at heights and deep excavations.

Part-time Health and Safety officer not required for projects with a Total of the Prices from R 0 to R 2 million where no high-risk factors present.

Part-time Health and Safety officer required for projects with a Total of the Prices from R 0 to R 2 million where high-risk factors are applicable to the project.

Part-time Health and Safety officer is required projects with a Total of the prices from R 2 million to R 10 million.

Client to appoint and pay for an independent Health and Safety Officer on all projects with a Total of the Prices from R 5 million to R 20 million.

Health and Safety requirements summary

Total of the Prices	**R 0 – R 2 million**	**R 2 – R 5 million**	**R 5 – R 20 million**
Safety Plan, File and Basic Mandatories	Yes	Yes	Yes
Safety Officer required	No	Part-time: Weekly inspection and weekly report	Part-time: Daily inspection and weekly report
High Risk Factors:			
Work at Heights	Part-time: Weekly inspection and weekly report	Part-time: Weekly inspection and weekly report	Part-time: Daily inspection and weekly report
Excavation	Part-time: Weekly inspection and weekly report	Part-time: Weekly inspection and weekly report	Part-time: Daily inspection and weekly report
Independent Monthly Audit (Client appointed and cost)	No	No	Yes

Monthly Preliminaries to be priced as a monthly cost for each value category as stated in the Schedule of rates.

3.3. Equipment

3.3.1. Enclosure of the works

- 1.8m High galvanised diamond mesh fence tied to and including posts, stays, etc. fixed in ground and covered with 50% green shade cloth.
- 900 x 1 800mm High single gate to suit fencing and covered with galvanised wire mesh and 50% shade cloth, including hinges, heavy duty lockable barrel bolt and 51mm "Union 3122" padlock.
- 6 000 x 1 800mm High double leaf gate to suit the fencing and covered with galvanised wire mesh and 50% shade cloth, including hinges, heavy duty lockable barrel bolt, 51mm "Union 3122" padlock and two heavy duty long barrel bolts, each with 200mm long keeps in ground.

3.3.2. Temporary barricades

- Drywall barricade 2.7m high of galvanised steel channel section rails and studs covered on one side with 12,7mm gypsum plasterboard and finished with two coats interior quality PVA emulsion paint, including corners, ends, etc.
- Extra over preceding item for hollow core single door 813 x 2 032mm high, including steel frame, two-lever mortice lock, primer and two coats paint.

4. SUPPLEMENTARY PREAMBLES FOR PROVISIONAL SUMS

4.1. Work for which budgetary allowances are provided will be measured and valued in accordance with the relevant building contract and deducted in whole or in part if not required without any compensation for loss of profit on the said allowances.

4.2. Prime cost amounts and provisional sums are net.

4.3. Prime cost amounts shall include for delivery to site of all articles concerned.

4.4. Provisional sums will be adjusted, deducted in whole or in part if not required without any compensation for loss of profit on the said allowances.

4.5. Provisional sums are for Plant and Material supplied and installed complete by firms of specialists.

4.6. Provisional sums are given in the Bill of Quantities in respect of work which is executed by specialist subcontractors or for builderswork and for which sufficient information is not available at this stage.

4.7. The Client's design team shall develop the Scope and the Bill of Quantities and draft the procurement documents for specialist subcontractors.

4.8. The Contractor shall call for tenders, from a list of tenderers agreed between the contractor and Project Manager and undertake the technical evaluation and in consultation with the Project Manager choose the compliant tenderer to be appointed.

4.9. Or by agreement the Client's design team may call for tenders on behalf of the Client and undertake the technical evaluation of the tenders. The Contractor shall, nevertheless, be responsible for finalising the subcontract and entering contracts with such Specialist Subcontractors.

4.10. All restrictions and requirements for subcontracting, to be detailed in the Scope of the Package Order.

4.11. At appropriate times during the execution of the Works, tender documents will be issued for the Provisional sums.

4.12. Upon receipt of the tender, suitable subcontractors to be appointed by the Contractor in terms of the conditions of the contract.

4.13. The Contractor's attendance on specialist subcontractors (if required):

- Designate an area for establishment of a temporary office and workshop and storage of equipment and materials.
- Allow the use of personnel welfare facilities, where provided.
- Provide water, lighting and single-phase electric power to a position within 50m of the place where the work is to be carried out, other than fuel or power for commissioning of any installation.

- Permit the use of erected scaffolding, hoisting facilities, etc. provided by the Contractor, in common with others having the like right, while it remains erected in the Working Areas

4.14. Work executed by separate direct contractors will be executed by contractors under direct agreement with the Client. The Contractor is to accommodate these direct contractors and allow them to execute their work unhindered. Damage caused by these contractors to the works completed by the the Contractor is to be recorded in detail to enable the Client to counter-charge the direct contractors the cost of making good such damages.

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