PART 1

PORT SHEPSTONE HOSPITAL
NEW PSYCHIATRIC WARD

AIR CONDITIONING AND VENTILATION INSTALLATION

(WIMS 044044)

PARTICULAR TECHNICAL SPECIFICATIONS

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PART ONE : PARTICULAR TECHNICAL SPECIFICATION

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PORT SHEPSTONE HOSPITAL – NEW PSYCHIATRIC WARDS

AIR CONDITIONING AND VENTILATION INSTALLATION

PARTICULAR TECHNICAL SPECIFICATION

1.1.0 General

1.1.1 Standard Technical Specification

This part of the specification takes precedence over Part 2 (Standard Technical specification) in respect of any discrepancies in the description of equipment or materials. The standard specification document is available as a soft copy upon email request from the tenderer.

1.1.2 Tender Drawings

The following drawings form part of this specification and must be read in conjunction with it:

M652/AC/01 (REV I) – Air conditioning layout – Basement Plan
M652/AC/02 (REV I) – Air conditioning layout – Ground Plan
M652/AC/03 (REV J) – Air conditioning layout – First Floor
M652/AC/04 (REV A) – Air conditioning layout – Piping Schematic and Section Drawings

1.1.3 Works Programme

Type of contract : as per contract data in main contract document.
Contract period : as per contract data in main contract document.

Unless otherwise stated, in the tender documentation, the successful Tenderer, shall within 14 days of appointment, provide the Engineer with a comprehensive programme of works to tie in with that of the main contract programme. The programme must be comprehensive and indicate lead times for equipment, production of shop drawings, first and second fix items, and commissioning. At least one month must be allocated for commissioning of the systems prior requesting the Engineer to inspect the works for practical handover.

1.1.4 Maintenance and Guarantee

All plant and equipment supplied under this contract shall be guaranteed for a period of twelve (12) calendar months from the date of practical or first handover of the installation, whichever occurs first.

The chiller shall be commissioned and serviced by the Supplier. However, the tenderer shall allow for the managing and coordination of the servicing of this chiller, as well as, any callouts arising during the 12-month maintenance period.

The balancing of the water and air systems shall be performed by a reputable specialist commissioning personnel or Contractor, with a good track record for similar size and type of installations. The Engineer reserves the right to reject a person offered for this function, should he find, in his opinion, that such a person does not have the necessary capacity or competency, and the contractor shall oblige at no additional cost by presenting an alternative, to the Engineer’s satisfaction.

1.1.5 Shop Drawings

The successful Tenderer will be required to issue for the Engineer's acceptance three copies of all shop drawings, including control board circuit diagram within three weeks of the tender being awarded or as and when requested by the Engineer.

These drawings shall be adjusted and re-submitted should they be red-lined by the Engineer.

The acceptance of shop drawings by the Engineer shall in no way relieve the air conditioning Contractor of his responsibilities, such as accurate dimensioning of builder's works, providing correct size and strength of supporting structures, location of plants, fittings and access panels for adequate access for servicing and maintenance, and adherence to all applicable regulations, generally accepted good practice, and the technical specification and drawings.

The Contractor must draw to the Engineer's attention, in good time, if any part of the design he believes to be not correct.

Drawings shall be produced using a reputable drawing package, and compatible with AutoCad.

1.1.6 Tender Price Details

The tenderer shall be required to complete the tender price schedule at the time of tender. Failure to do so may result in the tenderer being disqualified. Alteration to the bill of quantities, in anyway whatsoever, shall render the tender invalid.

1.1.7 Make and Model of Equipment offered

Where alternate make of equipment to that indicated in this specification is offered, then this shall be equal, and subject to acceptance by the Engineer, prior to submission of the tenders. Acceptance of the alternative shall not relieve the tenderer from his/her obligation to ensure compliance with the specification, compatibility with other components forming part of the system, and that the equipment will fit in the space available without compromising functionality and access. The Engineer reserves the right to reject the alternate, for any reason whatsoever, and call for the make and model specified to be provided at no additional cost.

1.1.8 Price Variance/Price adjustment

Refer to contract data in the main contract document.

1.1.9 Progress Payments

The Contractor shall submit his/her claim timeously to allow for the Engineer/Quantity Surveyor at least 7 working days to process and submit his payment certificate to the Professional Quantity Surveyor.

1.1.10 Ordering of Materials and Equipment

Within 3 working days of acceptance of the successful Tenderer, the Air Conditioning Sub Contractor shall submit, for the Engineer's approval, a list of make and model numbers of all equipment and materials to be utilised in this contract. An acceptance by the Engineer shall not absolve the Air conditioning Sub Contractor from complying

with the specification unless the Sub Contractor has specifically applied for deviation from the specification for the item in question.

The equipment and materials referred to above shall include but not be limited to;

- Air conditioning units
- Air handling units
- Chiller
- Cooling towers
- Pumps
- Switchboards
- Controls
- Fans,
- Valves
- Water softening plant,
- and what other equipment the Engineer shall request, during the contract

The Contractor shall be responsible to ensure that the contract programme is adhered to and that no delays are caused by late deliveries of equipment and materials. Other activities which must precede placing of orders must be taken into account when the Sub Contractor schedules his activities.

1.1.11 As-Built Drawings

The air conditioning Sub Contractor shall provide a complete set of as-built drawings one electronic copy on a compact disk in AutoCad Format, with each operating and maintenance manual and

The provision of complete set of approved as-built drawings shall be a prerequisite to first delivery.

A full set of As-built drawings shall be framed and mounted on the plantroom wall.

1.1.12 Maintenance and Operating Manuals and Maintenance Plan

Three (3) copies of maintenance and operating manuals, each with CD with a scanned PDF copy of the entire manual is required for this installation. The manuals must include the following items;

(a) List of contents.
(b) Client's, Consultant's and Sub Contractor's details including name, contact person telephone and fax numbers, etc.
(c) Full description of installation and operating features.
(d) Detail description of automatic control system, accompanied by control schematics and controller logic setup information.
(e) Step-by-step instructions for starting/stopping each item of equipment.
(f) List of all equipment with reference numbers, model numbers, Serial Numbers, and suppliers names and contact details.
(g) Names and addresses of firms from whom spare parts can be obtained if different from the above.
(h) Spare parts lists.
(i) Commissioning data (water flow quantities, temperatures, thermostat, pressurestat and timer settings, motor voltages, amperages, meg-ohm readings, trend logging, etc.,
(j) Manufacturers data, brochures, etc.

(k) Full maintenance and servicing schedules (as recommended by equipment suppliers and including schedules attached to this document)
(l) Full set of as-built installation drawings. wiring diagrams, piping schematics, etc.,
(m) CD with copy in PDF format of entire document and drawings.

Each manual must be bound in a hardcovered ring file or similar, with the project title and type of installation printed permanently on the face and spine of the manual.

A draft copy of the manual must be submitted to the engineer during commissioning stage for his approval and shall include all items stated above except for the commissioning data.

Once commissioning has been completed a draft copy of the commissioning data must be submitted to the engineer for his approval. The accepted commissioning data must then be bound with the rest of the manual for final submission.

The Engineer reserves the right, at any time, to request a resubmission of draft copies by the Contractor for the Engineers approval.

The provision of complete and approved set of Operating and Maintenance Manuals shall be a prerequisite to first delivery or beneficial handover.

1.1.13 Power and Water Supply for site Works

Power and Water supply to site works shall be as per the main contract. The main contractor will charge for provision of these services. Power requirements for welding and cutting purposes shall be allowed for under this subcontract.

1.1.14 Contracts Management

1.1.14.1 The air conditioning contractor shall at the time of appointment have a CIDB grading of ME6. Upon appointment, the Air Conditioning Sub Contractor shall allocate to this project, a suitably qualified Contracts Engineer and a site foreman, each with at least 7 years air conditioning experience of similar scope and extent of the works, which includes chilled water installations of similar magnitude, who shall at all times be in full control of, and be able to report expediently to the Engineer and the Main Contractor on all aspects of the the Contract. The site foreman will be required to be full time on site, and as and when the Engineer and/or the main Contractor deems it necessary.

1.1.14.2 Should the Engineer indicate that the Sub Contractor has not satisfactorily complied with the above and has failed to remedy the situation within 14 days of written instruction to do so, the contract may be cancelled or payments withheld.

1,2.0 **Site Description, Scope of Contract, etc**

1.2.1 Site Description

1.2.1.1 The site is located in the Port Shepstone hospital at 7 Bazley Street, Port Shepstone, Hibiscus Coast, 4240**.**

1.2.2 Site Conditions

Site conditions are as follows:

(a) Altitude: Sea level

(b) Electrical Supply 400 Volts (+/-10%), 3 phase, 50 Hz, 4 wire
(c) Design summer outdoor air condition: 35.0°C db/80%RH

Fault levels for Switchboards:

(a) Chiller Plantroom Switchboard – 10kA
(b) All other switchboards – 5kA

All equipment selected must be capable to operate safely at a voltage supply of 220V or 400V with +/-10% fluctuation.

1.2.3 **Abnormal and/or unusual conditions**

The tenderer shall make note of the following conditions, and shall make adequate allowance in his/her rates for such conditions;

i) The project is on a live hospital site, and due care must be taken at all times to ensure that no unplanned disruptions of services are experienced.

ii) Ensure that construction activities does not pose a safety hazard to the hospital staff and patrons utilizing the hospital.

1.2.4 **Scope of Contract**

1.2.4.1 This section of the contract incorporates the supply, installation, testing and 12 months guarantee and maintenance of air conditioning, ventilation, extract and smoke management systems to the new Psychiatric Ward block.

1.2.4.2 The air conditioning system primarily comprises of the following;

a) 2x Water-cooled chillers,
b) 2x induced draft cooling towers,
c) Primary and secondary chilled water pumps,
d) Chilled water steel buffer tank,
e) Condenser water pumps,
f) 12 x ducted air handing units,
g) Switchboards/controls
h) Individual split type air conditioners,
i) Smoke extract fans for basement and service floor, staircase pressurization systems,
j) Ablution, toilets, store extraction systems,
k) Building management system to monitor the system, set operating time schedules and adjust set points such as air temperatures and duct pressures,
l) Fire Stopping

1.2.4.3 Allowance shall be made for the chiller to be commissioned and serviced by the supplier under the supervision of the air conditioning contractor.

1.2.5 Electrical and Builder's Works

1.2.5.1 Power supply to control panels and at isolators to standalone fans or air conditioning units shall be provided by others. However, the final making good to equipment shall form but of this contract, and shall including allowing for openings in panel, glands terminals, etc., where applicable.

1.2.5.2 Unless otherwise specifically indicated, builder's works shall be by the main contractor. It will be the responsibility of the air conditioning contractor, to timeously provide the necessary information to the Main Contractor, including marking up on site, providing builder's works drawings, verification on site that builder's works has been correctly provided, and provide assistance to the main contractor in ensuring that the builder's works is timeously done. Where openings are required in slabs, this must be verified on site, prior to the concrete been poured.

1.2.6 Site Inspection

1.2.6.1 The contractor shall be required to inspect the site prior provide a quotation to suit.

1.3.0 DUCTWORK

All air conditioning and extract ducting shall be of galvanised sheetmetal to SABS 1238 latest amended for low pressure ducting.

Ducting shall be fabricated and installed by an approved specialist.

All sheetmetal ducting shall have "Mez" or TDC flanged joints with sealing gaskets. Slip and drive joints will only be accepted with prior approval by the Engineer and where spacing does not permit flanged connections.

All ducting shall be externally insulated with 50mm thick mineral wool, alluminium faced insulation. Insulation shall be glued onto the face of the ducting by apply adhesive evenly over entire surface area of ducting and insulation. In addition, the insulation shall be strapped using nylon straps at 800mm intervals.

Ducting exposed to the outside, and that in plantrooms shall be externally insulated with 30mm thick high density polystyrene, closed cell non-combustible, with a density of at least 16 kg/m³, vapour barrier and two coats of polymeric emulsion reinforced embedded in layer of open weave glass fibre membrane, and a protective epoxy based membrane coating such as Decadex, Foster Sealfas, etc,

Round spiggots to diffusers shall be externally lined with 50mm foil faced fibreglass insulation.

Flexible ducting shall be Europair insulated type, with 50mm fibreglass, lined internally and externally with aluminium foil face.

Flexible ducting shall be supported at not less than 1400mm intervals. Ducting shall be fixed to spigots by firstly strapping the internal aluminium lining on to the spigot by broad Q-bands, and then the insulation and external lining with ducting tape and an additional Q band strap.

Allowance shall be made for insulating of the diffusers.

Allowance must be made to paint the inside of ducting black, where visible through grilles, louvers, etc.

Internal surfaces of the ducting shall be kept clean at all times. The duct ends shall be temporarily covered if stored on site. Air handling unit fans shall be run to blow out dust prior to installation of terminals or ceiling tiles.

1.4.0 CHILLED WATER PIPING

1.4.1 The chilled water piping shall be a combination of Black Mild Steel and copper class 2. Piping from the chiller to and including main risers/droppers shall be of mild steel. Piping at the air handling units with valve clusters shall be in copper.

1.4.2 Medium black steel piping shall be to SABS 719 and SABS 62 with fittings to BS509 and BS 1740. Piping 65mm in diameter and larger shall be welded or flanged. Piping 50mm in diameter and smaller shall have screwed fittings.

1.4.3 Continuity of earthing shall be provided across any non-conducting components along the piping, such as anti-vibration couplings,

1.4.4 PIPE INSULATION (CHILLED WATER)

All chilled water piping shall be insulated with preformed sectional fire retardant polystyrene sections, minimum density of 40 kg/cu m.

Vapour barrier jackets shall only acceptable on drain piping. These shall be applied with a continuous, unbroken vapour seal. Hangers, supports, anchors, etc., that are secured directly to cold services shall be adequately insulated and vapour sealed to prevent condensation.

Inserts shall be installed at hangers. Inserts between the pipe and pipe hangers shall consist of rigid pipe insulation of equal thickness to the adjoining insulation and shall be provided with vapour barrier where required. Inserts shall be of sufficient lengths to support the weight of the pipe without crushing the insulation.

Exposed insulation and gaps around fittings such as valves, strainers, binder fittings, shall be seal with polyurethane foam.

Insulation thickness shall be as follows:-

Pipes from 15mm to 50 mm diameter - 30 mm

Pipes from 65mm to 300 mm diameter - 50 mm

Pipes bigger than 300 mm diameter - 65 mm

Apply insulation in two layers, staggered to avoid air bridges. Wire-brush pipe work and coat surface with one layer of Flintcote 5, a synthetic cold bitumen adhesive and wait until this is tacky. Apply a coat of Flintcote 5 to the inside of the styrene shells taking care to fill all air bubbles and depressions and when tacky place upon the metal surface. Allow to set firmly and repeat for second coat.

When dry, apply final coat of Foster 30-36 or Chemseal 4 onto the outside of the styrene sections and cover with a fibreglass scrim cloth taking care to smooth out all bubbles and wrinkles. When firmly in place apply two further coats of Foster of Chemseal until a smooth and even finish is achieved. All bends and joints to be purpose made, either moulded or segmented. Round off segmented sections to a neat workmanlike appearance before applying sealer. Each layer shall be a minimum thickness of 0.5mm.

All work shall be finished completely vapour sealed.

Aluminium foil faced insulation shall not be acceptable.

Armaflex or similar insulation on chilled water piping shall not be acceptable.

Insulation and vapour seal shall be done by an approved specialist company.

Particular care shall be taken to ensure that the outer surfaces of the insulation finished smooth, uniform and of a high standard. A sample section shall be completed for the Engineer's acceptance. This insulation shall be re-done should the Engineer be of the opinion that the workmanship is not satisfactory. The insulation specialist company shall be replaced with another one should it be warranted in the opinion of the Engineer. The standard of the approved sample section shall be maintained throughout the remaining part of the reticulation. However, should in the opinion of the Engineer, the quality of workmanship decrease then the Engineer will reject the affected part of the installation and the insulation shall be re-done until such time that the workmanship is satisfactory.

Directional flow arrows shall be provided on the face of the piping at 3 m intervals and 200mm from change in direction.

1.4.5 CLADDING

All piping on rooftop, in plantrooms and at the AHUs shall be finally clad with pre-rolled aluminium sheet metal cladding.

Cladding thickness shall be as follows:

Pipe size up to 150mm dia.	- 0,7mm thick
Pipe size greater than 150mm dia.	- 0.9mm thick

All bends to be full aluminium segmented lobster back. Cladding will be held in place using aluminium Q-bands. Screws or rivets will not be accepted.

Where exposed to the weather, the longitudinal joints shall lie in the lower sections of the piping and overlaps shall be in such a manner that ingress of water is prevented.

1.5.0 VALVES

Valves shall be of make as specified elsewhere.

All valves shall be fit for purpose, durable, generally of very high quality, and free of corrosion prone material. Modulating valves shall be Johnsons Control or Landis Gyr.

Valves in insulated piping shall be provided with extended stems such that the handles are free of the insulation.

All valves shall be labeled with tag and cross referenced in the as-built drawings.

1.6.0 DRAIN PIPING

1.6.1 Condensate drain from each AHU shall be piped under this HVAC contract, to a drain point provided.

1.6.2 All condensate drain piping from air conditioning units shall generally be uPVC and lagged with pre-formed "Armaflex" or equal and mitered neatly. All joints shall be glued and wrapped neatly with black broad adhesive tape.

1.7.0 WATER TREATMENT DOSING CHAMBER

1.7.1 A wall mounted dosing chamber shall be provided as specified on drawing to sample and chemically treat the chilled water for rust prevention.

1.7.2 System shall be filled and the water and descaling chemical and circulated sufficiently to flush the entire system before draining and filling with clean water, after which corrosion inhibitors shall be added.

1.8.0 CHILLER

Two new water-cooled chillers shall be supplied under this contract. The air conditioning contractor shall communicate with the supplier to coordinate the delivery of the chiller to roadside, as well as commissioning and regular servicing of the chiller.

The chiller shall be a water-cooled type of Daikin or Trane manufacture, or equal and approved prior to tender closing, The compressors shall be of the screw type, with R134a or R410A refrigerant and have a Modbus Communication interface unit.

Allowance shall be made in the price of the chillers, for the Chillers to be tested and commissioned by the supplier or their appointed specialist. Their full commissioning report shall be included in the Operating and Maintenance manuals.

Table 4. General Chiller plant technical Specification

PLANT REFERENCE	SPECIFICATIONS
i. CHILLERS	
No. of chillers	2
Total cooling capacity per chiller	340 kW each
Refrigerant	R410A or 134a
Entering and leaving water temp.	12°C / 6°C
Type condenser	water-cooled, shell and tube
Number of compressors per chiller	two
Compressor and motor	Semi-hermetic, rotary (screw) compressor with capacity control slide valve
Capacity control	Infinite, down to at least 25% for each chiller
No. of evaporator passes	Two (2)
Evaporator Fouling factor	0.0176 m2-deg K/kW
Evaporator Gross COP (EER)	5.1 minimum
No. of condenser passes	Two (2)
Condenser Fouling factor	0.044 m2-deg K/kW
Condenser Gross COP (EER)	6.1 minimum
Controls	Factory fitted microprocessor
Voltage/Hz/Phase	400/50/3
Starting method	Star-delta or part wind

1.9.0 **CHILLED WATER PUMPS**

1.9.0 **CHILLED AND CONDENSER WATER PUMPS**

The pumps shall be end-suction, centrifugal, horizontal and comply with specifications in table below.

The capacity of the pumps given below are provisional and for tender pricing only. The Contractor shall submit complete and detailed hydraulic calculations to determine the actual head, with pump curves indicating selected operating point prior to submitting to the Engineer for acceptance and procurement.

Table 8. Pump Specifications

PLANT REFERENCE	Primary Chilled water PCHWP1 and 2	Secondary Chilled water SCHWP1 and 2	Condenser water CNDWP1 and 2
Number off	2 (Duty and standby)	2 (Duty and standby)	2 (Duty and standby)
Total flow per pump	14 L/s	25 L/s	46.0 L/s
Make	Grundfos/KSB/Wilo	Grundfos/KSB/ Wilo	Grundfos/KSB/ Wilo
Total static head	16.0m	32.0m	23.0m
Nominal speed	1450 RPM	1450 RPM	1450 RPM
Motor rating	**140% of full load absorbed power**	**140% of full load absorbed power**	**140% of full load absorbed power**
Motor insulation rating	IP55	IP55	IP55
Electrical power	400V/3phase/50Hz	400V/3phase/50Hz	400V/3phase/50Hz
Pressure rating	16 Bar	16 Bar	16 Bar
Din rating.	24255	24255	24255
Pump bearings	ball	ball	ball
Lubrication	oil bath	oil bath	oil bath
Pump casing	Cat iron	Cat iron	Cat iron
Impeller	Bronze	Bronze	Bronze
Shaft seal	Mechanical	Mechanical	Mechanical
Shaft and shaft sleeve	Stainless steel	Stainless steel	Stainless steel
Drive	constant speed drive	Constant speed drive	Constant speed drive
Coupling type	Fenner rubber tyre	Fenner rubber tyre	Fenner rubber tyre
Mating flanges	Din 2533	Din 2533	Din 2533
Base plate	Hot dip galvanised	Hot dip galvanised	Hot dip galvanised
Drip tray	3CR12 (over entire pump)	3CR12 (over entire pump)	3CR12
Type of mounting	Mason spring mounts	Mason spring mounts	Mason spring mounts
Type of base	Steel frame	Concrete filled steel framed Inertia base	Steel frame

1.10.0 **WATER TREATMENT PLANT (COOLING TOWER)**

1.10.1 Two water treatment plants shall be provided, one for each of the two cooling tower systems. The water treatment plants shall be located adjacent to the cooling towers.

Each water treatment system shall comprise of the following;

a) Automatic chemical dosing for rust and scale inhibition
b) Automatic biocide dosing
c) Automatic bleed off system

All controllers shall be fitted in PVC splashproof enclosures and mounted on the plantroom wall.

Field wiring and tubing shall be run in PVC conduit.

Installation of this plant and the monthly testing and reporting on the condition of the system shall be done by an approved specialist.

1.10.2 Automatic chemical dosing for rust and scale inhibition

Automatic chemical dosing shall be done in proportion to makeup water measured via an impulse water meter. The meter shall include a counter to measure total water usage and shall have a working pressure of 1000kPa.

The system shall be supplied complete with dosing pump, related controls, polyethylene tank mounted on a metal frame stand, UV stabalised tubing, foot valve, strainer, loading valve and relieve valve.

The dosing pumps shall be manufactured of corrosion resistant components and suitable for 220V/50Hz supply and applicable working pressure.

A manual on/off shall switch be provided to test the system.

1.10.3 Automatic biocide dosing

Dosing of biocides shall be based on running time of the plant and shall be shock dosed via a dosing pump.

The plant running time shall be measured by means of a time clock. Dosing shall be done after a predetermined but adjustable accumulated running time.

The system shall be supplied complete with dosing pump, timer, related controls, polyethylene tank mounted on a metal frame stand, UV stabilised tubing, foot valve, strainer, loading valve and relieve valve.

1.10.4 Automatic bleed off system

Automatic bleeding of the cooling tower sump for the control of the level of the total dissolved solids, shall be done via a conductivity controlled bleed off with a solenoid valve located on the cooling tower drain line and a conductivity sensor located in the cooling tower circulating water

The control unit shall be complete with an auto/test and calibration facility.

1.11.0 COOLING TOWERS

Cooling towers shall be of the fiberglass, induced draft type with axial flow fan.

The cooling towers, shall be sized for the chillers specified, but shall not be less than that indicated in the table below and 1.3 times the cooling capacity of the chiller. Each chiller shall be served by two cooling towers.

The cooling tower construction shall be reinforced fiberglass. All bolts, nuts and washers, shall be of heavy duty galvanised. The steel base frame shall be galvanized.

PLANT REFERENCE	CT No. 1 and 2
No. of Towers	2
Total minimum heat rejection per cooling tower	450kWHR
Cooling tower capacity control	Variable speed drive on discharge fan
Drive	VSD
Entering water temp.	35 deg.C
Leaving water temp.	29.5 deg.C
Ambient wet bulb temp.	26 deg.C
fill and eliminator material	P.V.C.
Material of nozzles	P.V.C.
Strainer material	Stainless steel
Bolts and nuts	Stainless steel
Fan type	balanced axialflow with UV stabilized PVC blades, stainless steel shaft and fasteners and cast iron hub.
Motor	TEFC, Class F insulation, 400V/3ph/50Hz
Fan speed	As per supplier selection but not higher than 1440RPM

1.11.0 AIR HANDLING UNITS

All air handing units offered shall be of the same make and locally manufactured.

All cooling coils shall be pressure tested at place of manufacture. Pressure test certificates for each coil shall be submitted to the Engineer, prior to the air handling units been delivered to site. Fans speed selection shall take into consideration the noise criteria required for the office spaces.

Fan static pressures given below are provisional; It shall be the responsibility of the successful contractor to re-calculate the system static pressures to meet the design conditions. These shall be submitted to the Engineer with full details of the calculations and selections.

Table 2. Air handling Units: Plant Capacities

AHU Reference	AREA SERVED	Air--on-coil	Air-off-coil	Total Supply air	Total Fresh air	Total cooling	Total Heating
AHU1	Male Medium/Long Stay Wards	28.5/21.5	13.1/12.5	1167L/s	400L/s	41kW	16kW
AHU2	Acute Male Ward	28.5/21.5	13.1/12.5	1211L/s	461L/s	41kW	16kW
AHU3	Male Dining/Lounge	25.1/19.2	13.3/12.9	1436L/s	274L/s	31.4kW	12kW
AHU4	Clinical Support Consulting rooms (East and West)	25.7/19.6	13.1/12.5	2075L/s	560L/s	53.4kW	16kW
AHU5	Female Dining/Lounge	25.1/19.2	13.3/12.9	1436L/s	274L/s	31.4kW	12kW
AHU6	Acute Female Ward	25.7/19.7	13.7/12.2	984L/s	259L/s	25.3kW	12kW
AHU7	Female Medium/Long Stay Wards	28.5/21.5	13.1/12.5	1299L/s	491L/s	41kW	16kW
AHU8	1st Floor Double Volume/Ground Floor - Admissions/Reception	28.1/19.0	11.9/11.5	2900L/s	624L/s	75kW	24kW
AHU9	Ground Floor: OPD consulting/Counselling Rooms	24.4/17.9	11.6/11.0	2300L/s	558L/s	50.3kW	12kW
AHU10	1st Floor Occupational Staff Clinic/Board rooms	25.3/19.3	12.8/12.3	1744L/s	377L/s	44.2kW	12kW
AHU11	1st Floor Offices	24.6/17.4	10.3/9.7	3700L/s	586L/s	89.9kW	18kW
AHU12	1st Floor Staff training/meeting	24.3/18.0	12.3/11.7	3300L/s	417L/s	70.5kW	12kW

Table 3. General AHU Technical Specification

PLANT REFERENCE	AHU
Sections and type	Horizontal discharge with fan, coil, heater (where applicable), primary and secondary filter box
Unit casing	Double skin, Internal and external chrom-a-dek with 45mm thick polystyrene and aluminium anodized frame sections
Primary filters	Front withdrawal, 50mm thick pleated, washable
Access panels	Hinged airtight access panels to fan, coil, heaters and filter, with heavy duty reinforced nylon lever-cam door handles
Fan	Plug fan with EC motor for variable speed drive
Motor	Variable speed EC motor
Coil material	Copper tube and Copper fins

Drip tray and coil frame	316 Stainless steel
Pressure gauges	Magnehelic pressure gauges shall be provided across primary filter banks

1.14.0 ELECTRICAL SWITCHBOARDS AND CONTROLS

All air conditioning and ventilation switchboards to be manufactured by specialist manufacturers.

All electrical work shall be carried out in accordance with SANS standards, and what is considered as good practice. An electrical compliance certificate will be required.

All starting and stopping of equipment shall be sequenced as recommended by the supplier of the relevant equipment.

Emergency mushroom head type isolators shall be provided at each remote equipment, such as pumps, cooling towers and fans.

1.14.6 GENERAL:

The control panels shall be built in accordance with the SABS Wiring Code of Practice SABS 0142, and the SABS Specification for Low Voltage Switchgear and Control Gear Assemblies SABS 60439-1.

Load carrying equipment installed within the control panels must comply with the following specifications:

- IsolatorsIEC 60947-3
- ContactorsIEC 60947-1
- MCBsIEC 60947-2
- TerminalsIEC 6097-7-1
- FusesIEC 60269-1-2
- Thermal OverloadsIEC 947-4
- Manual Motor StartersIEC 947-4-1

Notwithstanding the requirements herein, the tenderer shall nevertheless include in his tender for all components and circuitry to ensure that the system operates correctly and safely, is to regulations, and is in accordance with the recommendations of the suppliers of the plants offered.

b. Cable Connections

Cable ends shall be finished off in the type of boxes as recommended by the manufacturers.

The steel wire cable protection shall be properly clamped between conical bushes and kept in position with lock nuts. Cable ends shall be properly earthed.

d. Wiring Channels

Channels must be current catalogued products of a reputable make and shall be complete with bends, T-pieces, corner-pieces, internal dividing plates, knock-out sections, etc. and all other accessories as may be required for the installation.

Channels shall be galvanised or properly cleaned and painted with a lead primer and finished off with two coats of approved enamel paint with colour to match the existing installation.

Wiring channels shall be provided with snap-on lids or if channels are too wide, lids will be neatly screwed on.

Knock-out holes for conduits will be provided on the sides of wiring channels in positions as shown on the drawings or as may be required.

g. Fault Level

The fault level of the distribution and protection system shall be in accordance with the fault level of the general electrical installation in the building.

The air conditioning Sub Contractor shall arrange with the Engineer for the witnessing of the testing of the boards at the manufacturer's workshop prior to they being transported to site and the Engineer must be notified in good time as to when the boards will be available for inspection.

A complete and detailed circuit diagram for each board shall be issued, in good time, to the Engineer for his approval prior to manufacturing. The Engineer reserves the right to request a resubmission of the diagrams for his approval.

Final CAD drawn circuit diagrams, drawn to European standards with grid and component references shall be produced and approved by the Engineer. These shall be included in the operating and maintenance manuals. In addition, a copy of the chiller plantroom switchboard circuit diagram shall be mounted on a frame and bolted on the plantroom wall adjacent to the board.

c. Pilots Lights

Pilot lights shall be flush mounted on panel doors and shall have coloured glasses which shall be removable from the front of the door for replacement of lamps. Provide one spare lamp for every five pilot lights. The colour of the lenses shall be:

RUN:Green
FAIL:Red
INDICATION:Amber

d. Starters, Contactors and Relays

Contactors shall be sized to take 10% higher load than the actual imposed load.

Contactors shall also be able to withstand the following:

Over current and fault currents that may occur for the time required for its own tripping device to operate.

All fault currents until the back-up fuses or circuit breakers trip.

All contactors shall be provided with at least two auxiliary contactors for interlocking and indication.

Starters, contactors and relays of a similar make and type shall be employed wherever possible to reduce the number of spares to be kept.

e. Labelling

All labels shall be of the engraved type with black letters on white/silver background.

f. Access

All equipment mounted in the electrical switchboards shall have sufficient space to be easily accessible for removal, repair and maintenance.

g. Wiring and Terminals

Copper stranded conductors with Polyvinyl Chloride Insulation shall be used for all small wiring in the switchboard.

Wiring inside the compartments shall be neatly bundled together and fastened with patented PVC bands and shall run in near horizontal or vertical lines wherever possible. Wiring from one compartment to another shall be done in wiring channels with clip on lids.

Wiring shall be connected to terminal blocks and no more than two wires shall be connected to any one terminal. Provide 10% spare terminals for possible future extensions or additions to the board. Identification of small wiring shall be in accordance with BS 158. Wiring connected to panel doors shall be protected by a plastic spiral wrapped around the conductor bundle and sufficient slack of wire shall be provided to allow easy opening of doors without putting any strain on the terminal connections.

Multi-core incoming cables shall be connected to the switchboard wiring by means of terminal blocks. All cables entering the switchboard shall be neatly finished off.

h. Switchgear

All switchgear shall comply with the relevant SABS and BS standards such as SABS 152 and 156 and BS 5419.

I. Isolators

All isolators shall be load break switches and shall be pad lockable off.

1.14.4 ELECTRICAL WIRING

All the wiring between localised motor control centres installed under this contract and from isolators provided by the electrician shall form part of this air conditioning contract. See enclosed tender drawings for the position of the Motor control centres.

All electric wiring reticulation is to be carried out in strict accordance and in compliance with the South African Bureau of Standards wiring code SABS 0142.

All electric reticulation must either be drawn in steel conduit or laid in a steel trunking/cable racks.

Upon completion of the Works, the Contractor shall issue a Certificate of Compliance for all electrical work undertaken.

a. Cables

Wiring shall be multi-strand silicone insulated copper wiring. Wire ways and layouts shall be planned in advance to minimise cable crossings. Wiring shall be installed parallel to one another and shall be properly fixed. Joining of cables will not be acceptable.

Each cable shall be identified with a metal tag bolted to the cable ends and identification numbers will be stamped on the tags.

b. Local Isolators

Provide local isolators adjacent to motor driven equipment remote from switchboards.

c. Cable Racks

Where cable racks are used the cables shall be laid on factory manufactured cable racks. Cable racks shall be current catalogued products of a reputable make complete with all bends, tee pieces, reductions, take-offs and clamps.

All cable racks shall be galvanised and painted with a lead primer and two coats of approved enamel paint with colour to match the existing installation. Sufficient support brackets shall be provided to prevent sagging of cable racks.

Cables and wires shall not be fitted directly to cable racks. All cable racks shall have earthing continuity

e. Conduit

Conduits shall be galvanised steel and shall bear the SABS mark. The minimum diameter of conduits used shall be 20mm.

Conduits shall be screwed and socketted and bends shall be of the long radius type. PVC conduits are not acceptable.

f. Draw Boxes

Draw boxes shall be installed so that not more that two bends occur between a draw box and the end of the conduit or between two draw boxes.

1.14.6 CONTROL METHODOLOGY

a. AIR DISTRIBUTION

The control methodology for the diffusers in the ducted system from each air handling system shall as given in table below.

Table 5: AHU Air Distribution System Control Methodology

AHU Reference	AREA SERVED	CONTROL METHODOLOGY
AHU1	Male Medium/Long Stay Wards	Constant volume with terminal re-heat
AHU2	Acute Male Ward	Constant volume with terminal re-heat
AHU3	Male Dining/Lounge	Constant Volume
AHU4	Clinical Support Consulting rooms (East and West)	Variable Air Volume (VAV)
AHU5	Female Dining/Lounge	Constant volume
AHU6	Acute Female Ward	Constant volume with terminal re-heat
AHU7	Female Medium/Long Stay Wards	Constant volume with terminal re-heat
AHU8	1st Floor Double Volume/Ground Floor - Admissions/Reception	Variable Air Volume (VAV)
AHU9	Ground Floor: OPD consulting/Counselling Rooms	Variable Air Volume (VAV)
AHU10	1st Floor Occupational Staff Clinic/Board rooms	Variable Air Volume (VAV)
AHU11	1st Floor Offices	Variable Air Volume (VAV)
AHU12	1st Floor Staff training/meeting	Variable Air Volume (VAV)

I. CONSTANT VOLUME SYSTEMS

Constant volume systems serving open plan areas in out-patients waiting and ward dining/lounge areas shall be controlled by averaging sensors located at the return air grilles. Heaters will be provided in the air handling units for winter heating. The controls to the AHUs will be configured to either cool or heat with mechanical safety interlock to ensure that the system does not heat and cool at the same time.

II. VARIABLE-AIR-VOLUME SYSTEMS

Variable-air-volume systems shall be provided with reverse acting diffusers such that operation of the diffuser is reversed depending on whether the system is on heating or cooling mode.

Duct static pressure sensors shall measure the duct pressure downstream of the ducting and control the speed of the supply air fan accordingly to maintain a constant duct static pressure.

Variable air diffusers shall be powered from the air-conditioning control panel.

b. CENTRAL CHILLER PLANT:

Each cooling tower shall be dedicated to a chiller. However, the condenser water piping at the cooling towers shall be configured with isolating valves such that any cooling tower can be allocated to any of the chillers. Cooling towers shall be controlled to provide a constant leaving condenser water temperature to the chillers via variable speed drive on the cooling tower fans.

The two chillers shall operate on a lead-lag basis and will flip/flop to maintain a relatively equal running time.

The standby/duty secondary chilled water pumps shall operate on a flip/flop controller to ensure an equal running time.

The primary condenser water pumps shall be run on constant speed with condensing capacity controlled via variable speed drives on the cooling tower fans. The condenser water pump shall operate in conjunction with the relevant chiller.

c. BUILDING MANAGEMENT SYSTEM:

The new air conditioning plant serving the Psychiatric Ward building shall be provided with a building management system linked to the existing central computer station located at the workshop managers office. Allowance shall be made to supply and configure a new computer station should the existing be found to be inadequate at the time of the installation.

The BMS system and its controllers shall use open protocols with web based interfacing and compatible with common communications and network protocols, including LonWorks®, Modbus®, BACnet™, TCP/IP, SNMP and Konnex, either directly or via interface cards.

The BMS and controller software and upgrades shall be available free of charge. The system must not require the maintenance of a proprietary license, such that it restricts the end user to any particular supplier for repairs or upgrades in the future. The system shall be configured such that the operation of the plants are not dependent on network connectivity and can run independently of the BMS system. The BMS system is designed to remotely monitor, make set point changes only and set on/off time schedules, and not to control the plant operation. Failure of network connectivity shall not compromise the operation of the system.

The adjustment of the time scheduling of the air conditioning system will be able to be managed via the BMS from the workshop managers office, thus allowing for effective energy management.

All systems including chillers, pumps, cooling towers, AHUs, buffer tank temp. smoke fans, hot water tank temp, etc., shall be graphically represented on the BMS screen pages with set points and live status of the various parameters.

The VAV diffusers shall be integrated with the BMS system via the diffusers MCU and displayed graphically on the BMS screen page with status (set point temp, actual room temp, status (Heating or Cooling) and motor position.

All controllers at the AHU control panels shall be with use interface screen display, accessible by opening the panel door.

TABLE 6: Schedule of input and outpoints on BMS system

The list below is not to be taken as complete, and points shall be in compliance with the requirements in this specification and that will be reasonably necessary to effectively monitor the HVAC system.

AIR HANDLING UNITS
Controller Bus Inputs:
Room temperature (measured in return air duct)
Supply air temperature
Ambient temperature (measured in fresh air duct)
Supply air duct static pressure (0-10Volts)
Fire signal (voltage free)
Primary filter dirty from static pressure switch
Fan run/trip status (relay input from motor thermal protection relay)
Chilled water leaving temperature (thyristor sensor in pipe)
User /Operator inputs (local controller and BMS PC interface)
Room Setpoints : 23deg C
Heating cooling dead bands: 2 deg C
Comparator slopes and operating ranges for PDI control to Chilled water modulating valve
Comparator slopes and operating ranges for PDI control to supply air fan VSD
Stop/start timer schedule (24/7)
Controller Bus Outputs:
0-10V to Supply air fan variable speed drives
0-10V to chilled water motorized modulating valve
Three step on/off signal to heater elements
Modulating valve position (percentage based on controller output signal voltage)
Fan speed (percentage based on controller output to signal VSD)
Interface outputs
Fan run/trip status
Heater step on/off status
Setpoint temperature
Return air temperature
Chilled water leaving temperature
Alarm Signal:
Fan trip
Filter dirty
CHILLER PLANT
Controller Bus Inputs:
Chilled water temperature at chiller #1 (in/out)
Chilled water temperature at chiller #2 (in/out)
Start signal (time scheduler)
Primary chilled water pump #1 run/trip status
Primary chilled water pump #2 run/trip status
Secondary chilled water pump #1 run/trip status
Secondary chilled water pump #2 run/trip status
Condenser water pump #1 run/trip status
Condenser water pump #2 run/trip status
Condenser water entering and leaving temperatures
User /Operator inputs (local controller and BMS PC interface)
Stop/start timer schedule chiller #1 (24/7)

Stop/start timer schedule chiller #2 (24/7)
Stop/Start signal – Cooling tower #1
Stop/Start signal – Cooling tower #2
Upper setpoint temperature of chilled water for alarm
Stop/Start signal - Primary chilled water pump #1
Stop/Start signal - Primary chilled water pump #2
Stop/Start signal - Secondary chilled water pump #1
Stop/Start signal - Secondary chilled water pump #2
Stop/Start signal - Condenser water pump #1 run/trip
Stop/Start signal - Condenser water pump #2 run/trip
Cooling tower condenser water leaving setpoint
Controller Bus Outputs:
0-10V to Supply air fan variable speed drives
0-10V to chilled water motorized modulating valve
Interface outputs
Run/trip Status of chillers, cooling towers and pumps
Chilled water entering and leaving temperatures at each chiller and system
condenser water entering and leaving temperatures
Alarm Signal:
Chiller t#1 trip alarm
Chiller t#2 trip alarm
Cooling tower #1 motor trip
Cooling tower #1 motor trip
Primary Chilled water Pump #1 motor trip
Primary Chilled water Pump #2 motor trip
Secondary Chilled water Pump #1 motor trip
Secondary Chilled water Pump #2 motor trip
Condenser water Pump #1 motor trip
Condenser water Pump #2 motor trip
Chilled water supply temperature above 15deg C
HOT WATER:
Hot water tank temperature
Hot water temperature Alarm – below 40 deg C

1.15.0 ELECTRICAL SWITCHBOARDS AND CONTROLS

All air conditioning and ventilation switchboards to be manufactured by specialist manufacturers.

All electrical work shall be carried out in accordance with SANS standards, and what is considered as good practice. An electrical compliance certificate will be required.

All starting and stopping of equipment shall be sequenced as recommended by the supplier of the relevant equipment.

Emergency mushroom head type isolators shall be provided at each remote equipment, such as pumps, cooling towers and fans.

1.15.6 GENERAL:

The control panels shall be built in accordance with the SABS Wiring Code of Practice SABS 0142, and the SABS Specification for Low Voltage Switchgear and Control Gear Assemblies SABS 60439-1.

Load carrying equipment installed within the control panels must comply with the following specifications:

- IsolatorsIEC 60947-3
- ContactorsIEC 60947-1
- MCBsIEC 60947-2
- TerminalsIEC 6097-7-1
- FusesIEC 60269-1-2
- Thermal OverloadsIEC 947-4
- Manual Motor StartersIEC 947-4-1

Notwithstanding the requirements herein, the tenderer shall nevertheless include in his tender for all components and circuitry to ensure that the system operates correctly and safely, is to regulations, and is in accordance with the recommendations of the suppliers of the plants offered.

b. Cable Connections

Cable ends shall be finished off in the type of boxes as recommended by the manufacturers.

The steel wire cable protection shall be properly clamped between conical bushes and kept in position with lock nuts. Cable ends shall be properly earthed.

d. Wiring Channels

Channels must be current catalogued products of a reputable make and shall be complete with bends, T-pieces, corner-pieces, internal dividing plates, knock-out sections, etc. and all other accessories as may be required for the installation.

Channels shall be galvanised or properly cleaned and painted with a lead primer and finished off with two coats of approved enamel paint with colour to match the existing installation.

Wiring channels shall be provided with snap-on lids or if channels are too wide, lids will be neatly screwed on.

Knock-out holes for conduits will be provided on the sides of wiring channels in positions as shown on the drawings or as may be required.

g. Fault Level

The fault level of the distribution and protection system shall be in accordance with the fault level of the general electrical installation in the building.

The air conditioning Sub Contractor shall arrange with the Engineer for the witnessing of the testing of the boards at the manufacturer's workshop prior to they being transported to site and the Engineer must be notified in good time as to when the boards will be available for inspection.

A complete and detailed circuit diagram for each board shall be issued, in good time, to the Engineer for his approval prior to manufacturing. The Engineer reserves the right to request a resubmission of the diagrams for his approval.

Final CAD drawn circuit diagrams, drawn to European standards with grid and component references shall be produced and approved by the Engineer. These shall be included in the operating and maintenance manuals. In addition, a copy of the chiller plantroom switchboard circuit diagram shall be mounted on a frame and bolted on the plantroom wall adjacent to the board.

c. Pilots Lights

Pilot lights shall be flush mounted on panel doors and shall have coloured glasses which shall be removable from the front of the door for replacement of lamps. Provide one spare lamp for every five pilot lights. The colour of the lenses shall be:

RUN:Green
FAIL:Red
INDICATION:Amber

d. Starters, Contactors and Relays

Contactors shall be sized to take 10% higher load than the actual imposed load.

Contactors shall also be able to withstand the following:

Over current and fault currents that may occur for the time required for its own tripping device to operate.

All fault currents until the back-up fuses or circuit breakers trip.

All contactors shall be provided with at least two auxiliary contactors for interlocking and indication.

Starters, contactors and relays of a similar make and type shall be employed wherever possible to reduce the number of spares to be kept.

e. Labelling

All labels shall be of the engraved type with black letters on white/silver background.

f. Access

All equipment mounted in the electrical switchboards shall have sufficient space to be easily accessible for removal, repair and maintenance.

g. Wiring and Terminals

Copper stranded conductors with Polyvinyl Chloride Insulation shall be used for all small wiring in the switchboard.

Wiring inside the compartments shall be neatly bundled together and fastened with patented PVC bands and shall run in near horizontal or vertical lines wherever possible. Wiring from one compartment to another shall be done in wiring channels with clip on lids.

Wiring shall be connected to terminal blocks and no more than two wires shall be connected to any one terminal. Provide 10% spare terminals for possible future extensions or additions to the board. Identification of small wiring shall be in accordance with BS 158. Wiring connected to panel doors shall be protected by a plastic spiral wrapped around the conductor bundle and sufficient slack of wire shall be provided to allow easy opening of doors without putting any strain on the terminal connections.

Multi-core incoming cables shall be connected to the switchboard wiring by means of terminal blocks. All cables entering the switchboard shall be neatly finished off.

h. Switchgear

All switchgear shall comply with the relevant SABS and BS standards such as SABS 152 and 156 and BS 5419.

I. Isolators

All isolators shall be load break switches and shall be pad lockable off.

1.16.2 ELECTRICAL WIRING

All the wiring between localised motor control centres installed under this subcontract and from isolators provided by the electrician shall form part of this air conditioning subcontract. See enclosed tender drawings for the position of the Motor control centres.

All electric wiring reticulation is to be carried out in strict accordance and in compliance with the South African Bureau of Standards wiring code SABS 0142.

All electric reticulation must either be drawn in steel conduit or laid in a steel trunking/cable racks.

Upon completion of the Works, the Contractor shall issue a Certificate of Compliance for all electrical work undertaken.

a. Cables

Wiring shall be multi-strand silicone insulated copper wiring. Wire ways and layouts shall be planned in advance to minimise cable crossings. Wiring shall be installed parallel to one another and shall be properly fixed. Joining of cables will not be acceptable.

Each cable shall be identified with a metal tag bolted to the cable ends and identification numbers will be stamped on the tags.

b. Local Isolators

Provide local isolators adjacent to motor driven equipment remote from switchboards.

c. Cable Racks

Where cable racks are used the cables shall be laid on factory manufactured cable racks. Cable racks shall be current catalogued products of a reputable make complete with all bends, tee pieces, reductions, take-offs and clamps.

All cable racks shall be galvanised and painted with a lead primer and two coats of approved enamel paint with colour to match the existing installation. Sufficient support brackets shall be provided to prevent sagging of cable racks.

Cables and wires shall not be fitted directly to cable racks. All cable racks shall have earthing continuity

e. Conduit

Conduits shall be galvanised steel and shall bear the SABS mark. The minimum diameter of conduits used shall be 20mm.

Conduits shall be screwed and socketed and bends shall be of the long radius type. PVC conduits are not acceptable.

f. Draw Boxes

Draw boxes shall be installed so that not more that two bends occur between a draw box and the end of the conduit or between two draw boxes.

1.16.3 CONTROLS

The air conditioning system shall be monitored and interacted with via latest version of programmable building management system, with open protocol and BACNet compatible controllers. The system shall also be WEB based, accessible via a common web based browser such as Windows Internet Explorer or CHROME. Makes such as siemens, Johnsons Controls and Carel Controls are preferred, provided they meet the specifications. Equal and approved alternate make may be accepted provided these are presented to the Engineer and approved prior to submission of the Tender price.

All controllers provided under this contract shall be hardwire networked and routed to the existing BMS system at the Workshop.

Although it is the intention that the existing desktop computer in the workshop be utilized, allowance shall be made for a new all-in-one touch screen computer to be provided should the existing be found to be inadequate at the time of the installation. The workstation allowed shall be a 24” FHD touch screen computer, with a mouse, keyboard and a backup 1000KVA UPS. The computer (Dell or HP) shall have the following minimum specifications;

- 500MB SSD,
- 1GB RAM
- 1GB Graphics
- Intel i7 CPU
- RJ45 socket, HDMI socket, USB C socket
- 24in hi resolution monitor

Allowance shall be made for the preparation of graphics, to display at least the following in a professional manner;

- schematic of overall system indicating status of each plant;
- schematic of central chiller plant, showing status of related parameters,
- schematic of AHU, showing status of related parameters,
- schematic of VAV diffusers on floor pans, showing heating or cooling status, setpoint and room temperatures and % open/closed.

All Controllers, shall be provided with display units.

The system must be able to trend log all parameters on an ongoing basis and must be user friendly, such that it is easily extracted by the client. For 1st handover purposes it will be a prerequisite to submit trend logs for all parameters over a continuous two week period, showing the system is operating problem free.

The controller at the chiller plant shall be provided with the following minimum function;

- Interfacing with the Chiller ModBus Interface system and monitoring chiller alarms,
- Monitoring of the run and trip status of each pump
- Start and stop time scheduling for chiller plant
- Scheduling of the selection of lead/lag and duty/standby position of the pumps and cooling towers,
- Control by-pass valves during startup,
- Monitoring of the status of the chiller, each pump and cooling tower, and shall include but, not be limited, to the following;
  - Run and trip status,
  - Entering and leaving chilled water temperatures,
  - Entering and leaving condenser water temperatures,
  - Flow switch in chilled and condenser water lines,
  - Status signals available from the chiller's standard microprocessor,
  - Low and high water level signal for each cooling tower.

The entire chiller plant shall be monitored by programmable open protocol BACNet compatible controllers with freely available software.

The time scheduling via the BMS controller shall start and stop the chillers on a daily basis. However, the starting of the pumps and the cooling towers shall be controlled by the chillers, such that the central plant can continue to operate should the BMS controller or its network fail. Should the BMS controller or its network cabling fail, the chiller plant must continue to operate with its set parameters. Should the BMS time scheduling controller or its network to the chillers fail while the chiller is off, then it must be possible to manually switching on the chiller plant by bypass switches on the chiller plantroom control panel.

The controllers shall be programmed to automatically alternate the use of the two pumps, and to automatically start up the standby pump if the duty pump trips.

The controllers shall provide the following minimum function;

The controllers in the **cooling tower** panel shall be provided with the following minimum functions;

- Controlling of the leaving condenser water temperature by controlling the fan speed via VSDs,
- Monitoring of the run and trip status of each fan motor,
- Monitoring the entering and leaving water temperatures,
- Monitoring the high and low water levels in the sumps,

The controllers at the **air handling units** shall be provided with the following minimum functions;

- Controlling of the supply air fan speeds via VSDs, using duct pressure sensors,

- Controlling of the chilled water modulating valves to the air handling plants to maintain constant return air /space temperatures,
- Controlling of heaters using pulse relays,
- Monitoring of the run and trip status of each air handling unit fan motor,
- Monitoring of supply and return air temperatures of the air handling plant
- Start and stop time scheduling of AHUs.
- Monitor VAV diffusers.

1.16.4 SCHEDULE OF SWITCHBOARDS AND PARTICULAR SPECIFICATIONS

Switchboards as indicated below shall be provided for the control of Air Handling units and central chiller plants.

TABLE 1: SCHEDULE OF SWITCHBOARDS

REFERENCE	EQUIPMENT SERVED	AREAS SERVED
MDB/CH	Chiller Plant, cooling towers and pumps	Central Chiller Plant
ACDB1	AHU1	Male Long Stay
ACDB2	AHU2	Acute Male
ACDB3	AHU3	Male Dining
ACDB4	AHU4	Clinical Support
ACDB5	AHU5	Female Dining
ACDB6	AHU6	Acute Female
ACDB7	AHU7	Female Long Stay
ACDB8	AHU8	Grnd. Admin/Reception
ACDB9	AHU79	Grnd. OPD
ACDB10	AHU10	1s Flr. Occupation Staff Clinic
ACDB11	AHU11	1s Flr. Offices (West)
ACDB12	AHU12	1s Flr. Offices (East)
EFDB 1 to 16	EF1 to EF16	Toilet/ablution extraction
FDB1 to FDB13	SF1 to SF13	Smoke control Fans

ADDITIONAL INFORMATION:

All controls supplied must be such that the plant or equipment will automatically resume its last status following resumption of power after a power cut.

THE VSDs shall be provided with all necessary filters to ensure minimum noise being experienced due to Harmonics.

a. MDB/CH: CHILLER PLANTROOM SWITCHBOARD

The chiller plantroom switchboard shall be of floor standing cubicle type with each motor control and chiller housed in separate cubicle. Ventilation fans shall be provided.

Each chiller shall be provided with one dedicated cooling tower and a condenser water and a Primary chilled water pumps. The switchboard shall have at least the following cubicles, viz.,

- incoming supply,
- Common controls, transformer, alarms, VAV diffuser MCUs, etc., (20% spare capacity to include additional controller for future expansion)
- Chiller No. 1,
- Chiller No. 2,
- Cooling tower No.1,
- Cooling tower No.2,
- Primary chilled water Pump No.1,
- Primary chilled water Pump No.2,
- Secondary chilled water Pump No.1,
- Secondary chilled water Pump No.2,
- condenser water Pump No.1,
- condenser water Pump No.1,
- Miscellaneous equipment (dosing pumps, FCU in chiller plantroom, water softening plant, etc).

The switchboard shall control the two cooling towers. Each tower shall be provided with a variable speed frequency inverter type drive for automatic capacity control.

The tower controllers shall receive a hardwired start signal directly from the chillers and not via the BMS controller in chiller plantroom.

Ventilation fans shall be provided to all panels.

This switchboard shall have the following minimum components;

- Programmable BACNet open protocol microprocessor controllers,
- Isolator, circuit breaker and low voltage/phase failure/phase reversal relay for Main incomer,
- Circuit breakers and contactors for each equipment,
- Auto/off/manual rotary switch for each equipment, i.e. chillers and pumps and cooling towers,
- Variable speed drives for secondary chilled water pumps, and cooling tower fans (Danfoss or Trane or Verispeed)
- Thermal overload relays for pumps,
- Hour run meter for pumps,
- Ammeters per phase for each pump and cooling tower
- Lamps for power on board, equipment running and trip for each equipment, and lamp test,
- High/low cooling tower water indicating lamps and mutable buzzers for each cooling tower.
- Switch on plantroom chilled water fan-coil-unit when plant is running.

High and low water level probes (conductivity sensor) shall be provided to monitor water levels in the cooling tower sumps. Independent probes shall be provided for each cooling tower. Should a low water level be detected, then the cooling tower controller shall send a signal to the respective chiller to shutdown until such time that the water level is resumed.

When a high or low level is detected, the relevant status signal must be relayed to the cooling tower controller to sound an alarm at the cooling tower panel and for remote monitoring via the BMS system

b. MDB/1 to 12 : Air handling units

Each air handling unit shall be provided with a switchboard for the supply to, controls, fans, motorized dampers and power and communication pack for VAV diffusers (where applicable).

Allowance shall be made for the panels to be mounted on a floor mounted Unistrut bracket frame, with the bottom of panel standing 1200mm above floor level.

The supply air fan shall be provided with Variable frequency speed drives (Trane, Danfoss or Verispeed)

Fan run-down delay protection shall be provided for the heaters when plant is switched off.

The control board for each air handling unit shall incorporate, but not be limited to the following;

- Main isolator on panel face,
- Phase failure/rotation and low voltage protection
- BMS compatible controller accessible from face of panel
- Circuit breakers for controls, fan motor, VAV diffuser power units,
- Variable speed drive (installed outside of the panel)
- Fire relay
- Transformer
- Power on, Heater on and fan and run and trip lamps
- On/off rotary switch for VAV diffuser power supply
- Ventilation/cooling/auto mode selection rotary switch

The controller and facilities provided shall monitor at least the following;

- Return air temperature (allow at least three averaging sensors)
- Supply air temperature
- Heater pulse relays
- Fan run/trip
- Duct static pressure transducer
- Filter differential pressure

The rate for the switchboard shall also allow for all ancillary equipment such as temperature sensors, pressure switches, etc.

The controller shall be setup to control the space (return air) temperature at a set point.

c. EFDB1 – EFMDB16: Ducted Extract Fan

The ducted extract systems shall be provided with a control switchboard

The control board shall incorporate, but not be limited to the following;

- Main isolator on panel face,
- Phase failure/rotation and low voltage protection
- BMS compatible Controller accessible from face of panel
- Circuit breakers

- Fire relay
- Transformer
- Power on, and run and trip lamps
- 24hr/7 day timer
- On/off/auto rotary switch

The controller and facilities provided shall monitor at least the following;

- Fan run/trip

Allowance shall be made for the panels to be mounted on a floor mounted Unistrut bracket frame, with the bottom of panel standing 1200mm above floor level.

d. FDB1 to FDB13: Smoke control DB

Smoke control extraction systems are to be supplied and installed in the slabbed accessible roof void under this contract. Each system shall be provided with a 2hr fire rated switchboard located adjacent to each fan, and incorporate isolator, relay, manual/auto switch, contactor, run, power on LED lamps, remote revolving beacon light mounted on to underside of ceiling and floor below.

Allowance shall be made for the panels to be mounted on a floor mounted Unistrut bracket frame, with the bottom of panel standing 1200mm above floor level.

All cabling shall be 2 hour fire rated or run in seamless galvanised steel tubing.

Smoke fans SF10 and SF12 shall be two speed fans with lower speed being for normal ventilation, controlled via a 24/7 timer, providing approximately 45% to 50% of maximum flowrate specified for smoke extraction. The related FD/DB10 and FD/DB12 shall have the necessary contactors, relays, timers and rotary switches to control the fans depending on the mode selected. The fans shall automatically speed to higher speed upon a fire signal, if the fans were selected for ventilation mode and revert to ventilation mode once the fire signal is removed.

1.17.0 WATER SOFTENING PLANT

An ion exchange resin water softening plant shall be supplied and installed to treat the water supplying the cooling towers. The plant shall be connected to the makeup water supply piping feeding the cooling towers. The plant shall comprise of necessary components and fitting to operate effectively, including a resin tank with a metering control unit, a brine tank complete with float and valve assembly inlet filter and drain piping to nearest drain point inside the plantroom

Allowance shall be made for a plant capacity of a 1.2L/s continuous flow.

The contractor shall provide water test results of the water before and after the installation.

1.17.1 SOUND ATTENUATORS

Sound attenuators shall be ducted type, with galvanised sheetmetal casing of DIN24157, with flanged connections. The attenuator splitter frames shall be of galvanised sheetmetal, with the absorption material being moisture repellent and erosion resistant up to 20m/s. Sound attenuators in air conditioning systems shall be

externally insulated to similar external specification for the ducting, failing which, with 50mm thick foil faced mineral wool.

1.18.0 SOUND LEVELS

All equipment shall be selected such that the following sound levels, are not exceeded.

i) All areas unless otherwise indicated : NC35
ii) In basement parking area : NC50

1.19.0 FIRE DAMPERS

The fire dampers shall be at least 2 hour rated and SANS 194 approved. Test certificates shall be provided for Engineer's acceptance prior to procurement.

Dampers shall be suitable for building into walls and floor slabs, and shall be complete with fusible link, subframe and inspection panels on two sides.

The open and closed position labels shall be provided on the damper.

The dampers shall be fabricated from galvanized sheetmetal.

1.20.0 TESTING & COMMISSIONING

1.20.1 Testing and commissioning shall be generally done in accordance with the Standard Specifications.

1.20 The contractor shall provide all necessary calibrated measuring instruments, ladders, etc., and assistants to the Engineer for validation of commissioning results and plant performance.

1.21.0 PLANT LABELLING

1.21.1 Allowance must be made to provide ivorene labels on all, switchboards, pumps, chiller plant, air handling units and plantroom doors, evaporators and condensing units, etc. Contents of these labels shall be as instructed by the Engineer during the construction period.

1.21.2 Piping shall be provided with flow direction arrows at 3m intervals and where piping changes direction.

1.22.0 PAINTING

1.22.1 Allowance shall be made for painting of concrete bases for plants installed under this contract.

1.22.2 All brackets exposed to the weather shall be galvanized and primed and painted.

1.23.0 LOGBOOK

1.23.1 Allowance shall be made for a hard covered log book on a wall mounted shelf in the plantroom. All events shall be logged following practical handover or beneficial use being passed to the client.

1.24.0 CORROSION PROTECTION

The tenderer shall note that the installation being at the coast and shall select appropriate material to ensure longevity of the installation.

All metal surfaces, unless otherwise stated shall be hot dipped galvanized to SANS121 (ISO 1461).

All nuts, bolts and washers exposed to the weather shall be stainless steel.

All quadrant position/stop plates on butterfly valves shall be removed and hot dipped galvanized.

All visible rust shall be treated immediately.

1.25.0 INSPECTIONS AND HANDOVER

Inspections of the works during installation and the handing over procedure shall be as stipulated in the Standard Specification of Part 2.

The contractor shall provide the Engineer with their comprehensive snag list prior to calling the Engineer for inspections.

1.26.0 SERVICE AND MAINTENANCE

The entire air conditioning installation shall be serviced and maintained for 12 months following practical handover.

A monthly maintenance inspection schedule shall be completed and signed off by the building manager and submitted to the Engineer. The schedule shall include all plants and verification of correct operations. Abnormal noise, vibrations, high operating temperature, leaks, sweating, rust shall be reported and rectified.

Allowance shall be made in the bill rate for the servicing of the chiller by the supplier as follows;
Minor service and report - 6th month
Major service and report – 12th month
Inspection and report – 3rd and 9th month

Tests shall generally be done in accordance with the Standard Specification.

A hard covered log book shall be supplied and chained to the wall bench in each plantroom.

All visible rust shall be treated immediately, by removing surface rust, treating with a rust inhibitor, painting with a primer and final coat of paint to match original finish.

1.27.0 COMMISSIONING

Comprehensive pre-commissioning, commissioning as well as quality monitoring shall be performed on the HVAC system and associated systems in a systematic manner and in exact accordance with CIBSE Commissioning Codes, as follows:

- CIBSE Code A – Air Distribution;
- CIBSE Code C – Automatic Controls;

- CIBSE Code M – Management;
- CIBSE Code R – Refrigerant Systems (Heat Pumps); and

The HVAC Subcontractor will be required to ensure the following information is available:

- Definitive commissioning specifications/Design intent report;
- 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;
- As-built drawings;
- Operational and Maintenance Manuals;
- Commissioning certification for each system countersigned by the HVAC Engineer/Specialist and accepting authority including the record sheets provided in each CIBSE code.

Further information is provided:

The Commissioning Report and Records:

- Must demonstrate that the services were commissioned in accordance with the CIBCE Commissioning codes for all services.
- Must have a record of commissioning dates, records of all functional testing undertaken, a list of future seasonal testing requirements and a list of outstanding issues.
- Must include any changes made to the building as a result of the commissioning process – and recommended changes.

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.

Training:

- 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.

1.28.0 STANDARDS

The following standards shall apply:

DescriptionCode

(a) Latest issue of SANS 0142: “Code of Practice for the Wiring of Premises” ,

(b) Occupational Health and Safety Act, 1993 (Act 85/1993),

(c) Municipal by – laws and any special requirements of the local supply authority,

(d) The local fire regulations and

(e) National Building Regulations and Building Standards Act 1977 (Act 103 0f 1977) as amended.

(f) The Standard Specification for the Air- conditioning and Ventilation Services from the Province of KwaZulu- Natal: Department of Works, Issue: August 1997 issued by the Head: Works of KwaZulu Natal Provincial Administration. (Available for inspection at Engineers offices).

(g) The Installation, testing and Balancing of Air-conditioning Duct Work as SANS 0173.

(h) The General Electrical Specification for the Provincial Administrations of the Republic of South Africa ; Part 2E.

(i) Telkom Regulations.

(j) The Contractor shall provide all guards and protective devices etc. and arrange for all Inspections, tests, certificates, etc. Necessary to comply with the said Acts, Regulations and By-Laws, whether specified herein or not.

(k)	Air Conditioners	SANS 1125
(l)	Air conditioners, electrical safety	SANS IEC 60335-2-40
(m)	Air conditioning equipment, performance testing	SANS ISO 5151
(n)	Air Conditioning systems	SANS 0147
(o)	Air Conditioning systems,ducts (building services)	SANS 1238
(p)	Air Conditioning systems,ducts (building services), installation, testing	SANS 0173
(q)	Air Conditioning systems filters	SANS 1424
(r)	Three phase induction motors Part1 : Low-voltage	SANS 1804 3:1998
(s)	Three phase induction motors Part2 : Low-voltage intermittently rated slip-ring motors	SANS 1804-3:1998
(t)	Single phase induction motors	SANS 1804-4:1999

1.29.0 TYPICAL MAINTENANCE SCHEDULES

These schedules shall not be taken as being conclusive and service contractor shall be als guided by the equipment suppliers requires and recommendations.

A. Air conditioning, ventilation and air pressurisation control systems

	Description of inspection/test	Frequency	Checked ✔ = OK X = not OK	Comments
1	Check operation of diffusers, dampers etc. (staggered over 6 months)	3 monthly		
2	Check for any abnormalities	monthly		
3	Check and note time indication on time switches. Adjust as required.	annually		
4	Check operation of all alarms and safety trips	monthly		
5	Check condition of temperature, humidity, pressure controller and associated solenoid valves as required. Clean contacts and reed valves as required.	monthly		
6	Check calibration of sensors and controllers	monthly		
7	Check and note controller settings. Adjust as required	monthly		
8	Check and note indoor dry bulb and wet bulb temperatures	monthly		
9	Check and correct operation of all control valves, dampers flow switches, etc. over their full range	monthly		
10	Lubricate valve/spindles as required	monthly		
11	Check control panels for correct operation, contactors, circuit breakers, overloads, ammeters, controllers, etc. (by qualified electrician)	monthly		
12	Clean inside and outside of DB and clean panel fan filter	6 monthly		

B. VENTILATION AND EXTRACTION SYSTEMS

	Description of inspection/test	frequency	Checked X = not OK ✔ = OK	Comments
1	Check for any abnormalities	monthly		
2	Check and note time indication on time switches. Adjust as required.	monthly		
3	Check operation of all alarms and safety trips	monthly		
4	Check operation of controls, timers, etc.,	monthly		
5	check for abnormal vibration and or noise	monthly		
6	check for any break in ducting, canvas collars and connections and make good where necessary	monthly		
7	Check for rust, treat and paint where necessary	monthly		
8	Clean/replace filters	monthly		
9	Clean intake and exhaust louvres, grilles, etc.,	monthly		
10	electronic motors - check and record motor running temp., check noise & bearing	6 monthly		
11	electric connections- check connections for tightness	monthly		
12	Air take-inspect air intake for blockage	monthly		
13	relief air grilles - check operation & for blockages	monthly		
14	fan blades - check for unbalance, vibration mounts, bolts tightness	annually		
15	exterior casing - check damage, rust, etc.	annually		
16	de-rust, touchup paint	annually		
17	Check flexible ducting/collars and repair where necessary	annually		
18	* visually inspect & report on complete installation	monthly		

B. AIR HANDLING UNITS AND RELATED CONTROL PANEL

	Description of inspection/test	frequency	Checked X = not OK ✔ = OK	Comments
1.	Check for undue vibration at supply air fans	monthly		
2.	Clean primary and secondary filters	monthly		
3.	Replace HEPA filters where applicable	annually		
4.	Clean inside of units including drip trays	monthly		
5.	Clean filter on VSD	monthly		
6.	Check that cooling fan on VSD is working	monthly		
7.	Check that heater banks are operating	monthly		
8.	Conduct continuity and earth test on heaters to check for faults (6-monthly – by electrician)	6-monthly		
9.	Tighten all terminals (in DB, on motor, on heater banks and VSD) – must be carried out by competent electrician only	annually		
10.	Check operation of Humidifiers where applicable	monthly		

1.30.0 INFORMATION SCHEDULE

	EQUIPMENT	MAKE AND MODEL
1.	Chiller	
2.	Cooling towers	
3.	Air handling units	
4.	BMS Controllers	
5.	Control panels	
6.	Midwall air conditioning split unit	
7.	Axialflow fans	
8.	In-line ducted fans	
9.	Modulating valves	
10.	Water flow Commissioning sets	
11.	Swirl diffusers	

PORT SHEPSTONE HOSPITAL
NEW PSYCHIATRIC WARD

AIR CONDITIONING AND VENTILATION INSTALLATION

(WIMS 044044)

STANDARD TECHNICAL SPECIFICATIONS

Prepared by:

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Prepared for: Dept. of Public Works

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Public Works
PROVINCE OF KWAZULU-NATAL

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AUGUST 2024

PART TWO

STANDARD AIR CONDITIONING AND VENTILATION INSTALLATION SPECIFICATIONS

4.1 GENERAL REQUIREMENTS FOR WORKMANSHIP, MATERIALS AND CONTRACT ADMINISTRATION

4.1.1 GENERAL

The Subcontractor will be required to provide all labour, materials, equipment and services and perform all operations required for the complete installation of all Heating, Ventilating and Air Conditioning Work as shown on the relevant drawings and in accordance with all applicable requirements of the Subcontract Documents.

This specification is of simplified form, and includes incomplete sentences. The omission of works or phrases shall be implied by inference.

The Detailed Technical Specification, part Five, takes precedence over this part of the Specification should there be any conflict in description of requirements referred to in both parts.

4.1.2 DEFINITIONS AND ABBREVIATIONS

Definitions of terms used herein:

"Provide"	To supply, install connect and hand over complete and ready for safe and regular operation of particular work referred to unless specifically indicated otherwise.
"Install"	To erect, mount and connect, complete with all related accessories.
"Supply"	To purchase, procure, acquire and deliver, complete with all related accessories.
"Work"	All labour, materials, equipment, apparatus, controls, accessories and other items required for correct and complete installation.
"Piping"	Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, accessories, drains, insulation and all related items.
"Wiring"	Conduit, fittings, wire, junction and outlet boxes, switches, cut-outs, socket outlets and all related items.
"Concealed"	Embedded in masonry or other construction installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces or in enclosed spaces.
"Exposed"	Not installed underground or concealed as defined above.
"Indicated", "shown" or "noted"	As indicated, shown or noted on drawings and/or specifications.
"Similar" or "Equal"	Of approved manufacture, equal in weight, size, design and efficiency of performance to product specified or mentioned by name.
"Approved",	As approved, satisfactory or accepted by the Architect,

"Satisfactory" "Accepted" or "Directed" and/or Consulting Engineer.

"SABS" South African Bureau of Standards.

"BSS" British Standards Specifications.

"ASHRAE" American Society of Heating, Refrigeration and Air Conditioning Engineers.

"ASME" American Society of Mechanical Engineers.

"ASTM" American Society of Testing Materials.

"ASA" American Standards Association.

"SMACNA" Sheet metal and Air Conditioning Contractor National Association Incorporated.

4.1.3 QUALITY, GAUGES, WEIGHTS AND MEASURES OF MATERIALS

All materials shall be new, best quality and free from defects.

All similar materials and/or apparatus used for a similar purpose shall be of the same manufacturer.

All electrical materials and apparatus shall be listed by SABS, or BSS, and shall bear their label or mark.

The approval of the Authorities having jurisdiction shall be secured for all materials, equipment and installation.

Gauges of wire and metal shall be metric unless otherwise specified.

All weights and measures shown or mentioned shall be taken to be according to the System Internationale units.

4.1.4 CO-OPERATION WITH OTHER TRADES

The Subcontractor shall render full co-operation to other trades, provide any information necessary to permit work of all trades to be installed satisfactorily and without interference or delay.

Where work is to be installed in close proximity to work of other trades, or where there is evidence that work may interfere with work of other trades, assist in working out space conditions to make satisfactory adjustment.

4.1.5 SUPERVISION

In addition to the requirements of the Conditions of Tender and Contract, the following shall apply:

The Subcontractor shall supply the services of an experienced and competent Project manager to be in constant charge of the work on site.

4.1.6 ACCESSIBILITY

Install work so as to be readily accessible for operation, maintenance and repair. Minor deviations from drawings may be made to accomplish this, but changes of magnitude of which involve extra cost shall not be made without prior approval.

4.1.7 MOVING EQUIPMENT

Investigate each space through which equipment must be moved. Where necessary equipment shall be shipped from manufacturer in crated sections of size suitable for moving through restricted spaces available.

4.1.8 STORAGE OF MATERIALS

In addition to the requirements of the Conditions of Tender and Subcontract, the following shall apply:

Materials permitted to be stored inside the building shall be safely stacked and shall not over-load the floor construction beyond the permissible limit.

Combustible materials shall not be stored on the premises for longer than the minimum period necessary for the execution of the work.

4.1.9 INSERTS

The Subcontractor shall provide all the required inserts, designed for maximum anchorage. The inserts shall not be loaded beyond 75% of the maximum recommended loading under any conditions of operation.

4.1.10 BUILDER'S WORK

Unless otherwise stated, all builder's work required for the Air Conditioning and Ventilation installation will be carried out by the Main Contractor (where applicable).

4.1.11 WATERPROOFING

Where any work pierces waterproofing, installation shall be as approved. Supply all necessary sleeves, caulking and flashing required to make openings absolutely watertight.

4.1.12 NOISE AND VIBRATION

Make necessary correction in an approved manner without additional charge for noise or vibration in excess of specified limits and for excessive transmission of noise or vibration due to faulty equipment of workmanship.

After commissioning of all plant, should the Client complain of noise problems in general, the Air conditioning Sub-contractor shall be requested to make sound level tests over the normal frequency bands to prove the NC ratings in the areas concerned. This shall be done at the Contractors expense.

Should any area have NC ratings exceeding those stipulated elsewhere in this document, the Contractor is to fully assist the Engineer in investigating the source of the problem. Should noise emanating from the suppliers equipment be cause for the complaint, onus will be upon theContractor to remedy the fault by replacement of the item or items concerned. Noise attenuation of sound baffles will not be considered as suitable for reduction ofexcessive noise from plantroom equipment.

4.1.13 SHOP DRAWINGS, AS BUILT DRAWINGS AND WIRING DIAGRAMS SHOP DRAWINGS

The Subcontractor shall prepare at his own expense and shall submit a sepia copy of shop drawings for all fabricated work, working or setting out drawings, shop details and schedules to

the Owner's Representative for approval as stated below, and related work shall not be performed by the Subcontractor until such approval has been given.

As soon as approval has been given, the Subcontractor shall furnish the Owner's Representative two prints of the approved shop drawings, setting out drawings and schedules. The Subcontractor shall also furnish to the Works as many prints of the approved shop drawings and schedules as are required. No work shall be performed from shop drawings and/or catalogues not stamped with the Owner's Representative's approval, and such stamped drawings and/or catalogues shall be kept available at the job site as evidence of such approval.

The Subcontractor shall be responsible for dimensions, design of adequate connections, details for the satisfactory construction of all work and the furnishing of materials for work required by the Subcontract even if not indicated on the submissions that have been approved by the Owner's Representative.
The Owner's Representative will check drawings for design only and approval of the drawings, schedules and catalogues by the Owner's Representative shall not be construed as a complete check and shall not relieve the Subcontractor of his responsibility as above stated. If the submissions differ from the requirements of the Subcontract, the Subcontractor shall make specific mention of each difference in his letter of transmission, with a request for substitution, together with his reasons for same, in order that, if acceptable, suitable action may be taken by the Owner's Representative. Otherwise, the Subcontractor will not be relieved of the responsibility for executing the work in accordance with the requirements of this Subcontract.

Corrections of shop drawings by the Owner's Representative are not intended to change the scope of work. Should any such corrections constitute a change of scope of work, the Subcontractor shall notify the Owner's Representative in writing within not more than seven calendar days of such change and shall not proceed with the fabrication until so authorised by the Owner's Representative. claims for change of scope, made after performance of the work constituting the claimed change of scope, will not be considered.

"AS-BUILT" DRAWINGS

This clause is applicable only where specifically called for under Part Five -Detailed Specification.

The Subcontractor shall provide the Owner's Representative with a complete signed transparent set of "as-built" drawings as a prerequisite to final payments; and the Owner's Representative shall turn the set over to the Owner after having established their correctness. The "as-built" set shall include all mechanical and electrical work.

Where possible, a transparent copy of Architect's drawings shall be used for the purpose, the Owner's Representative shall then furnish the Subcontractor with necessary transparencies. If "as-built" variations cannot be clearly shown thereon, then the Subcontractor shall prepare supplementary transparent drawings, that will properly impart the necessary information. Manufacturer's and Subcontractor's drawings, and two copies of each shall also be furnished to the Owner's Representative.

"As-built" drawings shall be maintained on a current basis as work progresses, with all deviations in work as actually installed accurately entered each Monday on paper prints of design drawings affected, with such prints kept available at the site for the inspection of the Owner's Representative. On the last day of each month, the record for four previous weeks, properly identified by notes, shall be transferred in ink to transparencies by competent draughtsmen. Within seven days after end of each bi-monthly period, submit to Owner's Representative one paper print of each drawing affected showing latest corrections.

WIRING DIAGRAMS

Although covered elsewhere, specific mention is made of the provision of wiring diagrams.

Apart from submitting comprehensive wiring diagrams for approval prior to the commencement of control board manufacture, the Subcontractor is to provide on completion, "as-built" wiring diagrams for all electrical work forming part of this Subcontract.

Copies of these diagrams and those for manufactured equipment are to be included in the Operating and Maintenance Instruction Manuals (refer to section headed MAINTENANCE AND GUARANTEES of this Specification) and a copy of each is to be framed, mounted behind glass and fixed on the wall along side each switchboard/control panel.

4.1.14 MAINTENANCE AND GUARANTEES

OPERATING AND MAINTENANCE INSTRUCTIONS

A condition of the final acceptance of the works will be the provision of three copies of an approved comprehensive Maintenance and Operating Instruction Manual.

The manual is to include the following:

A description of the system, equipment and operating features.

A list of equipment, giving manufacturer's name and local agent, descriptive literature and servicing instructions for each.

A maintenance and lubrication schedule based on the manufacturer's recommendations.

Description of automatic control system, accompanied by control schematics (where necessary.)

Step-by-step instructions for starting/stopping each item of equipment.

A record of relevant readings taken during final commissioning and hand-over tests.

As-built drawings, wiring diagrams, piping schematics, etc,.

4.1.15 INSTALLATION MAINTENANCE

The installation shall be serviced by the Contractor during the 12-month guarantee period under this contract. A submission of a maintenance plan, to the satisfaction of the Engineer shall be a prerequisite to a first delivery or practical handover.

4.1.16 GUARANTEE

The Subcontractor shall guarantee the material, apparatus and workmanship delivered by him for a period of twelve months. The guarantee must be valid for a period starting on the date when the Subcontract is accepted by the Engineer as complete and in working condition. The complete installation must be guaranteed against defects as a result of patent and latent defects of the design and apparatus, save design defects made or specified by the Engineer, as well as against faulty materials and workmanship. Fair wear and tear is excluded from the guarantee. The guarantee must provide that all parts, spares and appurtenances that become defective during the guarantee period be replaced free of charge.
The costs of labour and transportation required to replace such part of a defective installation shall be borne by the Subcontractor and shall be included in his guarantee. The Subcontractor shall cede to the Employer the remainder of any equipment guarantee which he has received from his suppliers and which extends beyond the period of twelve months mentioned herein.

In the event of the project being phased, guarantee on installation and equipment shall commence on the date on which it is put into operation for
beneficial use to the satisfaction of the Engineer.

4.2 **EQUIPMENT SPECIFICATIONS**

4.2.1 WATER CHILLERS

Chillers shall be of a standard, factory assembled, packaged type, pre-wired and pre-charged, manufactured by Daikin, Trane, York, Carrier or equal and approved, and shall include the features as specified herein.

Cooling capacity specified shall be selected using the following fouling factors:-

Condensers - 0,089 m^2 $^oC/kW$

Evaporators - 0,089 m^2 $^oC/kW$

Compressors shall be of multi-cylinder, semi-hermetic design with capacity control using cylinder unloaders.

Multiple compressor units shall be provided with independent refrigeration circuits for each compressor.

Reduced load starting with multiple step capacity control shall be provided. Minimum capacity control steps for each chiller shall be 100% - 75% - 50% - 25% - 0.

Motor starting to be selected to limit starting current of each chiller 1,5 times full load current.

Hermetic motor, suction gas cooled shall be equipped with motor winding thermostat for overheat protection.

Compressors shall be individually vibration isolated from chiller base frame.

Refrigerant piping shall be fitted with stainless steel flexible connections on suction and discharge.

Hot gas mufflers shall be provided on compressor discharge.

Eye bolts, or fixing points for eyebolts shall be provided for each compressor.

Compressors shall be provided with forced lubrication system with self-reversing oil pump and regulated oil pressure control. Oil level sight-glass shall be provided.

Evaporators and condensers shall be of the shell and tube type with integral finned seamless copper tubes expanded into steel tube sheets.

Evaporators shall be equipped with freeze-up protection thermostats.Chillers shall be supplied with self contained, machine mounted, factory wire control panel housing pressure gauges, control switches and safety cutouts, as follows:-

a) Gauges for high pressure, low pressure and oil pressure for each compressor.

b) Freeze-up protection thermostat.

b) High and low refrigerant pressure cutouts. (High pressure to be manual reset.)

d) Crankcase heater controls.

e) Motor winding thermostats.

f) Low oil pressure cutout, (manual reset.)

g) Indicating lights to be provided for (a) to (f) above.

h) Overcurrent relay.

i) Pumpdown relay.

Starters shall be housed in separate motor control panel, not forming part of chiller supply.

4.2.2 **COOLING COILS (CHILLED WATER)**

All coils shall be suitably protected during shipment and installation so that the fins and casing flanges are not damaged. If fins are damaged they may be combed so as to restore them to the original shape and/or spacing. If however, in the opinion of the Engineer the coils have loose or damaged fins at the time of final inspection they will be rejected and shall be replaced with new coils.

Coils shall be aluminium or copper fins mechanically bonded to seamless copper tubes. The tubes shall be provided with turbulators. For sprayed coils fins shall be of copper.

The fins shall be spaced not closer than 12 per 25 mm. The pressure parts of coils shall be constructed and tested to a pressure of not less than 1 700 kPa.

Each coil section shall be securely mounted on a die formed zinc coated sheet steel casing with a minimum thickness of 1,60 mm. Casing to be arranged for bolting to other sections, ductwork, unit casings, etc. Coil sections shall be supported on angle frame or other strong rigid construction. Supports shall be hot dip galvanised. Water cooling coils shall be of the serpentine type and headers shall be welded, steel cast iron, brass or copper. Headers shall be provided with vent or drain connections.

The coils shall be provided with eliminators if the air velocity specified is such that water carry over may occur.

The coils shall be rigidly braced to ensure that there is no bending or flexing.

Drain pans shall be provided with drain connections on both sides. The drain pan shall run the full width of the coil and shall be treated in an approved manner to prevent corrosion. Condensate drain piping shall be not less than 20NB.

Face velocities shall not exceed 2,75 m/s for cooling coils and 3,50 m/s for heating coils.

Coils shall be as manufactured by Carrier, Trane, Yucon or equal and approved.

4.2.3 **CENTRIFUGAL FANS**

Unless otherwise specified, centrifugal fans shall be backward curved blade type with single thickness, shaped blade, designed to give the fan a continuous rising pressure characteristic and a non-overloading characteristic.

Fan casing shall be fabricated from heavy gauge steel adequately reinforced and rigidly supported by means of an angle iron structure. Field joints shall be flanged and bolted with gaskets fitted between flanges to render these air tight. Where necessary casings shall be made in sections small enough to permit installation or removal through openings available in the building.

Shafts shall be steel, with sufficient mass so that the critical speed of the wheel and shaft is well above the operating speed of the fan. The wheel shall be tightly fitted and keyed to the shaft. Bearings shall be self aligning ball or roller type.

Fans shall be driven by an electric motor through a V-belt drive. The motor shall either be constant or variable speed as called for in Part Five of this Specification. The motor bracket shall be readily adjustable. Motor nameplate power shall exceed the absorbed power by a minimum of 15% and the motor shall be suitable for the starting method as further specified herein. Motors shall be rated for continuous operation.

The fan and driving motor shall be mounted on common steel base frame. This frame shall be fabricated from rolled steel section with strength and dimensions to match the fan/motor assembly and shall incorporate properly selected factory designed spring isolators.

Fans with wheel diameters above 1000mm shall be provided with access doors fitted to the fan casing.

Motors for centrifugal fans specified for variable volume applications shall be electronically speed controlled. Vortex dampers as a means of air volume control will **not** be accepted.

Fans shall be Donkin or equal and approved.

4.2.4 AIR FILTRATION EQUIPMENT

Filters are to be a standard product of a reputable manufacture regularly engaged in the fabrication of the particular type of air filter or if imported the product shall be well represented in South Africa.

Only filters for which it can be shown to the satisfaction of the Engineer that test results with regard to filter arrestance efficiency, dust holding capacity, air resistance etc., have been obtained by the manufacturer from an independent institute or bureau, generally accepted as being well equipped for and reliable in the carrying out of such tests and making use of the ASHRAE standard (standard 52-76 "Method Testing Air Cleaning Devices") whereby the efficiency curve can be determined can be used. Prior approval of the filters to be used is to be obtained before purchasing.

Maximum air flow through filters is not to exceed the manufacturers rated capacity.

Where called for in this Specification, a stationery inclined differential pressure gauge, complete with cocks, static pressure tips and necessary copper tubing similar to Dwyer shall be mounted where directed. The range of the instrument selected is to be suitable for the filter installation and is to be adjusted by the manufacturer ready for operation.

Provide access doors in ductwork or casing walls for servicing and removal of filters. Unless all parts of the filter installation can be readily reached through access doors, the doors shall not be less than 550mm wide and 1800mm high to permit personal entrance to chamber. The chamber shall be of ample size to allow operator to conveniently perform all necessary operations. Attention must be given to suring that all access doors are airtight.

Frames and filters shall be constructed so as to prevent the passage of unfiltered air with liners being provided between filter frames and unit casings, etc.

All metal parts of the filter shall be suitably protected against corrosion and shall be painted as specified elsewhere.

Where called for elsewhere in this Specification, differential pressure switches shall be provided which operate when the pressure drops across the filter exceeds the maximum pressure drop recommended by the manufacturer. The switch shall energize a warning light on the main control panel (or elsewhere as specified) or shall operate a control circuit as specified.

Filter units and filtration media shall be as specified in Part 5 - Detailed Specification.

4.2.5 PUMPING_EQUIPMENT

Pumps shall be of the non-overloading, volute, centrifugal type, horizontal, with bearing pedestal.

Volute casing shall be cast iron (or cast steel selected to withstand 1,5 times the operating pressures) and overhung from heavy duty bearing pedestal. Casing shall have axial suction and radial discharge nozzles and shall be fitted with renewable case wear rings of spun cast iron.

The impeller is to be bronze radial type overhung and is to be dynamically balanced.

Shafts shall be chrome or stainless steel of sufficient diameter to withstand all stress imposed and with a critical speed well above the maximum running speed. The shaft is to be supported axially and radially by two deep groove ball bearings built
into the bearing pedestal.

Pump is to be fitted with mechanical seals.

The pump casing shall be provided with an air vent cock at its highest point and a drain cock is to be provided at the lowest point.

The pump shall be directly coupled to an electric motor which shall be of sufficient capacity to operate over the entire range of the pump without exceeding the name plate power rating.

Coupling between motor and pump shall be by means of a pin and bush coupling. The coupling shall be provided with a removable galvanised expanded metal guard, minimum 1 mm thick which shall be securely bolted to the bedplate of the pump.

The pump characteristic curves shall be stable over the entire operating range. The pump shall operate at or near the point of peak efficiency, permitting operation at capacities approximately 25% beyond the design capacity without exceeding the break-off point. The Contractor shall submit pump curves for approval with shop drawings. Verify the system resistance (including pressure drops through all components) in order to establish the pump heads. The pumping heads as indicated under the schedule are a guide for tendering purposes.

Pump and motor shall be mounted on a baseplate of either cast iron or fabricated steel of ample size and strength to hold assembly in correct alignment. A suitable drip tray shall also be provided. The baseplate is to be filled with concrete and supported on spring isolators.

A pipe shall be run from each drain point on the assembly and terminate with a suitable gap over the nearest floor drain.

Pumps shall be K.S.B. or equal and approved.

4.2.6 DUCTING AND SHEETMETAL WORK

4.2.6.1 GENERAL

"Sheet Metal Work" and "Ductwork" shall mean all ducts, casings, drip pans, eliminators, dampers, access doors, joints, hangers, etc.

All sheet metal work shall comply with the requirements of these paragraphs.

All ductwork shall be manufactured in accordance with the latest specification for sheet metal ductwork by The Heating and Ventilation Contractors Association, (HVCA) ie. DW/141 and DW/132.

During construction, the Contractor shall close all duct-openings with sheet metal covers to prevent debris from entering the ducts.

All duct dimensions indicated on drawings, are sheetmetal dimensions. By "wide" is meant the greatest dimension.

Ductworks shall be constructed as shown on the attached drawings, and as specified herein.

All ductwork shall be of prime quality galvanised sheet metal, and gauges shall be sized and designed in accordance with the HVCA Standards for Low, Medium and High Pressure Ducting.

Where possible duct tapers shall not exceed 1 in 7.

For a distance of 3m from any fan inlet and outlet provide transverse reinforcing angles. Sizes of the transverse reinforcing shall be as laid down in
HVCA Standards.

Square elbows shall be provided with turning vanes: single skin type for low velocity/low pressure systems and double skin type for high velocity or high pressure systems.

For other elbows the ratio of the radius to the centre-line of the duct to the duct width, shall not be less than 1,5. Smaller ratios shall be permitted only when a minimum of two splitter vanes have been provided.

Supply, return and exhaust ducts, shall be sealed when ducts are longer than 6m. The sealer shall be applied at the joints and seams for airtight construction. Sealer to be hardcast or similar.

The ductwork supports specified herein are the minimum allowable sizes, and should be increased if necessary for loads and spans.

Reinforcing angle sections shall be galvanised. Rivets, screws, bolts and other fastening equipment shall be stainless steel.

Flexible ducts shall be either of the flexible metal type, or of the spiral reinforced fabric type. Spirally wound circular ducts shall be provided with adaptors to give plain circular ends for connections to spiggots. Sealant and clip-bands shall be used to ensure airtight and secure connections.

Overhead hangers for horizontal rectangular ducts shall be of the "Trapeze" type.

4.2.6.5 DUCTING SUPPORTS

Horizontal Ducts

Ducts which are less than 450mm wide, shall be supported by means of 25mm X 1,6mm galvanised flat hangers. For ducts between 450mm and 600mm wide
the hangers shall be galvanised 25mm X 3mm.

Ducts over 600mm wide and all ducts in plantrooms and other equipment rooms, concealed as well as exposed ductwork shall be supported by means of vertical threaded rods and 25mm X 25mm horizontal angles across the full width of the ductwork. Rods to be fixed by means of cast in inserts. Alternatively, approved expanding type bolts may be used. Threaded rods and angles shall be galvanised.

Duct supports shall be spaced at 3m centres for Ducts up to 760mm wide, and 2,4m up to 1500mm wide.

All flat hangers shall be bent under, and secured to the bottom and sides of ducts.

Vertical Ducts

Support ductwork at each floor with not less than two supports per duct adequately fastened to duct. Supports shall span the shaft opening and be securely fastened to floor or structural construction.

Duct supports shall not be less than 32mm X 32mm X 3mm angles for ducts up to 800mm wide: 50mm X 50mm X 3mm angles for ducts larger than 800mm.

Material: angles, black steel, hot dipped galvanised.

Where more than one duct is supported by a common set of angles, sum of wide dimensions shall determine support size.

4.2.6.6 DUCTING ACCESSORIES

Access Doors

The Contractor shall supply and install access doors as may be required for inspection, maintenance and replacement to all instruments, controls and other equipment.

Access doors shall be provided in the following places:

At all fire dampers

At all automatic dampers

For fan bearings enclosed in ducts or plenums

At filter banks

Main balancing dampers

Inlet and outlet side of each axial type fan

Wherever possible the size of the access doors in ducts shall not be less than 500 X 500mm.

Flexible Connections

Unless otherwise specified, make connections between sheet metal work and fan by means of airtight woven asbestos or approved flameproof fabric collars with sewed and cemented seams.

Flexible connection shall be airtight and shall allow minimum axial movement of 25mm.

Flexible connections shall be left unpainted.

Spiggots

Spiggots for air distribution outlets and inlets shall be securely fastened to the ductwork with self sealing pop rivets.

Openings in ductwork for spiggots shall be field-measured and cut to ensure proper location of air distribution outlets and inlets in finished construction.

Spiggots shall be fabricated properly to receive air distribution outlets and inlets for alignment in finished construction and to accommodate dampers, equalizing deflectors and accessories, in accordance with manufacturer's printed recommendations.

Proper care should be taken to stiffen spiggots where necessary to prevent drumming.

4.2.6.7 FLEXIBLE DUCTING

Flexible ducting shall be purchased from a reputable manufacturer and shall be approved by the Engineer.

Flexible ducting shall be provided from horizontal duct run to air terminal in modular ceiling.

Joints shall be made airtight and fastened with clamps as recommended by the manufacture of the flexible ducting.

All flexible ducting on supply air systems shall be insulated, unless otherwise indicated.

4.2.6.8 PLENUM CASING (SITE BUILT)

Casings shall be of double skinned galvanised steel panels filled with foamed polyurethane; density 43 kg/m^3, thickness 50mm; U value shall be 0,36 K cal/m^2h ^oC. Panel sizes shall be nominally 1200mm wide by the height required for the unit.

Panels shall clip together using PVC connector profiles to provide airtight joints. No bolts, screws or other fixing devices shall be allowed. panels shall fit into an inverted galvanised channel on the unit plinth. Channels to be firmly fixed to plinth by means of expansion bolts. Plinth shall form the unit floor. Calk joint between plinth and channel, so as to make it air tight.

Panels to be factory finished with self-etch primer. Casing to be finished with high grade gloss enamel of colour to Architect's requirements.

Access doors to be of double skinned galvanised steel (1,60mm gauge) filled with high density fibre glass, with suitable reinforcing angle irons to door jamb. Provide neoprene gasketing to door and at least two heavy duty handles/latches per door.

Provide all necessary galvanised steel safing (1,60mm gauge) to filter banks, coil sections, fan sections. Safing to be reinforced as required with angle irons.

4.2.6.9 CONTROL DAMPERS

All balancing dampers shall be manually adjustable and shall be so installed as to be both adjustable and accessible at any time after completion of the work. it shall be the responsibility of the subcontractor to ensure that adequate access panels are provided wherever the adjusting mechanism is concealed by suspended ceilings, furring-in, etc.

Balancing dampers installed in ducts where the minimum dimension is in excess of 450mm shall be of the multiple opposed blade type with individual blades not exceeding 165mm in depth and 1000mm in length.

Balancing dampers installed in ducts where the minimum dimension does not exceed 450mm may be of the single blade balanced plate "Butterfly" type. The blades shall be flat and rigid with close fitting hemmed edges. Damper rods shall not be less than 10mm square and may be either continuous or short stubs secured to the blade by not less than 2 bolts or rivets at each end. The square end of each rod shall be held in a lever type locking device with a central locking nut of large diameter, or a quadrant and locking screws.

Where dampers are specified for medium and high pressure ducts, the ends of the damper rods shall be provided with means of sealing to prevent air leakage.

Registers shall be provided with multiple opposed blade dampers.

4.2.6.10 Motorised Control Dampers

All automatically controlled volume dampers shall be of the multiple opposed blade type with individual blades not exceeding 165mm in depth and 1000mm in length. For greater lengths provide damper in equal sections as required.

Automatically controlled volume dampers shall have blades interconnected external to the damper housing by means of cadmium plated steel rods. All linkages are to be fitted with nylon bushes.

Provision to be provided for fixing either electric or pneumatic actuator to damper frame.

Damper blades shall be of galvanised steel construction, free of all rattling and vibration, with edges crimped or creased for rigidity and provided with neoprene sealing strip over full length and ends to ensure positive sealing action when closed.

All dampers shall have bolted through rods, not less than 10mm diameter or equivalent square rods fastened to blade with two or more set screws with steel washers at each end of damper rod.

Damper blades shall have "V" crease in middle to receive damper rod.

All dampers shall be of the opposed blade multi-leaf type similar to Trox or equal and approved.

4.2.6.11 Fire Dampers

Dampers shall meet local regulations, as laid down by the authority having jurisdiction over the said works. Dampers shall be sized so that the free air space is not less than the connected duct free air space. Dampers shall have a minimum four hour standard fire protection rating.

The frame shall be constructed so as to be unaffected by corrosion or high heat. Mechanical parts shall have bronze non-corrosive pins. When closed, the dampers shall be held closed by a spring loaded catch.

Fire dampers shall be arranged be arranged to close automatically and remain tightly closed upon the action of an approved fusible link or other heat actuated device, located where readily affected by an abnormal rise of temperature in the duct. Fusible links shall have a temperature rating of approximately 70^{o}C.

Fire dampers shall be installed so as to provide a positive barrier to passage of air when in a closed position. Dampers shall be so installed as to be self-supporting in case of duct destruction due to heat. Care must be exercised that the frame be set so that the closing device will not bind.

Suitable duct access hand hole openings shall be provided with tightly fitted covers to make fire dampers accessible for inspection and maintenance.

For systems where the air velocity is less than 12,65 metres per second the fire dampers shall be of the single bladed type for ducts up to 460mm diameter or 460mm in height. blade dampers for rectangular ducting shall not exceed 1220mm in length. For ducts having a greater dimension than 460mm diameter or 460mm in height, multi-blade dampers with 25mm overlaps shall be installed. Blade material in all cases shall not be less than 3,0mm steel.

For systems where the air velocity is 12,65 metres per second or higher the fire dampers shall be of the steel curtain type where the damper blades, in the open position, are outside the air stream.

Damper blades shall not exceed 150mm in width, and have rolled blades interlocking to form full length hinges upon which the blades will pivot when released.

The steel blades shall fold completely upon themselves and shall be stacked at one end of the damper to allow an unobstructed opening.

Blades shall be retained by a fusible link set to a temperature rating of approximately 70^{o}C.

The damper frame shall be a continuous channel enclosing the blades.

Pneumatic operated fire dampers, if required, including remote indication of damper status, shall be as specified in Part Five of this document.

4.2.6.12 Duct Mounted Electric Heaters

The heater element shall be incaloy sheathed 5,5W/cm suitable for operation in still air. The element shall be easily accessible and securely supported in the air stream.

The elements shall be mounted in a suitable withdrawable mounting frame with ventilated terminal cover. The duct section, housing the heater bank, shall be lined with 12 mm thick asbestos board for 450 mm on either side of the heater bank. Overheat cut out thermostats with manual reset shall be fitted and be readily accessible without removing any cover plates.

Electrical connection to the element shall be of heat resistant insulated wire.

An indication that the heater has tripped on over- temperature shall be given at the panel.

4.2.7 PIPING AND PIPE FITTINGS

4.2.7.1 GENERAL

Piping shall conform to applicable standards of current Specification of SABS and BSS. Reference to specification of recognized authorities, to establish basis of quality shall mean current edition at date of Tender.

All piping required to connect to apparatus shall be complete and ready for regular and safe operation. Unless otherwise noted, connect all apparatus and equipment in accordance with manufacturer's standard details, as approved.

Consult drawings and Specification to determine number and requirements of all items of equipment requiring piping connections. Provide accessory piping, such as vent, drain relief, etc., whenever equipment is provided with connections for such piping.

Cut pipe accurately to measurements established on site, work into place without springing or forcing, and to properly clear windows, doors, and other openings. Ream all piping after cutting.

Drawings are generally diagrammatic and indicative of work to be installed. Run and arrangement of piping shall be approximately as indicated, subject to modification as required to suit conditions on site, to avoid interference with work of other trades or for proper convenient and accessible location of all parts of piping system. All required offsets, fittings, valves, taps, drains, etc., may not be indicated.

Run piping as direct as possible, in general forming right angles with or paralleled to walls or other piping, and neatly spaced. Install piping so that there is sufficient clearance between finished coverings of piping, fittings and adjoining work. Hang piping at or in ceiling from construction above as close as possible to bottom of slabs, beams, etc., maintaining maximum headroom at all times. No item shall be installed so as to lower an established ceiling height without written permission. Provide sleeves where piping passes through partition, beams, slabs, etc. Sleeves shall be flush with each side of surface penetrated. Insulation shall be continuous through sleeves.

Pitch piping to ensure adequate venting and drainage.

Provide valved and capped connections necessary for the drainage of the entire system at all low points in piping systems.

During construction temporarily close open ends of pipes with sheet metal caps to prevent debris from entering piping systems.

Provision shall be made for expansion joints where required for proper control of expansion and contraction. Pipelines in which expansion joints are fitted shall be located and guided in accordance with the manufacturer's recommendations.

Support piping independently of all equipment so that equipment is not stressed by piping weight.

To facilitate maintenance:

a) Provide unions or flanged connections at connections to all equipment, apparatus and specialties requiring disconnection for repairs, replacement and adjustment. Locate unions between shut off valves and equipment.

b) Provide shut off valves where indicated and for individual equipment units at inlet and outlet, to permit unit removal for repairs without interfering with remainder of system.

c) Arrange piping for maximum accessibility for maintenance and repairs: locate valves for easy access and operation.

All necessary pipe hangers, supports, stanchions and anchors shall be supplied and installed by the Contractor, either as detailed on the drawings, or, if not detailed on the drawings, shall be supplied by the Contractor to spacings not greater than those given elsewhere in this Part.

4.2.7.2 MATERIALS

Except as otherwise noted piping 50mm and smaller shall have screwed joints, all piping 65mm and larger shall have welded or flanged joints.

Pipe threads shall be in accordance with BS 21, welded joints with BS 2633 - 1973 and flanges to ASA or BS 4504 standards.

Water piping shall be seamless steel in accordance with BS 1387 specifications.

Chilled water piping shall be of steel, seamless, medium black. Fittings shall be of malleable steel or malleable iron to BSS 1740 or SABS 509 specifications. Flanges shall be of cast-iron or steel to BS 4504 or ASA standards with reinforced rubber gaskets.

Hot water piping shall be of steel, seamless, heavy black. Fittings shall be of malleable steel or malleable iron to BSS 1740 or SABS 509 specifications. Flanges shall be of cast-iron or steel to BS 4504 or ASA standards with compressed asbestos fibre or metal gaskets.

Condenser water piping shall be of steel, seamless, medium or heavy black, but shall be hot dipped galvanised with a minimum coating of 300 g/m sq. Fittings shall be of heavy galvanised malleable steel or iron and shall be manufactured to BS 1740 or SABS 509 specifications. Flanges shall be cast iron or steel to BS 4504 or ASA standards galvanised as above with reinforced rubber gaskets.

Drain, overflow and make-up water piping and fittings shall be galvanised, with screwed fittings.

Where equipment is supplied with flanges not in accordance with the above standard, a matching flange is to be used.

4.2.7.4 PIPEWORK ERECTION AND JOINTING

Bends on mild steel and copper pipework shall be formed in pie lengths by machine building when this is the accepted practice. The internal radius of the bend shall not be less than two pipe diameters.

Galvanised pipework, lightweight copper tube to TABLE Z, and stainless steel tube shall not be bent with a bending machine. Fittings shall be used throughout the installation in these instances.

Only in exceptional cases will the use of elbows be permitted and only with the written approval of the engineer. Alterations to the cross sectional area of the pipe or rippling of the throat of a bend will make such a bend unacceptable for installation.

All galvanised mild steel pipework shall be protected against damage and corrosion prior to and during installation.

All horizontal services shall be laid to a slight fall so that the system is self draining to all low points, drain cocks and drain plugs.

Where screwed joints are used, bushings or long screw connections and backnuts will not be accepted.

The amount of flux and paste used in jointing shall be kept to a minimum and all excess flux shall be removed.

Care shall be taken to ensure fittings are not excessively tool marked. If in the opinion of the Engineer any fitting or piping is unacceptably marked, the Contractor shall replace the condemned section with new material. This section will be installed to the Engineer's satisfaction.

Piping when cut, shall be carefully reamed out to restore the bore and the Sub-Contractor shall allow for disconnecting and refixing any joint the Engineer may select to demonstrate that this has been done.

Before any part of the installation is commissioned, the pipework shall be cleaned of any accumulated dirt or debris by washing or blowing through the pipework at least twice. The Contractor shall allow for dismantling the pipework at the bottom of each riser to ensure that all debris is removed from the system.

All screwed joints shall be clean threaded and pulled up tightly. No caulking shall be permitted.

Vertical lines shall be dropped plumb, all multiple lines shall be parallel and must be spaced to permit lagging as specified under the insulation clause of this specification.

All black pipework and welded joints shall be painted two coats of red oxide after tests have been completed.

All flanged copper joints shall be made with corrugated full face rings.

all black mild steel pipework in floor ducts, chases, ceiling void and service shafts shall be welded. Flanged or screwed connections shall be made at valves, items of plant and elsewhere as specified.

For steel pipework, all pipe fittings 50mm diameter and below where exposed may be screwed pattern BS 143/SABS 1123.

All steel pipework 65mm and above shall be flanged to Table H, except for connections to items of plant where flanges to Table E shall be used.

All copper and stainless steel pipework up to and including 25mm bore shall be assembled with Delcoh capillary fittings. Fittings shall comply with BS 864.

Copper and stainless steel pipework 37mm bore and above, shall be assembled by capillary or approved compression fittings. Cast brass fittings shall be manufactured from non-dezinctification alloys. All copper pipework 76mm bore and above shall be flanged, faced and drilled to BS 10: Table D/SABS 1123.

Polythene pipework shall be assembled with compression fittings, strictly in accordance with the manufacturer's recommendation.

For all pipe services, union or flanged connections shall be provided at adequate intervals to facilitate disconnection for maintenance purposes.

All service connections to fixed points shall be made with an approved union connector.

The Contractor shall provide between all galvanised and copper pipework, connectors that will minimise electrolytic reactions between the materials.

Hot pressed or duplex brass fittings will not be permitted.

Unless detailed otherwise on the drawings, all external services pipework shall run at a minimum of 600mm below finished ground level.

4.2.7.3 VALVES AND FITTINGS

GENERAL

All valves up to and including 50mm shall bescrewed to BSPT. Valves 65mm and above shall be flanged to BS 10, Table M/SABS 1123.

All valves must have cast metal handwheels - pressed metal wheels must not be used.

Bolts and nuts in flanges are to be high tensile steel cadmium plated and the bolts are to be of the correct length such that no more than 1,5 clear threads protrude beyond the nuts after tightening to the correct torque. Cadmium plated washers are to be installed.

Where screwed joints are used, bushings or long screw connections and bushnuts will not be accepted.

FITTINGS

All bends shall be of long radius type, elbows will only be permitted where space restricts the use of bends.

All reducing fittings shall be reducer sockets, the use of reducing bushes will not be permitted.

Steel butt-welding fitting shall be seamless of the same weight as the pipe. Use seamless forged welding tees or reducing outlet tees for branches. Swept tees shall be used when indicated.

GATE VALVES

Gate valves shall be used for isolating and shutting off of equipment only.

Gate valves up to 50mm, brass solid wedge, screwed bonnet, rising stem to BS 1952. Valves 65mm and above cast iron body, flanged, wedge disc rising stem, outside screw and yoke, bronze trim to BS 1735.

Screwed valves: NEWMAN HATTERSLEY - Fig. 33X
Flanged valves: NEWMAN HATTERSLEY - Fig. 552E

GLOBE VALVES

Globe valves shall be used for balancing of systems, on bypass legs and return heades.

Globe valves up to 50 mm bronze body, renewable composition disc, screwed bonnet. Valves 65 mm and above, cast iron body renewable stainless steel disc and seat, outside screw and yoke, rising spindle, flanged.

Screwed valves: NEWMAN HATTERSLEY - Fig. 16
Flanged valves: NEWMAN HATTERSLEY - Fig. 18h

BUTTERFLY VALVES

Butterfly valve to BS 3952. Cast iron wafer type body, aluminium bronze disc with EPDM seat and wrench operated. Where butterfly valves are used a suitable spacer piece shall be installed to hold valve in location when equipment is disconnected.

CHECK VALVES

Check valve up to 50mm shall be horizontal lift type with bronze body, screwed bonnet, screwed BSP ends, spring loaded and renewable composition fibre disc.

Check valves 65mm and over shall be wafer type silent operating with non-slam type cast iron body, EPDM seat, balanced twin aluminium bronze flappers and stainless steel trim.

Up to 50mm: NEWMAN HATTERSLEY - Fig. 1213
65 and over: NEWMAN HATTERSLEY - Fig. 850

COMMISSIONING VALVES

Commissioning or balancing valves shall be installed where indicated and shall be calibrated with provision for connecting a portable differential pressure meter. Meter connection to have built in check valves. An integral pointer shall register degree of valve opening. After setting of all valves a metal tag shall be attached to the valve with the setting stamped thereon.

15 to 50mm - screwed, bronze body
65 to 300mm - flanged, cast iron body

Screwed valves: NEWMAN HATTERSLEY - Fig. CV2432
Flanged valves: NEWMAN HATTERSLEY - Fig. CVM 2733

CONTROL VALVES

Control valves shall be of the 2-way or 3-way type in accordance with the drawings and detailed specifications. Control valves of the 3-way type shall be installed as mixing valves, unless specified otherwise.

Normally closed and normally open ports shall be suitable for the air conditioning and control system, and are as shown on the drawings. The control supplier shall provide the Subcontractor with all valves to be installed in pipe systems in reasonable time before required for installation. The Subcontractor shall give special attention to the correct installation of control valves in accordance with the control supplier's requirements.

Valves of 50 mm and smaller shall have brass bodies and screwed connections.

Valves of 65 mm and larger shall have cast-iron bodies and flanged connections.

Valve trim shall be suitable for the specific application.

Valves shall be selected according to the system working pressure, and shall be provided with servos of sufficient size for the expected pressure differentials under normal operation.

Valves required for proportional control shall be selected for a pressure drop equal to the pressure drop of the controlled item. Valves shall be selected for a full open pressure drop of not less than 25 percent of the closed pressure drop.

Control valves shall be of the pneumatic diaphragm type, shall have suitable spring ranges and shall be provided with pilot operators where required. Control valve servos shall have sufficient capacity against the closed pressure drop to prevent chattering.

WATER STRAINERS

Water stariners shall be of the pot or angle type. Strainers of 38mm size and smaller shall have bronze or iron bodies, screwed connections and 50mm strainers and larger shall be designed for not less than 1035 kPa working pressure.

Screens shall be bronze monel metal or stainless steel with perforations as follows;

Strainer Size	Perforations
20mm to 50mm	0,8mm
55mm to 150mm	1,6mm
200mm to 300mm	3,2mm
over 300mm	6,4mm

THERMOMETER

Thermometer shall be mercury in glass, brass shrouded, 0,5 Deg.C accuracy installed in oil filled thermometer well. The bulb shall project 50mm into the pipe. Pipes smaller than 65mm in size shall be enlarged at the points where the wells are installed. Wells shall be set vertically or at an angle, so as to retain oil.

PRESSURE GAUGES

Pressure gauges shall be of the dial type with a diameter not smaller than 100 mm diameter, bourden tube type, dial range 200% normal pressure, calibrated in kPa. Gauges to be mounted on a U type syphon tube with gauge cock. The accuracy of all gauges shall be not less than 2%.

PRESSURE REUCING VALVES

Pressure reducing valves shall be single seated, tight closing internal spring loaded with spring suitable for the proper pressure differential.

Valves shall be flanged ends all bronze construction, and springs shall be phosphor bronze. adjusting screws shall be protected with tamper proof caps. All internal parts shall be replaceable and adjustable without removing the valve body from the pipe line.

All pressure reducing valves shall have a strainer on the inlet side, an isolating gate valve and pressure gauge on each side, and a relief valve on the outlet side.

STEAM SEPARATORS

Install steam separators in the steam supply line before each steam pressure reducing station. Steam separators shall be "Spirax" with screwed connections up to 25mm and flanged 40mm and over.

STEAM SIGHT GLASSES

Install a combined steam sight glass and non- return valve after all trap sets. The sight glass/ non-return valve set shall be "SPIRAX HILL" or equal and approved having a gunmetal body and toughened glass tube. They shall be utilised in systems with upto 3,5 bar working pressure. Above this pressure a cast iron body suitable for working pressures of 21 bar shall be used such as "SPIRAX SARCO" type PMO or equal and approved. The sight glass is to be installed at least 1m from the steam trap outlet and followed be a check valve.

CONDENSATE CHECK VALVES

Non-return valves shall be of the swing disc type (mushroom seating types are not acceptable). The body and disc shall be bronze similar and equal to "SPIRAX SARCO WCVI".

AUTOMATIC AIR VENTS

Automatic air vents shall be bronze body, brass ball, stainless steel valve and seat. They will be installed at all high points in the water systems as shown on the drawings (BRAUKMANN EA122).

VACUUM BREAKERS

Vacuum breakers shall be installed on all liquid storage vessels. THey shall be constructed of a brass body with stainless steel valve disc and seat with stainless steel enclosed operating spring. Minimum size to be 25mm.

4.2.7.4 PIPEWORK SUPPORTS, ANCHORS AND ISOLATION

All anchors, brackets and anti-vibration supports shall be supplied and installed under this contract to support and control the movement of pipes.

Detailed drawing for the pipework supports shall be approved by the Engineer prior to fabrication.

Pipework shall generally be supported as follows:

i) Ceiling and Floor Supports

All piping connected to rotating equipment shall be supported from resilient hanger rod isolators providing a minimum static deflection of 15 mm. Hanger rod isolators shall be a combination of steel spring and neoprene in-shear mountings.

The first four piping isolating hanger supports from rotating equipment shall be capable of supporting piping during installation at fixed elevation regardless of load changes. These isolation hanger supports shall incorporate an adjusting feature to transfer the load to the spring element within the hanger mounting after the piping system has been filled with water. Piping which is free of vibration and where specifically indicated, shall be fixed to steel channel or angle section brackets using 'U' bolts or single ring clips. Piping subjected to expansion and contractions shall be supported by Solar 2000 support system or equal and approved.

Floor supported piping shall be isolated by mountings free standing, laterally stable without housings, snubbers or guides, and complete with 6mm ribbed acoustical neoprene pad cold bonded to the underside of the base plate. All mountings shall have bolt holes in the base plate and be provided with adjusting bolts for levelling and attachment to the equipment. Horizontal and vertical spring constants shall be equal so as to ensure the same protection from horizontal disturbance as from vertical. Mountings shall have additional 50% capacity beyond the rated load.

Floor supported piping in the main plantroom and condenser water piping shall be supported by mountings as described above except except that mountings shall incorporate a resilient vertical limit stop to prevent spring extensions during weight changes. A minimum clearance of 13mm shall be maintained between the steel springs and the limit stop housings and around the restraining bolts so as not to interfere with normal spring performances.

ii) Wall Mounted Supports

Where pipes are hung from dedicated anti-vibration hangers, these hangers shall be supported from galvanised mild steel frame of channel or angle sections.

Wall rack mounted piping shall be rigidly supported from the rack and the entire rack

resiliently isolated by means of steel spring mountings on either end of the rack and in turn hung from galvanised mild steel frames. The spring mountings shall provide a minimum static deflection of 25mm and shall incorporate a leveling device.

The mountings shall incorporate a design feature, to maintain a constant piping elevation during installation and also after the piping system has been filled with water.

Piping which is free of vibration and where specifically indicated, shall be fixed to steel channel or angle section brackets using 'U' bolts or single ring clips. Piping subjected to expansion and contractions shall be supported by Solar 2000 support system or equal and approved.

iii) Support in Shafts

Each floor supported pipe riser clamp shall be isolated from the masonry or steel framing by means of two layers of ribbed or waffled neoprene pad loaded in accordance with manufacturer's recommendations.

Between each layer of pad, a 3 mm galvanised plate shall be provided. A suitable load distributing steel plate shall be provided between the pipe riser clamp and isolation pad.

iv) Guides in Shafts

Neoprene-in shear mountings installed at right angles to the axis of vertical piping and mounted within a suitable structural perimeter frame shall vertically guide pipings and provide support in all lateral directions. Mountings shall be Type ND and entire resilient guide assembly shall be Type PRG as manufactured by Mason Industries or as approved.

v) Anchors in Shafts

Pipe anchor points shall be capable of accepting the static and thermal loads without direct metal- to-metal contact of the pipe to the support. The anchor points shall be isolated with 25 mm thick pad-type mountings.

Were piping is to be supported off walls, the Contractor shall supply and install galvanised mild steel channel or angle support. Pipework may be either supported by the steel or hung from it using 'U' bolts or single ring clips.

Exposed services shall be supported by Solar 2000 pipe support system or equal and approved system.

4.2.7.6 MAXIMUM SPACING OF PIPE SUPPORTS

Type of PipingPipe	Dia. (mm)	Spacing for Horizontal Runs(mm)	Spacing for vertical Runs (mm)
Cold Water Pipes:			
Polythene (type 32)	up to 25	12 x o.d. of pipe	24 x o.d. of pipe
	over 25	8 x o.d. of pipe	24 x o.d.of pipe
Polythene(type 50)	9.5	600	1,200
	12-25	700	1,500
	32-38	900	1,800
	50	1,200	2,400
uPVC	19-25	900	1,800
	50-75	1,200	2,100
	100-125	1,500	2,400
	150	1,800	3,000
Hot and Cold Water Pipes	Lead	all sizes	600

and Gas Pipes:			
Copper (light Gauge) Stainless Steel	12	1,200	1,800
	15-28	1,800	2,400
	35-42	2,400	3,000
	54	2,700	3,000
	76-133	3,000	3,600
	159	3,600	4,200
Steel to BS1387 and copper (Heavy grade)	10-15	1,800	2,400
	20-25	2,400	3,000
	32	2,700	3,000
	40-50	3,000	3,600
	65-80	3,600	4,500
	100-125	4,000	4,500
	150	4,500	5,400
Cast or Spun Iron	50	1,800	1,800
	75-100	2,700	2,700
	150	3,600	3,600

These spans may be exceeded when clearly necessary provided the working stress in the longitudinal axis plus bending stress, is well within pipe manufacturers recommendations.

Where services are grouped together and are supported from a common channel, the spacing shall be as for the smallest diameter service pipe.

4.2.7.5 ALLOWANCE FOR EXPANSION

Expansion

Make proper provision for expansion and contraction in all parts of piping systems wherever possible by means of pipe loops, swing connections, or changes in direction of piping.

Where pipe loops or changes in direction of piping cannot be employed to absorb expansion and contraction, provide expansion joints.

Provide anchors and guides where necessary or requested to confine lateral movement of piping.

Provide guides on both sides of all expansion joints and loops and in additional locations recommended by expansion joint manufacturer.

Expansion Joints

Expansion joints and connecting piping to be installed, anchored and guided in conformance with manufacturer's recommendations.

All joints to be single type, unless otherwise indicated and with flanged ends, flanges: to BSS 4504.

Where indicated, joints shall have base for anchoring. Provide additional structural steel as required.

Expansion joints, where required, shall be packless, equalizing type stainless steel bellows

and stainless steel sleeves and shall be approved by the Engineer.

5.2.7.7 PIPEWORK IDENTIFICATION

Pipelines

Identification banding shall be used to identify all pipelines (insulated or uninsulated), and shall also apply to piping concealed in ducts, voids, and spaces above false ceilings. It shall be self-adhesive cellulose tape laminated with a layer of transparent ethyl cellulose tape.

The contents of the pipeline shall be readily identified by an adhesive band of the appropriate ground colour detailed in BS 1710/SABS 0140(111) with an explanatory text approved by the Engineer, printed upon it in a contrasting colour detailing the contents of the pipe.

All colour bands shall be 300mm wide and spread at approximately 5m centres. Where pipes are installed in underfloor ducts, colour bands etc. shall only be provided at access covers.

Direction arrows shall also be provided on the pipes at 4m intervals to indicate the direction of flow.

Valve labels

The Contractor shall provide chain and brass labels for all valves, stopcocks, etc., with engraved lettering to indicate their purpose, as directed by the Engineer.

Provide approved ceiling tile markers in areas where removable ceilings or access panels occur to indicate location of valves or other devices.

5.2.7.7 FLUSHING AND TESTING

All water piping shall be tested hydraulically to a pressure at least 1,5 times the maximum operating pressure (but not less than 7 bar) for a sufficiently long time determined by the Engineer, to detect leaks and defects which after testing shall be made good in an approved manner. Leaks in welded joints shall be cut out and the joint rewelded. Caulking of leaks will not be permitted. The Engineer shall witness the pressure test.

The Subcontractor shall be responsible for all testing required by State and local authorities or other statutory bodies as requested by the Engineer, or required by the Specification. The Subcontractor shall provide four sets of all test certificates, witnessed by the Subcontractor, Authorities, and Engineer's Representative, and detailed so as to identify the area tested.

Acceptance of a test by the Engineer will not relieve the Subcontractor of responsibility for proper materials and workmanship. It shall be the Subcontractor's responsibility to rest all piping, valves, fittings and other items erected by the Subcontractor in accordance with the Local South African Standard.

The Subcontractor shall remove all safety valves, gauges, instruments and items which could be damaged by the test pressure and shall supply and install blanks, blinds or temporary fittings for testing.

The Subcontractor shall supply all test equipment and materials.

The Subcontractor shall be responsible for the removal of water used in flushing and testing from all piping systems, including attached equipment.

Where temporary lines are required for draining, these shall be supplied by the Subcontractor and removed after use, leaving the area in its original condition.

Where removal of all moisture or special cleaning is necessary, the method may be specified as additional to any other procedure which follows.

All lines and attached equipment shall be thoroughly flushed and cleaned before testing, usually be washing with water. The Subcontractor shall supply and install temporary flushing screens on the upstream side of all equipment, and shall remove same on completion of flushing.

During flushing, all flanged elbows etc., noted as being for flushing purposes will be removed by the Subcontractor until the flushing has been completed to the Engineer's satisfaction.

All such flanged elbows etc, will be re-installed after completion of flushing-out and before hydrostatic testing.

The Subcontractor shall supply a safety or relief valve which shall be used at the pressure source to protect systems under test. The Subcontractor shall be responsible for venting all sections of piping systems, vessels and equipment while flushing, testing and draining to ensure against their collapse by vacuum.

Variations of pressure and volume due to temperature changes will be taken into account by the Engineer during pressure testing and the Subcontractor will be responsible for measuring and recording the average ambient air temperature at the beginning and completion of any test to support any claim for pressure drop due to temperature change. Such temperatures may be checked by the Engineer by reference to an independent body.

In the event of a pipeline system failing a test, a new test shall be applied after repairs and corrections have been made. Under no circumstances may repairs and connections be made whilst the pipeline is filled with water.

After completion of repairs, the lines will be re-filled, vented, pressurised and tested, including any parts which may have passed a test but which, in the opinion of the Engineer, may have been affected by the repairs.

The Subcontractor shall supply test pressure gauges which shall either be dual scale test type gauges, or, if single, indicating scale types, a second gauge shall be used immediately adjacent to the test gauge. Gauges shall be suitable for maximum test pressure, with dials at least three inches in diameter. The maximum pressure capacity of the gauge shall not exceed twice the test pressure. Gauges shall be checked against a standard gauge.

4.2.7.8 WELDING, BRAZING AND SOLDERING

This specification covers the gas and arc welding of butt, fillet and socket welds in piping. The welding may be done by shielded metal-arc welding, gas tungsten-arc welding, gas metal-arc welding or oxy-acetylene welding process, using a manual, semi-automatic or automatic welding technique or combination of these techniques. The welds may be produced by position welding or roll welding or by a combination of position welding and roll welding.

Welding of piping shall be carried out only by qualified artisans. Details of these qualifications shall be submitted to the Engineer for approval prior to the commencement of work.

The Engineer shall have the right to test any welds in the piping installation during the installation period or before final acceptance.

The Subcontractor shall at his own expense cut out the required welds for testing and also re-weld the piping where such test pieces have been removed.

Use the following spacing on all butt welds.

Nominal Pipe Wall Thickness	**Spacing**	**Bevel**
6 mm or less	3 mm	37,5 degrees

Over 6 mm to 20 mm	5 mm	37,5 degrees
Over 20 mm	5 mm	20-degree "V"

Before starting any welding, remove all corrosion products and other foreign material from surfaces to be welded by scraping, brushing, chipping and swabbing as may be required.

Welding Process: Perform welding by either manual shielded metallic arc process, or automatic submerged arc process. Use direct current exclusively. Electrode used shall conform to BS639. All pipe line welding shall conform to SABS Code of Practice 044-1967, and in accordance with latest accepted practice applicable to particular service.

Weld metal shall be thoroughly fused with base metal at all sections of weld and penetration of weld shall include unbevelled portion and extend to inside walls of pipe.

All production welds will be inspected visually by the Engineer and the Subcontractor's supervisory personnel. Any defective weld shall be chipped out for full depth and rewelded.

4.2.8 ELECTRICAL EQUIPMENT

4.2.8.1 ELECTRICAL WORK

GENERAL

All electrical works shall conform to the "Code of Practice for the Wiring of Premises" SABS 0142 -latest amendment and any additional requirement of the Supply Authority. All work shall be carried out in a neat and creditable manner.

POWER SUPPLY BETWEEN EQUIPMENTS

Power supply to and from switchboards, motors, heaters, etc., shall be done either with **armoured** cables run in galvanised cable trays or trunking or with insulated wiring in galvanised conduits.Trunking and conduits shall be painted to colour advised by Engineer.

Cables shall be of the PVC/PVC/SWA/PVC type complying with SABS 150. These cables shall be fitted with approved glands at entry to equipment and shall be secure and safely made off.

In cases where permission has be granted by the Engineer to run cables without trays or trunking, these cables shall be saddled at intervals not greater than 1 000 mm. Saddles shall be either multiple or single type and compatible with the cable material.

Earth continuity conductors shall be installed in all conduits, and provided for in all cables. The armouring of cables alone shall not be relied upon for earth continuity.

Where special E.C.C. cable is used approved glands designed for use with this cable shall also be used.

Unless otherwise stated, conduits shall be of the **galvanised metal** type with screwed or unscrewed joints. Unscrewed conduits shall be in accordance with SABS 1007.

Terminals shall be enclosed approved terminal boxes. The terminal boxes shall be generously sized and be made of 1,3 mm steel and provided with:-

- Brass terminal screws
- Removable 1,3 mm coverplate
- Adequate cable or conduit entries

Where multiple circuits are run in parallel runs, the use of wiring trunks with PVC cables drawn in will be permitted. Such wiring trunks shall be:-

- Totally enclosed
- Electrically continuous
- Bonded
- Provided with removable coverplates
- Securing screws every 230 mm

All electrical equipment shall be delivered to site fully wired internally and shall be provided with suitable terminals for all connections and connecting boxes for conduit or cable entry.

The Subcontractor shall be responsible for the setting and adjustment of all controls, overloads, etc., and shall attend to the first start of all equipment, and any re-adjustments as may be necessary.

4.2.8.2 MOTORS

Motors shall be built in accordance with BSS or SABS, except where otherwise noted.

Motors shall be tested in accordance with the relevant standards of SABS or BSS, and shall conform thereto for insulation resistance and dielectric strength.

All motors shall be provided with adequate starting and protective equipment as specified or required, and have terminal boxes of adequate size to accommodate the conduit or cable connections to the motor.

The capacity of the motors shall be sufficient to drive the associated device under all conditions of operation and load without overloading. Power shall not be less than that indicated.

All motors except those forming part of or provided integrally with equipment, shall be of the same manufacture.

4.2.8.3 MOTOR CONTROL PANELS

General

Motor control panels shall be specified in the Particular Specification as either the multi-motor, common baseplate type (MMCB) or of the cellular type (MCCT) in which the starter is housed in an individual compartment.

Provide each board with a fluorescent lighting fixture which will light the equipment mounted in the panel door. This light shall be switched by a conveniently and safely situated switch on or close to the panel.

The panels shall be provided with a lockable door mounted on sturdy hinges. Both panel and doors shall be fabricated out of sheetmetal of suitable thickness to give the required rigidity and strength.

All internal wiring shall be connected to readily accessible numbered terminal strips from which all external circuits to be connected. Terminals shall be of the standard rail mounted type (similar to “Klippon”). No terminal shall be used where the terminal the screw exerts pressure directly on the wire strands thereby effecting a cutting action; the terminal block must employ a plate or shoe under the terminal screw so as to clamp the wire strands tightly and evenly.

No more than one wire is to be connected to any one terminal and if several wires are to be commoned this is to be carried out by means of bridging strips on the terminal block.

All wire ends at terminals of equipment to have bead type numbered ferrules to correspond with numbering on the manufacturer’s wiring diagram.

Internal wiring run via plastic trunking shall not exceed 50% of the trunking cross-sectional area.

Testing

Full functional and operational test shall be carried out on every completed control panel at the manufacturer's works. The Engineer's representative will be present at these tests.

Tests on site shall be limited to operational and insulation resistance tests.

Three copies of all test records shall be submited to the Engineer for approval.

Metal Work

Panels shall be constructed with sheetmetal of the following thicknesses;

i) Panel box .....2,0 mm
ii) Doors .....1,6 mm
iii) Gland plates .....3,0 mm
iv) Base plates .....2,0 mm

The board shall be neatly finished, with all welds smoothly rounded off.

Doors shall be folded braced and secured to the hinges using chrome plated 6mm dome nuts and washers.

The fabricated sheet steel components shall be degreased, derusted and thoroughly cleaned then primed with an epoxy primer. Final coats of polyurethane acrylic enamel shall be applied until a final dry film thickness of 60-70 micron is obtained.

Instruments and control boards shall be designed and sized so as to allow for future addition. Spare capacity of approximately 20% worked out on component space and terminal requirements, shall be provided.

Instruments and panel shall be of approved manufacture with supplies and spares readily available. All contractors, relays and timers shall be rated as specified on the drawings. Coils and contacts shall be replaceable from the front of the contactor. All components shall operate effectively within the range of voltage fluctuations as specified in Part Five.

MMCB Panels

Multi-motor control panels shall consist of a sheet metal enclosure, housing a common baseplate onto which all motor control devices are installed. A main isolator shall be provided on the incoming side of the board, interlocked with the access door(s) in order to prevent access to the baseplate when the supply is switched on. The incoming supply shall be connected through the main isolator, to a set of busbars extending across the length of the board. A full length tinned copper earth bar 40mm x 6mm shall also be provided along the lower edge of the panel, unless otherwise specified.

All copper busbars will be rated to suit the fault level of the incoming supply. Current ratings will not exceed 1,25 Amps per square mm. The busbars will be taped with "3M Scotch" type of PVC tape of correct phase colouring as specified or heat shrink PVC tubing of the correct colour.

Both ends of all connections to the starter equipment and the terminal strips will be clearly identified with numbered tags. All numbers must correspond with the approved engineering and wiring diagram drawings for the starter panel.

The main isolator shall be installed on a separate framework in order that the incoming feeder connections and the connections to the busbars are not disturbed when the work is required on the baseplate. Suitable supports for cable and wiring shall be provided on the framework and

baseplate(s). The connection between the busbars and each starter set shall be rated for the fault level indicated for the panel.

On the common baseplate, all items of equipment of each individual starter shall be grouped to indicate association and shall be separated from the adjacent starters by the lines of wiring channels.

The common baseplate shall be of sufficient area to accommodate all starters and any space required for the installation of future equipment. The baseplate shall be sufficiently rigid and vibration free to ensure firm support for the equipment at rest and under operating conditions.

The area of the baseplate should not extend 1,5 meter square in order that the weight and the bulk of the assembly do not exceed the physical limits of manual handling into position.

If the area of the baseplate required for installation of all equipment exceeds 1,5 metres square, it is recommended that two or more baseplates be used and installed adjacent to one another within the sheetmetal enclosure.

In this instance, each motor starter circuit set shall be completely installed on one baseplate and no part or wiring of a particular starter must overflow into the adjacent baseplate.

It shall be possible to remove any one of the baseplates without disturbing the adjacent equipment or wiring.

The baseplate(s) shall be electrically continuous with the sheetmetal enclosure and it is recommended that a brazed earth stud be provided on each one for connection onto the main earth bar.

Clip-on type terminals similar to "Pratley" manufacture rated at least 50% in excess of the contactor rating for outgoing motor connection or control cables up to 70mm square or 100 kW motor ratings shall be provided at the top or bottom of the enclosure, as specified. The terminal blocks shall be fixed to the removable baseplate of the panel and not on to the framework, and shall have ample space above or below them for making off the cable terminations. Allowance must be made on the terminal block to accommodate 25% of spare ways.

The wiring between all starter components, isolators fuses, overload relays, etc., and the terminal strips is to be rated to suit the maximum capacity of the starter and or the rupturing capacity of the board whichever is the larger and all this wiring will be completed at the factory and will not be done on site. All panel wiring will be encased in PVC cable trunking of Hellerman manufacture.

A cable gland plate 300mm from the terminal strip will be fixed to the framework with bolts either at the top or bottom of the board and the terminals will be situated in line with the starter equipment and the outgoing cables.

For motors exceeding 100kW rating, no terminals will be permitted and the cable tails will be terminated directly into the terminal block or contactor unit of the starter.

All phase wiring will be done in red, white and blue PVC insulated conductors.

If control and supervisory wiring is required to equipment installed on the doors of the panel the wiring shall be and suitably strapped together with "Hellerman" spiral binding in the form of a vertical "U" loop between the door and panel, to ensure that there is no torsion on the wiring, when the door is rotated along the longitudinal axis of the conductors. Wiring supports shall be fixed to the hinged panels, to relieve the weights of the cables off the equipment terminals.

MCCT Panels

These boards shall be of the cubicle type, the cubicles being uniform in size.

The cubicles shall be stiffened and braced, and shall be totally enclosed. The cubicles shall each be fitted with hinged, folded braced doors.

Each cubicle shall house a single motor control starter, complete with all supervisory equipment.

Access to the various starters shall be possible without isolation of the entire board, but the door corresponding to each compartment shall be interlocked with a local isolator in order that any compartment can be isolated before access to the equipment is be obtained.

Supervisory and control equipment pertaining to the starters, shall be installed on the corresponding compartment door, or it may be grouped with others in a particular position, as may be specified.

Particular attention shall be paid to the method of wiring from busbars to the individual compartments, in order to avoid any cable crossing through a compartment with which it is unrelated. sealed wiring channels crossing through compartments, however, will be acceptable. Outgoing cables in general, shall be located and terminated in the lower terminating compartment where suitable "Pratley" terminal blocks as specified above are mounted on a clip-type fixing, mounted 300mm above the gland plate.

The bottom plate of this lower compartment which shall be at least 300m above the base will contain all the cable glands for incoming or outgoing cables.

A tinned copper earth bar 40mm x 6mm running the entire length of the board will be fixed 150mm above this gland plate, onto which all ECC and earth conductors are bolted using cadium plated high tensile steel nuts and bolts and brass washers.

In order to achieve the dust and vermin proofing requirements of this specification, it may be necessary to provide at the back of the compartments, a sealed wiring chamber in which all wiring will be accommodated and which shall be accessible only when the main isolator is switched off.

All wiring between busbars and starter equipment and to terminal blocks will be done in the factory. The sizes of wiring and ratings of terminals will be as detailed above under MMCB panels.

All hinges and door locks on every panel shall be of BARKER & Nelson, Zeuss, Yale or equivalent quality to ensure satisfactory operation and a neat appearance.

All wiring identification, fixings, tapping of busbars etc., will be specified under MMCB panels above.

Cabling, Wiring and Busbars

The current rating of copper busbars will not exceed 1,25 amps per square mm.
The phase identification colours shall be red, white and blue (R-W-B) from top to bottom, from left to right, from front to back when facing the front of the board, unless otherwise specified.

The minimum clearance between live conductors or live conductors and earth shall be 40mm for systems up to 550V.

Insulated conductors shall not be bunched in large numbers, to avoid heat accumulation within the core of the bunch or damage to healthy circuits in the event of an individual fault.

If bunching of conductors is not avoidable, the conductors should be de-rated in accordance with the relevant table of the SABS wiring regulations. Power and control or supervisory cabling must be kept separate from each other, and run in PVC cable truncking manufactured by "Hellermann".

All connections between the incoming supply and the busbars, or between the busbars and the incoming side of the outgoing circuits protectors, shall be made with conductors having a fault capacity equal or higher than the fault lavel indicated for the board.

Sub-distribution circuits protected by HRC fuses need only be rated for the maximum prospective asymmetrical fault level possible when the largest fusible link is installed in the fuse base.

The contactors and/or starters shall be rated for breaking currents laid down in VDE 0660 Part 1, Category AC3 and shall be protected with suitable back-up HRC fuses to protect the equipment against abnormally high currents or short circuits developing in the system.

The minimum conductor area of any power circuit shall not be less than 2,5mm square. Suitable protected control and supervisory circuits may be wired with 1,5 mm square conductors.

The maximum current density for all copper busbars shall be 1,25 amps/mm square and for all aluminium busbars 0,8 amps/mm square and shall, in all respects, be in accordance with DABS Addendum No.1 (1971). The minimum design of the busbars therefore is required to withstand the fault level of the board, regardless of actual loading. Busbar cross-section may not in any way be reduced without the prior approval of the Engineer.

Multi-stranded conductors between all items of equipment shall be used in preference to solid conductors. The insulation of the conductor shall not be stripped beyond the leading edge of the terminal in which is has to be accommodated.

Stripping shall be carried out without damage to the conductors, preferably by means of a stripper. Crimping lugs and ferrules shall be used for connection into equipment not provided with compression type terminals.

All wiring shall be readily accessible from the front of the board, except where front and back access is specified for the board.

All wiring shall be carried out neatly along vertical and horizontal lines, or where practical, it shall be accommodated in enclosure PVC wiring channels, manufactured by Hellermann.

The wiring shall not preclude the removal or block off the access to any item of equipment.

All bolted connections to busbars shall be made, using cadmium plated high tensile steel nuts and bolts and brass washers or high tensile phosphor bronze nuts, bolts and washers.

Single phase panels shall be wired in red and black PVC insulated conductors, for phase and neutral respectively and green earthed circuits.

Live control, instrument and supervisory circuits shall be wired, with 2,5mm square yellow PVC insulated conductors. Other wiring shall be grey.

Neutral connections shall be black and this colour must not be used for any other connection.

Earth connections may be bare conductors, but green PVC insulated conductors are preferred.

Cable colour coding shall be discussed with the Engineer, when foreign equipment, wired to different standards, is to be incorporated in the installations.

Gland Plates

The galvanised gland plates for floor standing panels shall be 300mm above the bottom of the board.

Gland plates shall be machine punched in the factory to suit each and every cable gland required and under no circumstances will any filing be allowed on site.

The gland plate shall be at least 3mm thick and securely bolted to take the load of the cables being terminated on it.

Fuses

The rating and selection of the fuses shall ensure that they remain intact and shall provide satisfactory operation for starting the motors under all normal short circuit conditions.

Insulation

All busbars and uninsulated connecting lines shall be taped with "3M Scotch" brand tape or sleeved with heat-shrunk material be the board manufacturer, using colour to suit the particular application. All take-off, joints and cable lugs shall be neatly taped with "3M Scotch" tape after installation of the boards or panels on site.

Earth Bars

Boards, panels and pillars are to be provided with suitable arranged tinned copper earth bars mounted on glass fibre insulators, at least 40mm high, having sufficient accommodation for separate wire for each circuit requiring one. The earth bar
shall have a cross sectional area of 240 mm sq. Provision for connections to earth electrodes and all ECC must be allowed for and nuts, bolts and washers shall be supplied on earth bar accordingly.

Provision for Incoming Cable

Suitable and proper provision is to be made in all boards and panels to allow space between incoming cables and switchgear terminals, busbars and other equipment. Only if the size of the incoming cable exceeds 70 sq. mm shall it be terminated directly onto the isolator and not via the terminal block.

Instruments

Indicating instruments such as volt, Ampere and power factor meters, etc., shall be of the moving iron flush pattern type with physical dimension of not less than 96mm x 96mm, having a 90 degree quadrature scale with pointer fulcrum in lower right hand corner and calibrated as specified in the detailed specification or as indicated on drawings. PCI or equivalent instruments, are preferred.

Current Transformers

Current transformers are to have ratios as specified in the detailed specification or on drawings, and have suitable burdens for the particular application, current transformers are to be installed on the load side of each phase and to be wired back to a suitable selector switch or instrument as specified.

Phase colour coding must be provided where possible for all wiring to current transformers. Numbered ferrules, or other suitable identification at both ends of wiring connections to current transformers and instruments, shall be provided.

The suggested class of accuracy for transformers shall be as follows:-

i) Indicating instruments such as ammeters, etc. -Class 5 or 3

ii) Metering - normal commercial grade kilowatt hour meters, etc., - Class 1 or 0,5

iii)Relays generally- Class 10p5 or10p10

Lightening Surge Arrestors

All boards and panels are to be equipped with lightening arrestors or surge divertors of approved manufacturer and bearing the SABS mark, type "AEI" LV 280W, where voltage does not exceed 380 volts, unless the incoming line is protected by previous board containing such arrestors.

The arrestors or divertors shall be mounted inside the panel on the incoming unit. The supply side connections shall be made in the factory to neutral and phase busbars, and earth side connections to earth bar of the board.

Spare Fuse Cartridges

Where HRC or other type fuses are specified, the board or panel shall be suitably equipped with a compartment or other approved facility for housing at least one third of every type of fuse cartridge specified, having a minimum of one set (ie. 3 fuses) of each rating specified and all such spare fuses shall be provided inside this compartment on handing over. The compartment shall be clearly labelled.

"Spare fuse cartridge: REPLACE USED-UP FUSES"

Phase Distribution and Balancing of Load

Where multi-phase boards or panels are specified, single phase circuits shall be wired in such a manner as to ensure that the electrical loads are evenly distributed over the three phases.

Labelling

All door panels, cubicles, and all internal equipment, e.g. circuit breakers, isolators, lamps, switches, instruments, relays and fuses shall be identified with engraved nameplates indicating their function.

Labels on face of panels shall be fixed by means of either blunt end screws or rivets or by gluing into metal label holders.

Lettering shall not be less than 6mm in height and mounted centrally below each respective switchgear or equipment generally in an approved position.

Where it is not possible to label each separate item of switchgear or equipment, MCB's fuses and light switches shall be numbered in numerical order and a legend type-written on cardboard provided in a cardholder frame behind optically clear plastic, such frame being fixed to the door of the board, or on a surface of the board where no door is specified.

Name or designation of boards, panels, size of feeder, circuits, etc., shall be carried out as follows;

a) Name or designation of sub-board or panel, eg. "Sub-Main Board A", "Workshop", on panel.

b) Source of supply or size of feeder, eg. "Fed from SMB A with (2 x 6mm sq.) in 25mm conduit or fed from main board with 300mm sq. x 4 core aluminium cable etc., shall be fixed to every circuit at the terminal block or outgoing or incoming cable supply.

c) Each item of equipment shall be labelled on the door of the board,
eg. "Cond. Pump No. 1 - 5kW".

d) All current transformers operated instruments or meters shall be clearly labelled with current transformer ratio or clearly labelled with current transformer ratio or multiplying factor on each instrument or meter, eg.

CT ratio 400/5

Reading X80

All current transformers themselves shall be clearly labelled or installed in such a manner that their CT ratio indication and polarity markings on any name plate are clearly visible.

4.2.8.4 INSTALLATION & PROTECTION OF ELECTRICAL EQUIPMENT

It is the Air conditioning Contractor's responsibility to furnish the switchboard manufacturer with all relevant information regarding cable trenches, ducts and whether there is sufficient space and access available in switchboard rooms, meter rooms, meter cupboards, etc., for the installation of boards or panels.

Where possible the largest number of cubicles or panels should be installed intact, to avoid assembly on site, provided space and handling facilities and conditions do not lead to damage of the unit.

No piping shall pass through any Elevator Machine Room, Transformer Room, Emergency Generator Room, Switchboard Room or Electrical Duct.

In general no piping shall be located in the same room within 1,8 m in plan view of any part of any electrical switchboard.

Where the above is not practical, protect electrical apparatus as follows:-

Provide watertight drip pans of 1 mm galvanised sheet metal, reinforced and properly supported, under all piping near electrical, control boards. provide 32 mm drain outlet pipes to spill over nearest floor drain.

4.2.8.6 MATERIALS AND EQUIPMENT

Unless otherwise stated on the drawings, the following minimum specification shall be assumed for equipment to be installed in the panels:-

Air Circuit Breaker (ACB): Specification IEC 292 IEC 157-1 Class 25 kWA or as specified.

Moulded Case Breakers (MCB): Specification IEC 292 IEC 157 Class 10kA or as specified.
Miniature Circuit Breaker: SABS Class 5 kA or as (MCB) specified.

HRC Fuses and Fuse Switch: BS.88: Part 2 1975
(CFS)

HRC Fuse Links: BS.88: Part 2 1975

Motor Contactors: Specified IEC 292-1 Triple pole, hand reset, Phase failure protection. Separate relays will be specified on larger motors.

The following list of manufacturers and suppliers of electrical equipment is enclosed for the convenience of the tenderers.

Other makes and suppliers of electrical equipment may be considered by the Consulting Engineers, but the tenderer is presumed to have included the following equipment in his offer;

Air Circuit breakers (ACB)	Siemens
	Merlin and Gerin
	Unelec
	Sace
	Novamax

Moulded Case Breakers (MCB)	FW Industries Heinemann Siemens Mitsubishi
Combination Fuse Switches	Stromberg English Electric Wallacetown Dorman Smith
HRC Fuses and Cartridges	English Electric Reyrolle Siemens Hazemeyer Crady
Contactors and Overload relays	Sprecher & Schuh Telemecanique Siemens Cutler Hammer MTE
Relays and Timers	Sprecher & Schuh Telemecanique Siemens Omron MTE
Terminal Blocks	Sprecher & Schuh Telemecanique Klipon, Pretley
Push Buttons, Selector Switches	Sprecher & Schuh Telemecanique Cutler Hammer MTE Omron
Electric Clocks	Omron Venner Horstman Theben
Instruments	Precision Control Instruments Crompton Parkinson ATW

Panel Indicator Lights- 24 volts light emitting diode and holders should be mounted on metal base plates.

4.2.8.7 MANUFACTURERS

The following is a list of preferred manufacturers of distribution boards and motor control panels. Other manufacturers may be considered by the Consulting Engineers.

a) Consolek
b) Siemens
c) Electron
d) Gamma Electric
e) Ottermill
f) Klockner Moeller

4.2.8.8 CONTROL EQUIPMENT

Control equipment includes the following:-

Thermostats

Room thermostats shall be of the proportional type with adjustable sensitivity. The thermostat dial shall be calibrated in 0C with a range suitable for the specific application. The dial shall not be visible, but shall be covered under a removable cap for adjusting purposes. The cap shall be secured with screws requiring a special tool for removal. Thermostats shall be direct or reverse acting, depending on the application as shown on the Engineer's drawings. Room thermostats shall be suitable for ceiling or wall mounting.

Humidistats

Humidistats shall be of the proportional adjustable type with variable sensitivity. A covering cap shall be as supplied and adjustment shall be specified for thermostats.

The humidistat sensor element shall be of the type which does not require re-adjustment after the element has been exposed to a relative humidity as slow as 20% RH and as high as 90% RH.

Controllers

Controllers used in conjunction with sensor instruments shall be of the single or double input type as required for the function which must be performed.

Controllers shall have temperature ranges, ratios and sensitivities suitable for the specific application.

Controllers shall be provided complete with pressure gauges and temperature indicators.

Temperature Sensor Instruments

Sensor instruments shall give an output signal which varies linearly with the measured variable. The temperature range of the instrument shall be as near as possible to that required for the application. Where temperatures are measured in large air ducts or plenums, the instrument shall be provided with an averaging element. Where temperatures are measured in pipelines, the sensor instrument shall be provided with a removable thermometer well.

Pressure Differential Sensor Instruments

Pressure differential sensor instruments shall be of the diaphragm type, giving an output signal which varies linearly with the measured variable. The pressure differential range of the instrument shall be as near as possible to that required by the application.

Pressure Differential Controller

Pressure differential controller shall be of the proportional acting diaphragm type, with a range and sensitivity suitable for the specific application.

Pneumatic Electric-Switches

PE switches shall have cut-in and cut-out pressures suitable for the application and as shown on the drawings.

Cut-in and cut-out pressures shall be adjustable.

Where switches are used to switch electric currents on or off, for example, electric heater applications, the switches shall be rated to break the full load current without damage to the switch. Switches shall have a 5 kA fault rating.

Pneumatic Step Control Instruments

Pneumatic step control instruments may be of the combined pneumatic-electric switch type, or may be of the servo controlled follower type, but shall be rated for the electric currents to be switched.

Control pressures shall be adjustable.

Pressure Selector Relays

Pressure selector relays may be of the minimum pressure or maximum selector type, as required for the specific application.
Instruments shall be suitable for wall or panel mounting, and shall be provided with pressure gauges on both incoming pressure lines.

Pressure Reversal Relays

Pressure reversal relays shall give an output signal which is linear and inversely proportional with the input signal. If required for more accurate control, the output signal range may be increased above the input signal range.

Temperature-Indicators and Pressure Gauges

Temperature indicators and pressure gauges used with control instruments shall have a minimum diameter of 50 mm. Calibration shall be in accordance with the S1 system.

Dial Type Thermometers

Dial type thermometers shall be mounted on all air handling units before, after and between heat exchange equipment. Dials shall have a minimum diameter of 80 mm. Thermometers shall be installed in positions where the representative temperature will be measured and where the temperature can be read by a standing person and with normal lighting.

Thermometers shall be provided with an averaging sensor element with minimum length or 2000 mm and shall have a range suitable for the temperatures measured.

Immersion Thermostats

Immerson thermostats shall be of the remote sensor type with a capillary tube of 3000 mm length minimum. Instruments shall be complete with pressure gauges.

Instruments shall be of the proportional direct or reverse acting type with adjustable sensitivity. Instruments shall be suitable for panel mounting with the step controller for cooling tower control.

Vortex Damper Servos

Vortex damper servos shall be supplied and installed by the controls supplier. The servos shall be suitable for the vortex damper provided by others, and shall be selected according to the fan size, fan inlet velocity and the range over which the vortex damper is to be controlled. Servos shall be sized for 1,5 times the torque required to operate the damper.

The damper shall be moved smoothly to control the static pressure in the duct as accurately as possible.

The servo range shall be suitable for the control system wherein it functions, and as shown on the drawings.

Pressure Reducing Stations

The required pressure reducing stations are shown on the drawings.

Each pressure reducing station shall consist of:-

Incoming pressure shut-off valve

Incoming pressure gauge

Pressure reducing valve

Outlet pressure gauge

Outlet pressure safety valve

Outlet pressure shut-off valve

Outlet pressure shall be adjusted to 120 kPa.
Safety valve shall be adjusted to 150 kPa.

The pressure reducing valve shall control the outlet pressure within a range of 4 kPa, independent of incoming pressure variation.

Pressure reducing stations shall be selected for a capacity suitable for the air consumption of all the instruments supplied with air from the reducing station.

4.2.9 THERMAL INSULATION

4.2.9.1 GENERAL

All thermal insulation work shall be executed by specialists in the specific field. Recommendations of manufacturers regarding application of insulation materials, insulation cladding, adhesives, etc., shall be strictly observed. The work shall be executed in a workmanlike manner and the final surface shall have a neat, smooth and symmetrical finish.

Before the application of thermal insulation, steel surfaces shall be treated and prime coated as specified elsewhere.

No equipment shall be insulated until tested and approved.

Adhesives, sealants and coatings shall be compatible with the insulation material.

Certified test reports for approval by the Engineer shall be submitted by the Subcontractor in which the following information is given:-

a) The thermal conductivity of insulating materials at operating temperature.

b) The surface spread of flame of insulating materials, adhesives and other finishes.

c) The permeance of vapour barrier systems (chilled water systems.)

Surface spread of flame for insulation shall be in accordance with BS 476 Class 1 Specification.

Vapour barrier permeability on chilled water pipes shall be not more than 0,6 grams/m sq. per 24 hours in accordance with BS 3197 - 1959 temperature test.

Insulation, adhesives and finishes shall be resistant to rotting, mould, fungus growth, decay or attack by vermin.

Where insulation is specified for piping, insulate similarly all connections, vents, drains, and any piping connected to systems subject to heat loss or gain.

4.2.9.2 PIPE INSULATION (CHILLED WATER)

All supply and return pipes in plantrooms shall be insulated with preformed sectional fire retardant polystyrene sections, minimum density of 24 kg/cu m.

Where vapour barrier jackets are used, these shall be applied with a continuous, unbroken vapour seal. Hangers, supports, anchors, etc., that are secured directly to cold services shall be adequately insulated and vapour sealed to prevent condensation.

Inserts shall be installed at hangers. Inserts between the pipe and pipe hangers shall consist of rigid pipe insulation of equal thickness to the adjoining insulation and shall be provided with vapour barrier where required. Inserts shall be of sufficient lengths to support the weight of the pipe without crushing the insulation.

Insulation thickness shall be as follows:-

Pipes from 15mm to 50 mm diameter - 25 mm

Pipes from 65mm to 300 mm diameter - 50 mm

Pipes bigger than 300 mm diameter - 65 mm

Apply insulation in two layers, staggered to avoid air bridges. Wire-brush pipework and coat surface with one layer of Flintcote 5, a synthetic cold bitumen adhesive and wait until this is tacky. Apply a coat of Flintcote 5 to the inside of the styrene shells taking care to fill all air bubbles and depressions and when tacky place upon the metal surface. Allow to set firmly and repeat for second coat.

When dry, apply final coat of Foster 30-36 or Chemseal 4 onto the outside of the styrene sections and cover with a fibreglass scrim cloth taking care to smooth out all bubbles and wrinkles. When firmly in place apply two further coats of Foster of Chemseal until a smooth and even finish is achieved. All bends and joints to be purpose made, either moulded or segmented. Round off segmented sections to a neat workmanlike appearance before applying sealer.

Where called for in the particular specification, finish with 0,5mm thick snap on aluminium sleeving. All bends to be full aluminium segmented lobster back. Screws to be stainless steel and hidden from view on top of piping. However, where exposed to the weather, the longitudinal joints shall lie in the lower sections of the piping and overlaps shall be in such a manner that ingress of water is avoided.

All work shall be finished completely vapour sealed.

4.2.9.3 DUCT INSULATION

GENERAL

All supply air ducts shall be either externally or internally insulated with 25 mm thick resin bonded glass fibre with a density of 75 kg/m^2 or mineralwool having density of 96 kg/m^2.

The insulation shall be installed in accordance with the manufacturer's instructions and shall be adequately fixed to prevent dislodgment from the duct.

Hanger pins for the fastening of internal and external insulation shall comply with requirements as specified in "Duct Liner Application Standard" (SMACNA) where applicable, with respect to construction, distance between hanger pins and positioning of hanger pins. Hanger pins shall preferably be of the electric stud weld type.

Welding time shall be sufficient to ensure a firm adhesion. If the "gripnail" type is used and the hanger pins show evidence of poor fastening during inspection, the Subcontractor may be requested to replace all fastener pins with the electric stud
weld type.

Return air, fresh air and exhaust air ducts shall not be insulated unless otherwise indicated.

The necessary care and caution shall be exercised when handling internally insulated ducts, so that the insulation surface will not be damaged. Any such damage shall be repaired to the satisfaction of the Engineer.

EXTERNAL INSULATION

Air Ducts in Plantrooms or Exposed

Ducts shall be externally insulated with resin bonded glass fibre of 25 mm thickness and with a density of 75 kg/m^2. The insulation shall be cut accurately so as to butt closely at all joints and projections through the insulation. Insulation shall be bonded to the duct surface by "Foster Safetee Ductfas 81-99" equivalent.

Inverted and side insulation shall be additionally supported by the use of hanger pins. Where insulation is cut to provide for duct hangers or supports for instance, or at projections through the insulation, the insulation shall be sealed for the full thickness with "Foster Foamseal 30-45" or equivalent. The surface of the insulation shall then be brush coated with one application of "Foster Sealfas Coating 30-36" at 1,6 m</1 or "Decadex Firecheck" or equivalent. A 170 g rot-proof canvas shall then be laid into the wet film and smoothed to remove all air pockets and wrinkles. Canvas laps shall be at least 25 mm and shall be adhered by means of "Foster 30-36" or "Decadex Firecheck" or equivalent. The canvas surface shall receive one brush coating of "Sealfas 30-36" at 1,6 m^2/1 or "Decadex Firecheck" at 1 m^2/1 or equivalent.

Ducts Outside Plantrooms or in Concealed Areas

Ducts shall be externally insulated with resin bonded glass fibre of 25 mm thickness and density of 24 kg/m^2 and covered with a factory applied aluminium foil facing. Insulation shall be adhered to the duct surface by means of "Foster Safetee Ductfas Adhesive 81-99" or equivalent. Inverted and side insulation shall be additionally supported by the use of hanger pins. All protrusions and cuts through the insulation shall be sealed for the full insulation thickness by one brush application of "Foster Foamseal 30-45" or equivalent, to obviate moisture migration at these points. Duct supports shall not be covered by insulation. Hangers shall be removed when applying external insulation.

INTERNAL INSULATION

Internal insulation of ducts, where specified, shall be carried out as follows:-

Duct shall be internally insulated with neoprene faced resin bonded glass fibre of 25 mm thickness and density of 75 kg/m^2. The insulation shall be bonded with Foster Safetee Ductfas Adhesive 81-99 or equivalent.

Insulation shall be additionally supported with Foster Nylon Clipfas hangers and washers or equivalent, which shall be bonded to the duct surface at approximately 500 mm centres.

All transverse and longitudinal joints to insulation on low and high velocity systems shall abutt tightly and shall be sealed with Foster Lagtone Coating 31-95 or equivalent to obviate flow at these points.

Free edges of the insulation at terminal points, transverse to the air stream shall be mechanically fixed to prevent damage or detachment.

Lining damaged in handling shall be repaired before erection of the ducting.

4.2.10 NOISE AND VIBRATION CONTROL

GENERAL

All equipment, piping, etc., shall be mounted on or suspended from approved foundations and supports, all as specified herein. The noise and vibration generated by equipment shall be isolated from the structure by means of anti-vibration mountings, spring hangers or flexible pipe connectors.

Unless otherwise specified, all floor mounted equipment shall be erected on a reinforced concrete pad, cast into a channel frame. Where vibration isolation between machine and base is used, the base shall be extended to supporting the isolating system.

All vibration isolators shall be selected and supplied by the same manufacturer and shall be approved by the Engineer before installation.

Vibration isolators shall have a guaranteed static deflection as specified and the isolators shall be installed in accordance with the manufacturer's recommendations.

NEOPRENE MOUNTINGS

Neoprene mountings shall have a minimum rated static deflection of 10mm. All metal parts shall be moulded into the neoprene to prevent corrosion and to provide friction, so that the mounting need not be bolted to the floor.

UNRESTRAINED SPRING MOUNTINGS

This specification covers three alternatives:-
i) is preferred, (or iii) when equipment is mounted on a deep concrete base), being more economical and efficient than ii). However iii) shall be used when additional lateral support is required, to ensure stability during starting and stopping.

i) Open Spring Mountings

Spring mountings shall be open and free standing and laterally stable without any housing. The springs must be isolated from the floor by neoprene friction pads or cups. Mountings shall have levelling bolts that can be rigidly bolted to the equipment. Spring diameters shall not be less than 80% of the compressed height of the springs at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. When the load per mounting exceeds single spring capacity, springs may be clusters in units of two or more.

ii) Housed Spring Mountings

The housing shall consist of cast iron top and bottom elements, separated by neoprene sponge inserts, to provide lateral support. The mounting shall incorporate a height adjusting bolt and a friction pad bonded to the bottom element, which must have provision for bolting down to the floor. Spring diameters shall not be less than 80% of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. When the

load per mounting exceeds single spring capacity, springs may be clustered in units of two or more.

iii)Open Spring Mountings with Concrete Bases:-

When equipment is installed on a concrete base (without steel framework) the height of the base shall be cast on a plastic sheet to facilitate separation from the floor. Cast iron or fabricated steel housings shall be case into the base, so that spring mountings as described in Specification i) can be neatly recessed into the base. The housing shall have an internal height equal to the height of the mounting and shall have a means of locating the adjusting bolt of the mounting in the centre of the housing, so that the mounting can be used to elevate the concrete base.

RESTRAINED SPRING MOUNTINGS

Equipment which has an operating mass different from the installed mass, such as cooling towers, chillers and boilers and equipment exposed to the wind, shall be mounted on spring mountings as described for unrestrained spring mountings, but installed in a housing hat includes restraining bolts to prevent extension when the mass is reduced. The housing shall also serve as blocking during erection so minimum clearance of 5 mm shall be maintained around the retraining bolts and of 12 mm between the housing and the spring, so as not to interfere with the spring performance. The housing shall be not dipped galvanised.

SPRING HANGERS:-

This specification covers three alternatives:-

i)This is a basic spring hanger incorporating a low profile spring that ensures that the hanger rod does not touch the hangers shall consist of a steel spring housed in a steel cage. The spring shall fit into a neoprene cup which locates in the cage, to prevent contact between the cage and lower hanger rod. The cup shall contain a steel washer to evenly distribute the load on the neoprene. Spring diameters shall be not less than 80% of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. The spring height and diameter, and the neoprene cup containing the spring, shall be so dimensioned as to allow the lower hanger rod to swing through the 30 arc before coming into contact with the cup. When the load exceeds single spring capacity, springs may be clustered in units of two or more.

ii)This adds a neoprene element to i) for better efficiency, particularly in eliminating high frequency noise, and is to be used when superior performance is required. Hangers shall be as specified in i) above but shall incorporate a neoprene element with a minimum rated static deflection of 8 mm. The element shall locate in the top of the cage in order to prevent contact between the cage and the upper hanger rod.

iii)This adds a fixed elevation device to i) and ii), to facilitate installation. I also ensures that excessive load is not put onto equipment flanges, and is to be used for the three hangers nearest the inlet and outlet of each item of equipment. Hangers shall be as specified in i) and ii) above but shall have provision for the spring to be precompressed o the rated deflection so as to keep the piping or equipment at a fixed elevation during installation. The hangers shall be provided with a method of releasing any residual precompression after installation is complete and the hanger is subjected to its full load. Deflection shall be indicated by means of a scale. Precompressed hangers shall be used at the three support points neatest the inlet and outlet of each item of equipment.

FLEXIBLE RUBBER CONNECTORS

Flexible rubber connectors shall be used in the positions indicated in the drawings, or where otherwise required, to reduce transmission of vibration or noise from equipment to pipework, accommodate pipe expansion and contraction, take up minor misalignment and facilitate connecting up. Where equipment is provided with a shut-off valve, the flexible connector shall be installed between the equipment and the valve.

Connectors shall be moulded in neoprene rubber with nylon reinforcing. Steel rings or wire reinforcement shall not be permitted. Only connectors of the spherical or arch type, allowing movement and misalignment in all planes, shall be used. Rubber hoses are not permitted.

The neoprene body shall be fitted with loose flanges, free to rotate, so as to facilitate lining up. Flange bolts must be fitted with the heads towards the rubber body. Where desirable for space saving or economy, elbow connectors can be used. For nominal diameters of up to 65 mm flexible connectors with threaded ends, instead of flange may be used.

Neoprene connectors may be used with single arch construction but where large movement or misalignment must be accommodated, or where maximum vibration and noise control is required, double arch connectors are preferred.

Neoprene connectors must be correctly installed in accordance with the manufacturer's directions, proper account being taken of whether pipe anchors are installed on both sides of the connector, or whether the piping is unanchored, or whether the piping is connected to equipment, such as pumps, mounted on spring supports.

In cases where the piping is unanchored and the operating pressure (or test pressure or possible pressure surges) could over-extend the connector, rods or cables must be used to isolate the rods or cables from the flanges, or prevent Neoprene connectors offered must have a guaranteed burst pressure of at least three times the required working pressure. When allowance is made for temperature/pressure de-rating. Connectors must be rated for continuous operation at the pressure and/or temperature are excessive for neoprene connectors, flexible stainless steel connectors must be used.

FLEXIBLE STEEL CONNECTORS

Flexible stainless steel connectors shall be used in the positions indicated in the drawings, or where otherwise required, to reduce transmission of vibration or noise from equipment to pipework, accommodate pipe expansion and contraction, take up misalignment and facilitate connecting up. Where equipment is provided which a shut-off valve, the flexible connector shall be installed between the equipment and the valve.

This Specification refers to flexible connectors built up form annular corrugated stainless steel hose, reinforced with an external shroud of stainless steel wire braid, with the ends of the braid locked so as to allow the connector to flex but not stretch. It does not refer to unbraided stainless steel bellows, generally known as expansion joints.

Flexible rubber connectors are preferred for sound and vibration attenuation, but flexible stainless steel connectors should be used :-

a)When the temperature or pressure is excessive for rubber.

b)When maximum flexibility is required.

c)When maximum safety is required.

Flexible stainless steel connectors should be fitted with loose flanges, to prevent twisting and facilitate lining up.

Minimum lengths shall be as follows (but no longer lengths must be used where necessary for the required flexibility, or to exceed the manufacturer's recommended minimum radius of:-

DIAMETER (MM)	50	65	80	100	125	150	200	250	300
LENGTH (MM)	300	325	350	400	450	500	550	600	700

It must be noted that, unlike flexible rubber connectors, flexible stainless steel connectors cannot accept axial movement, but only transverse (flexing) movement. If a single connector is used it should therefore be installed parallel to the equipment shaft to accommodate vibration, or at right angles to the direction of movement to accommodate pipe expansion. When the movement is in two planes, two flexible connectors at right angles are to be used.

Flexible stainless steel connectors offered must have a guarantee burst pressure of at least three times the required working pressure. When allowance is made for temperature/pressure derating, connectors must be rated for continuous operation at the required working pressure and temperature.

FOUNDATIONS

All rotating equipment shall be provided with concrete foundations with approved vibration isolators for rotating equipment. Refer to section "Noise and Vibration Control".

The foundations shall be not less than 100 mm high and extend not less than 150 mm beyond the equipment on all sides. The Subcontractor shall provide galvanised steel channel forms the size and shape of each foundation. These forms shall be of suitable strength such that they will not distort when cement is cast therein. The foundations are to be case on an insulating layer which shall be provided by the Subcontractor. The forms and the insulating layers shall be provided to the Builder together with any holding down bolts required and drawings giving all necessary dimensions.

These foundations shall be painted by the Subcontractor once cast in position. A suitable etching primer shall be used on the exposed surfaces of the galvanised steel. Colour of paint to be used to be selected by the Engineer.

SOUND ATTENUATORS

Sound attenuating units and sound absorption lining in ductwork shall be provided as required to control the system sound level within the limits specified.

Sound attenuators shall be supplied by an approved manufacturer. Published data of attenuator performance must be available.

Detailed calculation sheets substantiating the selection of attenuators to achieve the sound levels specified in Part Five of this document shall be submitted for approval by the Engineer, prior to ordering.The sound attenuator's casing shall be made from galvanised sheet steel at least 1.6mm thick. All joints shall be made airtight for pressures up to 1 kPa.

Connection between attenuator and ductwork shall be by means of matching angle iron flanges.

Flanges shall be at least as follows :-

Longest side up to 1000 mm - 30 X 30 X 3mm angle

Longest side greater than 100 mm - 40 X 40 X 4 mm angle

The matching flange is to be sized such that it will accommodate the connecting ducting without restriction.

When required, splitters shall be made with a galvanised steel frame and an acoustical fill of mineral wool covered with galvanised perforated sheet.

4.2.11 WATER TREATMENT PLANT

GENERAL

The chemical treatment programme for all water systems shall perform the following functions:-

Inhibit corrosion

Inhibit formation of scale

Protect system against algae growth
Protect system against sludge formation

Chemicals shall comply with the Local Health Authority regulations and shall be compatible with all materials forming part of the piping system.

Chemicals shall be readily available from a recognised supplier.
Chemicals shall be selected so as not to interact with or neutralise each other.

Concentration of chemicals in pipe systems shall be in accordance with supplier's recommendations.

Service visits by the supplier of the water treatment systems with water analysis tests an recognised corrosion tests shall be conducted at monthly intervals during the twelve (12) month maintenance period. Reports on the above shall be sent to the Engineer.

The Subcontractor shall provide sufficient chemicals for twelve months operation at an average refrigeration load of 60%.

Water treatment systems and chemicals shall be supplied and serviced by Portals Water Treatment, or other, to be approved.

CLOSED SYSTEMS

Systems shall be filled and the water circulated sufficiently to flush the entire system before draining and filling with clean water, after which corrosion inhibitors shall be added.

The Subcontractor shall provide a dosing pot to facilitate addition of the inhibitor.

4.2.12 GRILLES AND DIFFUSERS

GENERAL

All grilles and diffusers shall be capable of delivering the air quantity as stated without noise or unnecessary draughts. The grilles shall be pleasing in appearance. All mitres, welds, etc., shall be neat.

Unless otherwise stated, the builder will supply wood or other framework, to which grilles may be screwed. Sub-frames, where specified, must be supplied and handed to the builder for building-in.

The fixing of grilles shall preferably be concealed or, alternatively, by means of neat countersunk Phillips type screws, A felt or plastic foam gasket shall be installed behind grille flanges to ensure air-tightness and prevent dust streaks.

All supply and return grilles and diffusers shall be fitted with approved opposed-bladed volume damper control, adjustable from the face of the grille.

Sample grilles, diffusers and louvres to be submitted for approval prior to purchasing.

4.2.13 PAINTING AND FINISHING

GENERAL

All paint shall be delivered to site in the manufacturer's original sealed containers, and all paint shall be of the highest quality, applied strictly in accordance with the manufacturer's directions.

All metal, surfaces, whether painted in the workshop, factory or on site, shall be wire brushed and cleaned to remove all dirt, rust, grease or other foreign matter before the application of the priming coat.

Hangers, including, rods and inserts, shall be painted with one coat zinc chromate primer unless galvanised. if galvanised, where finished painting is required an approved etching primer shall be used.

All uninsulated piping shall be coated with one coat of red lead or zinc chrome primer, field applied after erection, and finished with two coats high gloss enamel. The painting of all plant, piping, fitting etc, forming part of this subcontract is the responsibility of the subcontractor.

Insulated piping shall be prime coated and inspected by the engineer prior to insulating.

Black steel or iron shall be painted as above for uninsulated pipework.

Arrows shall be stencilled on all piping to indicate direction of flow .

All ductwork of which the inside is visible, shall be painted with flat black paint, for as far back as visible.

All fans, pumps, motors and equipment, except as otherwise specified, shall be painted with a factory applied primer coat, and finished with two coats high gloss enamel paint.

Fire dampers, unless galvanised, shall be painted with prime coat, and finished with corrosion inhibitive paint.

All equipment supplied with factory applied prime coats shall be spot coated on all damaged areas.

COLOUR SCHEDULE

Unless otherwise indicated, the following colour schedule shall apply:-

Plant Description	Colour	Plascon Code
Chilled Water Expansion Tank	Minuet	G124
Chilled Water Pumps	Midnight Blue	G116
Chilled Water Supply	Midnight Blue	G116
Chilled Water Return	Light Blue	G16

Condenser Water Pumps	Midnight Blue	G116
Condenser Water Supply	Olive	G401
Condenser Water Return	Fairy Green	G71
Hot Water Expansion Tank	Aluminium	HRA4
Hot Water Pumps	Midnight Blue	G116
Hot Water Supply	Medium Yellow	G6
Hot Water Return	Sunlight Yellow	G12
Air Handling Units	Minuet	G124
Supply Air Fans	Minuet	G124
Return Air Fans	Minuet	G124
Ducting	Light Blue	G16
Duct Flanges	Black	G2
Air Compressor Receivers	White	NY1
Pneumatic Air Mains	White	NY1
Fan and Pump Guards	Signal Red	G7
Bases	Black	G2
Drain Pipes	Black	G2

4.2.14 **TESTING AND COMMISSIONING**

General

The subcontractor shall test, balance and commission the entire installation as required for the efficient operation of the system.

The subcontractor shall carry out such preliminary test as are necessary to ensure that the system is in order before requesting acceptance and witnessing of the test on installation by the Engineer.

ADJUSTMENTS AND COMMISSIONING

Commissioning of equipment shall not be undertaken if damaged to the equipment systems or the building could result due to incomplete and incorrect installation work.

Commissioning procedures as stipulated by the suppliers of equipment shall be strictly adhered to.

The commissioning of equipment such as centrifugal refrigeration machine, boilers, air compressors, etc., be undertaken by the suppliers.

Calibrated instrumentation required to measure flows, pressures, temperatures, etc., shall be provided by the sub-contractor.

Commissioning data shall be fully tabulated in conjunction with the design data and submitted to the Engineer prior to any performance inspections being carried out by the Engineer.

The entire control systems shall be adjusted and placed in to operations by the control system specialist contractors.

All safety protection systems shall be fully commissioned and setpoints properly checked out and adjusted, before equipment shall be allowed to run for commissioning purposes. A responsible commissioning Engineer employed by the sub-contractor shall be present to supervise the operation and adjustment of the equipment during the entire commissioning stage.

Air duct systems shall be adjusted and balanced so that air quantities at outlets are as specified, and the distribution from supply outlets is free from drafts and uniform over the face of each outlet.

Air duct systems shall be adjusted and balanced in accordance with the "Manual for the balancing and adjustment of air distribution systems" as compiled by SMACNA.

Air quantities specified for fans include for duct leakage of 2,5%. The sum of air quantities of all outlets would normally be acceptable at a tolerance of +/- 5% of that specified for the fans.

The air quantities would normally be accepted at a tolerance of +/- 10% and as long as the total air supplied to that space is within a tolerance of +/- 5%.

Air flow quantities shall be determined by a combination of the following:

- Air flow reading over filter banks or dampers
- Air flow reading over coil
- Pressure differential over fan
- Main supply air duct pitot tube traverse
- Supply air quantities measured with an adaptor fitted over the outlets
- Fan power consumption

Water and air flow quantities shall not be reduced by artificially increasing the system's resistance by more than 5% of the total system resistance.

Chilled water systems shall be fully commissioned and adjusted to the design flow requirements, shall be free of air and excessive dirt and shall the specified water treatment in working order before refrigeration equipment is commissioned.

Water circulating systems shall be adjusted and balanced so that water quantities circulated through condensers, chillers, coils, towers, etc., will be as specified. Tolerance of -5% and +10% would normally be acceptable but should be clarified with the Engineer in writing prior to commissioning.

Chilled water, hot water and condenser water systems shall not remain in operation for a period of more than five days without the water treatment systems being in proper functioning condition.

If the sub-contractor should fail to comply with the above requirement, then the sub-contractor shall open up all heat exchanging equipment and clean out to the satisfaction of the Engineer.

Water flow quantities shall be determine by a combination of the following;

- pressure differential across equipment
- Orifice plates
- calibrated balancing valves
- pressure differential across pump

4.2.15 TESTS

Where the Engineer is to witness tests, the sub-contractor shall ensure that the Engineer receives one week prior notice in writing before such tests commence. Tests to demonstrate the capacity specified and general operating characteristics of all apparatus, etc., shall be made under the direction of the Engineer at time of final inspection under conditions imposed by him.

Test instruments shall be tested for accuracy by an approved laboratory or by the manufacturer and certificates showing degree of accuracy shall be furnished to the Engineer.

Instruments and appliances required for tests shall be furnished by the sub-contractor. If gauges, thermometers, etc., which are to be left permanently installed are used for tests, they shall not be installed until just prior to the test to avoid possible changes in calibration.

After completion, either in a part or as a whole, the complete installation shall be subject to acceptance tests by the Engineer. The sub-contractor shall assist the Engineer during any test carried out and must supply instruments required for testing purposes.

Capacities of refrigeration machines, cooling towers, pumps, heating and cooling coils, fans and other equipment shall be determined by operating test for a period of not less than four hours duration. Test procedures shall be in accordance with applicable sections of ASME. The test must be witnessed by the Engineer.

The vacuum test shall follow the pressure test. Charging of the equipment with refrigerant shall follow the vacuum test. After charging and prior to capacity test, joint in refrigerant piping and apparatus shall be checked with a leak detector. If leaks are found, the system shall be pumped down and the leaks corrected. The test must be witnessed by the engineer.

Compressed air piping (except low pressure control piping) shall be tested at not less than 1000 kPa. This pressure shall be maintained for one hour without pumping. A correction of final pressure of not more than 12,5 kPa for each 3 C change in average ambient temperature during the test will be permitted. Leaks shall be corrected as specified for water piping. The test must be witnessed by the engineer.

Low pressure control air piping shall be tested with 200 kPa air pressure. This pressure shall be maintained for one hour without pumping, during which time the pressure shall not drop more than 7 kPa. A correction of the final pressure of not more than 3,5 kPa for each 3 C change in average ambient temperature during the test will be permitted. Leaks shall be corrected by remaking the joints. Caulking will not be permitted. The test must be witnessed by the engineer.

Testing of duct and piping

All medium and high pressure air duct shall be tested in accordance with SMACNA ("High velocity duct construction standard").

The subcontractor shall include for blank-off plates to isolate the main supply duct system from the branch duct for test purposes. The complete main supply duct system shall be tested.

The subcontractor shall provide the required test fan and approved instrumentation and the test shall be witnessed by the engineer.

The first complete branch duct from the main supply duct to the supply air diffusers shall be pressure tested while witnessed by the engineer.

The Subcontractor shall allow for the closing off of spigots.

Ducts classified as "low pressure ducts" shall be smoke tested and only be visually inspected by the Engineer.

Water piping shall be tested with water pressure of not less than 1,5 times the maximum working pressure. Care shall be taken to avoid putting excessive pressures onmechanical seals, safety devices, etc. The system shall be filled and all air vented at least 24 hours before the actual test pressure is applied. Test pressure shall be applied when water and average ambient. Temperatures are approximately equal and constant. The pressure shall be maintained for not less than twelve hours without appreciable drop after the test pump has been disconnected. Leaks in screwed fittings shall be corrected by remaking the joints. Leaks in welded joints shall be cut out and rewelded. Caulking of leaks will not be permitted. The test must be witnessed by the Engineer.

4.2.16 **INSPECTIONS**

The Subcontractor must allow for reasonable assistance to the Engineer during the following inspections:

First physical and mechanical installation acceptance inspection. The completeness and correctness of the installation will be checked; all workmanship and materials will be checked for compliance with the specification.

Final physical and mechanical installation acceptance. The remedial work pointed out in previous inspection will be checked. Any new items noticed will also be pointed out to the Subcontractor.

First performance acceptance inspection. The operation of all equipment in the installation will be checked.

Final performance acceptance inspection. The remedial work pointed out in the previous inspection will be checked. Any new items noticed will also be pointed out to the Subcontractor.

Handover inspection. The outstanding items from the first physical and mechanical fist performance acceptance inspections will again be inspected. The Subcontractor will be given two weeks for remedial work and reinspection.

Handover will be taken after this inspection only if the Engineer is satisfied that only minor items are outstanding.

Certificates confirming inspections and listing faults will be issued by the Engineer for every Inspection held.

The Subcontractor must ensure that the installation is correct, complete and to specification before calling for an inspection.

The cost of any abortive inspections, where the Engineer is called to site, but finds the Subcontractor ill-prepared for it, will be deducted from the Contract Price by Variation Order.

The Subcontractor shall provide is competent person to accompany the Engineer or his representative during inspections. The person shall know the installation, shall be in a position to accept and carry out instructions and shall take notes during the inspections so that the remedial work can commence immediately and is not held up while waiting for the inspection certificate.

The Subcontractor must replace any portion of the installation that does not meet with the requirements of this Specification as may be imposed thereon by test or inspection. Such replacements shall be done at his own cost.

Recording charts of all tests by the Subcontractor must be submitted to the Engineer before applying for acceptance inspections.

The Subcontractor must preferably keep an inspection table of all tests to be witnessed andall inspections to be held by the Engineer.

The times and dates for tests and inspections must be agreed to by all parties after the receipt by the Engineer of the Subcontractor's written application for such tests to be witnessed or inspections to be held. Application for acceptance test can only be made when the Subcontractor is satisfied that the section for which application is being made, compliesfully with thespecification.

The Subcontractor shall carry out all reasonable tests and measurements requested by the Engineer to prove that the system or parts thereof complies with the specification document.

The Engineer can request that any part of the system or the complete system be retested, recorded and measured as part of the acceptance inspections if there exists reasonabledoubt about the accuracy of the test.

4.2.17 **OWNER INSTRUCTION**

The Subcontractor shall operate the whole plant for a period of five consecutive full working days after the plant is handed over.

During this period, the Subcontractor shall instruct the owner in the operation of the plant.

4.2.13 **OPERATING AND MAINTENANCE INSTRUCTIONS**

Provide, before requesting acceptance of work, four (4) printed and bound sets of complete operating instructions and parts lists for each system and each piece of equipment provided, including the following information:-

Brief description of equipment and systems and basic operating features.

Manufacturer's name, mode number, service manual, spare parts list and descriptive literature.

Maintenance and lubrication instructions.

Listing of possible breakdowns and repairs for each type of equipment.

Step-by-step operating instructions for starting operation of equipment and systems.

Manufacturer's wiring diagrams. In addition a wiring diagram shall be mounted behind glass and hung in the plant room.

Field test reports.

As-built drawings. In addition one reproducible sepia of each as-built drawing shall be provided.