MOKOLO AND CROCODILE WATER AUGMENTATION PROJECT PHASE 2 (MCWAP-2)

TENDER NO 054/2024/PMID/MCWAP2/RFB

PART C3.1
SPECIFICATION

SECTION 42

HEATING, VENTILATION AND AIR CONDITIONING

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SECTION 42

HEATING, VENTILATION AND AIRCONDITIONING (HVAC)

42.1 SCOPE

The modular HVAC system is designed by the Employer. Certain system components are to be designed by the Contractor. This Section specifies the Employer's requirements for the HVAC system components, the manufacture, shop assembly and testing, supply, installation, Site testing, Site commissioning, all operating and maintenance during the Defects Notification Period of the HVAC for the MCWAP-2 Low- and High-Lift Pumping Stations and associated buildings constructed under this Contract.

(a) Low-Lift and High-Lift Pumping Stations

The main pumping station room will be mechanically ventilated using filtered outside air, pressurising the area. There are several rooms inside the pump building which will either have extract ventilation, supply ventilation and/or air conditioning.

(b) The Operational and Control Centre, Offices and Guard Houses

The various offices, reception, induction room, etc. will be air conditioned and filtered outside air will be supplied to these areas. The ablutions and locker rooms will be ventilated by openable windows.

(c) Warehouses and Workshops

These areas will have mechanical extract systems installed and the small offices inside the buildings will have air-conditioning and filtered outside air.

The work shall be undertaken as per the system specifications and requirements set out below:

a) Low- and High-Lift Pumping Station pump rooms: The system consists of intake louvres, filter banks, sound attenuators, fans, un-insulated ducting, Drum louvres, and other associated miscellaneous Plant items. Outside air will be filtered and discharged into the general pump room as indicated on the Drawings. The room will be pressurised to prevent ingress of unfiltered outside air;

b) High- and Low-Lift Pump Medium Voltage. Low Voltage UPS room and Battery room as well as Staff Facilities: The system will consist of intake louvres, filter banks, sound attenuators, axial fan, un-insulated ducting and supply air grilles. Outside air will be filtered and discharged into the various rooms and will escape via the associated door grilles. The control room will also be conditioned with a DX split air-conditioning unit;

c) High and low lift pumping station, VSD room: Chilled water air handling units will be used to supply conditioned filtered air to the room with 100% return air. The AHU's will be supplied with chilled water from air cooled chillers;

d) Control Rooms, PLC and Server Rooms: These areas shall be air conditioned using multi-split-type air conditioning units of capacity as indicated on the Drawings; and

e) Guard Houses: These buildings shall be air conditioned by using various DX split air conditioning units which shall feature indoor units, an associated outdoor units and an outside air system of capacity as indicated on the Drawings.

This document shall be read in conjunction with Section 28 – Mechanical General, Section 37 – Painting and Corrosion Protection, Section 38 – Electrical General, Section 39 – Electrical Plant and Installation, Section 48 – Tests on Completion, the Bill of Quantities and Drawings listed in Table 42/1.

TABLE 42/1
LIST OF DRAWINGS RELEVANT TO THIS SECTION

DRAWING NO.	DESCRIPTION
2A-M1-002	General – HVAC Legend
2B-M3-001	Low-Lift Pumping Station – Pump Building - HVAC Layout
2B-M2.1-001	Low-Lift Pumping Station – Chilled Water Piping Schematic
2E-M3-001	High-Lift Pumping Station – Pump Building - HVAC Layout
2E-M2.1-001	High-Lift Pumping Station – Chilled Water Piping Schematic
2E-M3-006	Operational and Control Centre – HVAC Layout
2A-M3-001	Standard Drawing – Guard House – HVAC Layout

42.2 REFERENCES

When reference is made to a code, specification or standard, the reference shall be taken to mean the latest edition of the code, specification or standard; including addenda, supplements and modifications and revisions thereto at the time of Tender, unless otherwise specified. The requirements of this Section shall prevail and shall take precedence over any referred code, specification or standard. Where an ambiguity exists between this Section and any code, specification, standard or drawing, then this shall be referred in writing to the Engineer for clarification.

42.3 DEFINITIONS AND ABBREVIATIONS

42.3.1 Definitions

For the purpose of this document:

a) **"Supply"** shall mean the purchase of materials or goods, design, obtaining approvals, manufacture, fabrication and assembly, corrosion protection and all off-site inspection, testing of materials or parts and delivery to storage on Site.

b) **"Installation"** shall mean all handling and transport, all erection, assembly, pre-commissioning, energising, commissioning and setting to work.

42.3.2 Abbreviations and Material Symbols

For the purpose of this document, the following shall have the meaning given:

a.f.f.l. : Above finished floor level
Arr. : Filter arrestance in %
CIBSE : Chartered Institute of Building Services Engineers (UK)
dB(A) : Sound pressure level, "A" weighed in decibels
DB : Air Dry Bulb temperature

DFT	:	Dry Film Thickness
Eff.	:	Filter efficiency in %
HVAC	:	Heating, ventilation and air conditioning
kWe	:	Electrical power in kilowatts
kWr	:	Cooling or heating capacity in kilowatts
ℓ/s	:	Flow in litres per second
LV	:	Low Voltage
masl	:	metres above (mean) sea level
mm	:	Dimension in millimetres
m/s	:	Air speed in metres per second
MV	:	Medium Voltage
Pa	:	Pressure in Pascals
rpm	:	Rotational speed in revolutions per minute
WB	:	Air Wet Bulb temperature
°C	:	Temperature in degrees Celsius
m	:	Distance in metres
SABS	:	South African Bureau of Standards
SANS	:	South African National Standards
SWA	:	Steel Wire Armoured
VRF	:	Variable Refrigerant Flow
DX	:	Direct Expansion
HR	:	Heat recovery

42.4 OPERATING CONDITIONS AND CLIMATE

The Low- and High-Lift Pumping Stations will be built near Thabazimbi. The materials and Plant to be supplied and installed shall be selected appropriately and be fit for the purpose to operate under the conditions as per Clause 42.5.1.

The HVAC systems installed shall be suitable in all respects for operation under the atmospheric and installation conditions and electricity supply as outlined in this Specification. The Contractor shall ascertain any other local conditions or peculiarities which might affect the working of the Plant and design the system accordingly without any additional payment or change in standards of materials and Plant supplied or workmanship in this respect. This also applies to the nature and construction of the building, details of which are indicated on the Drawings.

42.5 DESIGN AND GENERAL REQUIREMENTS

42.5.1 General

The system component design, the materials used, and installation shall comply with the design requirements set out below.

42.5.2 Ambient Temperature and Altitude

Ambient Conditions:

• Summer	DB	:	45°C
	WB	:	22°C
• Winter	DB	:	0°C
	WB	:	-1°C

Ambient Condensing Temperature : 50°C

Altitude:

- Low-Lift Pumping Station : 909 masl
- High-Lift Pumping Station : 916 masl

42.5.3 Required Room Temperatures and Humidity

Staff Facilities Indoor Conditions:

• Summer Inside	DB	:	22°C ± 2°C
• Winter Inside	DB	:	20°C ± 2°C
• Relative Humidity		:	No Control

Server Rooms, Indoor Conditions:

• Summer Inside	DB	:	18°C ± 2°C
• Winter Inside	DB	:	18°C ± 2°C
• Relative Humidity		:	No Control

High and Low Lift Pump Station, VSD Room Indoor Conditions:

• Summer Inside	DB	:	28°C ± 2°C
• Winter Inside	DB	:	28°C ± 2°C
• Relative Humidity		:	No Control

42.5.4 Noise and Vibration Control

The Contractor shall be responsible for limiting noise and vibration transmission from the Plant to the building structure and adjacent rooms within the limits specified in SANS 10103: “The measurement and rating of environmental noise with respect to annoyance and speech communication”:

- Noise levels inside the Pumping Stations shall not exceed 75 dB;
- Noise levels inside the HVAC plant room shall not exceed 75 dB;
- Noise levels inside the Variable Speed Drive, Medium Voltage and Low Voltage and Motor Control Centre (MCC) Rooms shall not exceed 50 dB;
- Noise levels in the Control Room shall not exceed 40 dB; and
- Noise levels in the Guard Houses shall not exceed 40 dB.

The Contractor shall submit noise estimating sheets for all HVAC components as well as the insertion loss ratings of sound attenuators to the Engineer for approval. Failure to do so will result in replacement of Plant at the Contractor's cost should the noise levels in any area exceed the limits specified above. The installed noise levels on the HVAC components will be measured with the pumps not in operation.

Noise generating HVAC Plant such as fans, compressors, pumps, motors etc. shall be selected to operate as close to the point of maximum efficiency as possible.

42.6 DRAWINGS

The Contractor shall submit relevant component design, workshop and installation drawings to the Engineer for approval, at least 12 weeks before commencement of installation of the HVAC system. The drawings shall be submitted as per the requirements set out below and in Clause 38.35, and shall confirm the information provided in the Tender and include dimensions, material details of Plant and descriptions of the proposed systems, including the Contractor's Installation Test Procedure and Method Statement.

The Contractor shall be responsible for the provision of "as-built" drawings of all hardware and Plant installed as part of this Contract.

42.7 MATERIALS AND PLANT

42.7.1 General

All materials shall be suitable for the purpose for which they are to be used. All materials and properties claimed for these materials shall, unless specified otherwise in this Section, comply with the requirements of the latest edition of the appropriate South African or other internationally recognised standard specification at the time of Tender.

For each type of Plant, the Contractor shall indicate the materials used for each of the proposed sub-assemblies.

The Plant shall be manufactured using new prime quality materials taking into account the latest technical innovations. Recycled and/or reconstituted materials will only be considered if they are fully justified and approved by the Engineer prior to manufacture and/or supply.

The Contractor shall provide full references of suppliers and materials and Plant supplied as well as all original copies of all the Certificates of Conformity regarding raw materials used to manufacture the Plant.

42.7.2 Axial Flow Fans

Vane axial fans shall be axial fans with individually adjustable multiple aerofoil blades. Fans shall be selected for the lowest practicable blade tip speed and noise level but shall never exceed 1450 rpm.

Casings shall be fabricated from mild steel with a minimum thickness of 3 mm. Predrilled flanges shall be welded to both the inlets and outlets. When the Vane axial fan-inlet and outlet are both connected to ducting, the long casing type shall be used, such that the casing completely shrouds the impeller and motor. Where bifurcated casings are specified, the bifurcation shall be streamlined, and a shaft seal shall be provided.

Impellers shall be statically and dynamically balanced, in accordance with ISO 21940-11:2016 within G6, 3. Impeller blades shall be either cast aluminium, steel, stainless steel or moulded reinforced plastic, to suit the application and conditions specified in the Detailed Specification.

Fans fitted with bearings requiring regular lubrication, shall be fitted with extended lubrication lines to the outside of the casings.

Vane axial fans shall be directly coupled, and impellers shall be overhung on the motor shafts. Motors shall be totally enclosed squirrel cage induction motors and shall comply to SANS 1804, with a protection rating of IP 55. Motors shall be selected to be continuously rated at a maximum operating temperature of 55 ºC for Class "F" insulation in accordance with IEC 85.

Only fans with long casings shall be used for outside applications. An external weatherproof terminal box shall be mounted to the casing with a sealing gasket fitted between the terminal box and lid.

All fans shall be selected to handle at least the quantity of air specified against the relevant system static pressure. Motors and starters / VSD's shall be suitable for local and remote starting and for remote status indication as specified. Axial flow fans shall be mounted on anti-vibration mountings and shall be connected with flexible connections to ducts, silencers, etc.

42.7.3 Window Mounted Fans

Window Mounted fans shall be capable of handling the amount of air specified. The fan unit shall have a single-speed and shall be controlled as specified on the drawings. The unit shall be equipped with a discharge louvre and an automatic shutter which shall close automatically if the fan is not running. A 220 V single phase power supply and isolator / plug shall be supplied adjacent to each fan.

42.7.4 Wall Mounted / Plate Axial Fans

Fans shall be selected for the lowest practicable blade tip speed and noise level but shall never exceed 1450 rpm.

The mounting plate of the fan shall be hot dipped galvanised and the mounting points shall be pre-drilled. The intake of the fan shall have a stainless steel protection grille, to prevent accidental access to the fan, and the exhaust shall have an automatic discharge louvre shutter.

Impellers shall be statically and dynamically balanced, in accordance with ISO 21940-11:2016 within G6, 3. Impeller blades shall be either cast aluminium, steel or stainless, and corrosion protected by means of a galvanised or epoxy powder coated finish, to suit the application and conditions as specified.

All bearings shall be of the sealed type. Motor bearings shall be silent running ball or roller bearings except for small fans for which bearings may be porous bronze. Sealed ball bearings with life lubrication may also be used.

All fan motors shall be directly coupled, and impellers shall be overhung on the motor shafts. Motors shall be totally enclosed squirrel cage induction motors and shall comply to SANS 1804, with a protection rating of IP 55. Motors shall be selected to be continuously rated at a maximum operating temperature of 55 ºC for Class "F" insulation in accordance with IEC 85. The fan (motor) shall be rated flame-proof and suitable for use in an explosive environment for the battery room.

Fans shall be supplied with neoprene vibration isolating fixings.

The motor supporting arms shall have resilient supports where connections to the ring or diaphragm plate are made.

All fans shall be selected to handle at least the quantity of air specified against the relevant system static pressure.

Louvre shutters, impellor side guards and cowls shall be included.

42.7.5 Weather Louvres

The weather louvres shall be manufactured of extruded Type 50S grade aluminium and have a natural anodised finish if not specified otherwise on the drawings. All blades shall be 50mm and of the fixed horizontal type. Blades shall be spaced 50 mm apart. Ingress by birds, leaves, etc. shall be prevented by a galvanised, small-aperture wire-mesh screen fitted to the back (inside) of the louvre. All fixtures shall be concealed and the louvres shall be installed into a 25 mm thick industrial plywood frame.

42.7.6 Air Filters, Frames and Clips

The supply air filter plenums shall accommodate 50 mm thick washable pleated filters housed in galvanised steel frames. The plenums shall be constructed from 1.2 mm thick galvanised steel plate and feature access panels to the filters. The filters shall be of a standard proprietary type with pleated media bonded into galvanised steel channel surrounds. The filters shall have a minimum efficiency of 20% (EN779) and arrestance of 90% (EN779). The filters shall be supported in galvanised steel holding frames fitted with sealing strips or gaskets and four galvanised clips per frame to prevent air bypass of the filter media. A suitable, easily read manometer shall be permanently mounted against the filter plenum and shall be installed to show the differential pressure drop across the filters. The manometer shall be graduated in Pa and shall indicate when a filter change or wash is required. The manometer must have PVC tubes connected to the measuring points. The tubes are to be installed in Ega-tubing securely fixed along their route. Stickers shall be fitted onto the manometer to indicate the maximum pressure drop across each filter bank. An extra spare set of filters shall be supplied on completion.

The face velocity of the filters shall not exceed 2.5 m/s.

42.7.7 Sound Attenuators (Silencers)

Sound attenuators shall be supplied and installed in the positions shown on the Drawings. The sound attenuators shall be procured and supplied from an approved and reputable specialist manufacturer, shall be in accordance with the specifications and shall be selected and installed so that sufficient sound attenuation is obtained to limit the noise level created by the ventilation Plant to below the specified standard. The units shall generally be manufactured from galvanised mild steel with mineral wool faced with non-woven glass fibre media retained behind a galvanized wire mesh. Insertion loss measured in accordance with ISO 7235. The acoustic media shall have a Class 1 fire rating to EN 13501. The unit shall be compatible with the fan diameter and at least twice the length of the fan diameter unless calculated otherwise by the manufacturer.

The Contractor shall recalculate the pressure rating requirements of fans at the specified air flow rate to take into account the pressure drop across sound attenuation Plant proposed. Sound attenuators in the ductwork before and after the fans shall be designed for an insertion loss large

enough to limit the total sound pressure level of the noise at a distance of 1.5 meters directly in front on the first air outlet in the duct system to the noise level specified. The discharge noise from the attenuators shall not exceed 65 dB(A).

42.7.8 Industrial Drum Louvres

The louvres shall be the “Trox Type AIL” type or equal approved and shall consist of drum louvre sections of extruded aluminium mounted in an extruded aluminium border for mounting onto a 150 mm deep plenum and have a powder coated finish. All fixtures shall be hidden. The drum louvre shall be adjustable, in the vertical plain, to max 30° upwards and 30° downwards airflow direction and held in place by means of friction held fixings. The drum louvre guide vanes shall also be horizontally adjustable to enable the airstream to be fully directional. All drum louvres shall be supplied with opposed blade volume control dampers to the rear and shall be easily adjustable from the face of the drum louvre. The air throw achieved shall be at least 12 m with a maximum core velocity of 0.5 m/s at 10 m. The drum louvres shall be balanced to achieve the required air flow as stipulated on the drawings.

42.7.9 Pressure Relief Dampers

Pressure relief dampers shall be the “Trox Type AUL” type or equal approved and shall have a frame manufactured from extruded aluminium. The blades shall be manufactured from formed aluminium sheet with blade stub shafts from brass. The bearing section shall be in PVC with sealing strips on blades in polyester foam. The flange shall be drilled and countersunk. The ingress by birds, leaves, etc., shall be prevented by a galvanised small-aperture wire-mesh screen fitted to the back (inside) of the louvre. The dampers shall be neatly drilled on site and fixed and installed into a 25 mm thick industrial plywood frame.

42.7.10 Door Louvres

Door louvres shall be the “Trox Type AGS-T” type or equal approved and shall be standard type manufactured of extruded Type 50S grade aluminium with fixed inverted V blades and have a natural anodised finish. The blades shall be spaced tightly so as to ensure that the louvre is non-vision.

42.7.11 Supply Air Louvres

Supply air louvres shall be the “Trox Type AT” type or equal approved and shall be manufactured of extruded Type 50S grade aluminium, finished in natural anodised and mounted on a duct collar or wooden frame. Supply air grilles shall be provided with double deflection aerofoil vanes adjustable from the front of the grille, with the front vanes vertical. Supply air grilles shall be provided with opposed blade volume control dampers adjustable from the front of the grille.

42.7.12 Split Type Air Conditioning Units

Split type air conditioning units shall be reverse cycle heat pump, direct expansion air conditioning units each complete with an indoor and outdoor air cooled condenser.

The indoor and outdoor unit shall be mounted according to the manufacturer’s recommendations in the positions as shown on the Drawings. Hanging units shall have threaded rod of appropriate size fitted, which shall either hang from the structure above or from cantilever-type brackets, fixed to the wall or shall be mounted on a 75 mm concrete base 200 mm larger than the footprint of the condensing unit.

Only R410a shall be used and the units shall have the latest energy efficiency technology such as inverter compressors and the units shall have a COP greater than 3.0.

The unit shall be tested by the SABS in terms of ISO 5151:2017 and certified test reports shall be supplied by the manufacturer of the following ratings:

- Total cooling capacity;
- Total sensible cooling capacity;
- Total heating capacity;
- Airflow rates; and
- Electrical input.

The units shall be acoustically tested by the SABS in terms of SANS 10196:1984 and ISO 13253:23017 and certified test reports shall be supplied by the manufacturer.

Temperature controls shall include a fan switch and a temperature adjustment facility and temperature scale as a minimum. Each unit shall be equipped with a time delay safety circuit which shall delay the restart of the compressor for approximately 3 minutes even if the air conditioner is manually restarted. The remote control shall be wireless and shall be supplied with a mounting bracket.

All split type units installed in server or UPS rooms shall be fitted with a stainless-steel drain pan underneath the unit. The stainless-steel drain pan shall be suitably sized to overlap the entire internal drain pan of the indoor unit by 30 mm. This stainless-steel drain pan shall be sloped to corner to a drain point that must be drained to the nearest external wall. This drain pan must capture all condensate leakages on the indoor unit.

42.7.13 Multi-split-type Air Conditioning System

The multi-split type (VRF) air conditioning system shall be heat recovery, inverter, direct expansion, multi-split type air conditioning system complete with multiple indoor units and modular outdoor air cooled units and be of the heat pump reverse cycle type. The system shall use a refrigerant control box / distribution box as specified by the manufacturer to connect the multiple indoor units to the modular outdoor unit/s. The number of units to be supplied and the installation positions are indicated on the Drawings.

All units shall be manufactured in accordance with SANS-1125; 2004 .a.a: Room Air Conditioners and heat pumps. The manufacturer shall supply a certificate of the SABS to certify that the unit is electrically safe. All units shall be manufactured and tested in accordance with ISO 15042:2017 – Multiple split-system air conditioners and air to air heat pumps and certified test reports shall be supplied by the manufacturer of the following ratings:

- Total cooling capacity;
- Total sensible cooling capacity;
- Total heating capacity;
- Airflow rates; and
- Electrical input.

The unit shall be acoustically tested by the SABS in terms of SANS 10196:1984 and ISO 13253:23017 and certified test reports shall be supplied by the manufacturer.

Only R410a shall be used as refrigerant gas and the proposed VRF system shall have the latest energy efficiency technology such as dual inverter compressors.

The outdoor units shall be factory assembled units and shall be of the same manufacturer and supplier as the indoor units. The outdoor units' capacity shall match that of the indoor units it serves 100% unless specified otherwise.

Outdoor units shall be of the inverter, heat recovery type. Inverter units shall have variable speed compressors to deliver a variable cooling / heating output from 5% - 100%. Each outdoor unit shall be equipped with more than one scroll compressor. The outdoor unit must be able to continue functioning in the case where one compressor is out of order. The compressors must be hermetic scroll type compressors. The aluminium fins on the heat exchanger must be coated by an anti-corrosion resin film. The refrigeration circuits shall include liquid and gas shut off valves and solenoid valves. Units shall be equipped with oil recovery systems. All outdoor units shall be mounted on anti-vibration pads. The outdoor units shall be complete with high pressure switches, overload relays and inverter overload protectors.

All power supplies to the outdoor units shall be fitted with a Schneider Multifunction phase control relay "RM35-TF30", or equal approved, that will monitor the incoming power supply for power quality issues and break the supply if required. The following parameters shall be monitored:

- Asymmetry;
- Phase Failure; and
- Phase sequence.

The refrigerant control box / distribution box must be from the same manufacturer and supplier as the rest of the VRV/F system. The indoor units will have refrigerant heat / cool control by means of refrigerant control box / distribution box units. The refrigerant control box / distribution box units serving two or more indoor units shall provide cooling to one / multiple AND heating to one / multiple rooms SIMULTANEOUSLY.

All indoor units must be from the manufacturer and supplier as the outdoor unit and refrigerant control box / distribution box unit/s. The indoor units shall have an electronic expansion valve to control refrigerant flow rate in response to load variations from the rooms. The indoor unit fans shall be of the dual suction multi blade type with minimum noise levels. All indoor unit installations shall be complete with a wall mounted wired remote controller located as indicated on the drawings. For rooms with more than one indoor unit one wall mounted controller shall be used to control temperature set points for all indoor units.

Temperature controls shall include a fan switch and a temperature adjustment facility and temperature scale as a minimum. Each unit shall be equipped with a time delay safety circuit which shall delay the restart of the compressor for approximately 3 minutes even if the air conditioner is manually restarted.

42.7.14 Factory Assembled Air Handling Units

Air-handling units consist of plenum casing, Primary air filters, coils, Drip tray, supply air fans, outside air damper, return air damper and exhaust air dampers and electrical equipment. Air-handling units shall be of the horizontal, floor mounted type.

The positions and sizes of air-handling units and their components are indicated on the Engineer's drawings.

Finished concrete bases, on which air-handling units shall be mounted, shall be provided by the Main Contractor. The base frame of the air handling units shall be manufactured from heavy duty structural steel and shall be hot dip galvanised. The base frame shall be supplied with lifting hooks.

Plenum casings shall have flat sides and flat top. Plenum casing construction and access door size shall be such as to facilitate easy removal of filters. The casings shall be constructed of Chromadek sandwich panels with a 50 mm polyurethane insulating material between the two Chromadek panels with an aluminium frame. Panels shall fasten to each other in an airtight and watertight manner by means of an efficient and suitable locking arrangement and the use of a suitable sealing compound.

Construction of panels and the locking method shall be designed so that flexure of the composite side panels of the casing will not be more than 1/200 of the span under a stress equivalent to static air pressure of 450 Pa. If necessary, structural reinforcement shall be provided to ensure the required rigidity. Junctions between the floor and side panels and the roof and side panels shall be rigid, strong, watertight and airtight.

Doors shall be manufactured from the same material as the plenum casing specified above and shall hinge on sturdy hinges. Doors shall be provided with two door handles which can be operated from inside or from outside the plenum. Doors shall open against the system air pressure and shall be airtight. It shall always be possible for one person to open a door against the operating pressure. Large doors shall be fitted with pressure relief panels if necessary.

All water connections shall be flanged.

Where equipment such as coils or filters is smaller than the cross-sectional area of the plenum, the spaces around the equipment shall be sealed off by means of sturdy blank-off plates. Coils shall be fixed to plenum casings in such a way that easy removal is possible. Coils shall be manufactured from copper fins with mechanically bonded aluminium fins with copper headers contained in a rigid aluminium frame or a hot dipped galvanised frame. The unit shall be designed to ensure that even air distribution across the face of the coils is achieved. Face velocities shall not exceed 2,75 m/s.

A stainless-steel drain pan shall be fitted to the unit and shall cover the cooling coil with no joints. The condensate pan shall be sized to prevent any moisture to carry over into the air stream and shall be insulated with seamless polyurethane insulation with a minimum thickness of 10 mm. Drip drays shall be provided with a galvanised steel drainpipe of 40 mm installed to the nearest drain point. The pipe shall discharge into a tundish, with an air space left between the end of the pipe and the tundish. The drain trap shall have a water seal with a sealing pressure of at least twice the static pressure as developed by the fan at the drain pan.

All fans shall be energy efficient direct drive plug fans that allows for a varied fan speed. The fans shall be statically balanced before installation and dynamically balanced and tested after being installed in the casing. All fans shall be installed with motor guards in order to provide safety from all moving parts. Each fan shall be installed with anti-vibration mounts.

All filters shall comply with EN-779. High performance washable pleated panel type filters, with a minimum of 50 mm thickness, shall be installed in each unit and housed in adequate holding frames. The holding frames shall be fitted with gaskets to ensure an airtight seal around the filters. A pressure differential switch shall be fitted across the filters with indication light on the control panel. A magnehelic gauge shall also be fitted over the filter bank for manually reading the pressure differential. Filters shall have a maximum face velocity of 2,5 m/s.

The mixing plenum of unit shall be fitted with an adjustable low leak outside air damper with an aluminium weather louvre. The damper shall be fitted with a fine stainless steel or aluminium screen to prevent debris entering the unit and clogging up the primary filters.

Sound power levels (S.W.L.) in DB (RE 10-12 WATTS) for the unit at the specified air quantity and static pressure shall be available in octave bands for:

- In duct noise calculations;
- Casing radiation noise calculations; and
- Free discharge noise calculations.

All electrical equipment shall comply with SANS. A distribution board shall be fitted to each unit and shall contain all the necessary circuit breakers, contactors, relays and protection devices necessary for the control of cooling, heating and fan speeds as specified. The board shall be fitted with an adequately sized main isolator with an associated safety fuse with a minimum capacity to suit the system fault level. All wiring inside the distribution board and inside the unit shall comply to all relevant local regulations and shall be installed neatly in vertical / horizontal PVC trunking. All exposed current carrying parts shall be fully insulated with PVC tape.

All wiring inside the distribution board and unit shall be fitted with numbered ferrules and both ends of the same wire shall have the same number. The unit shall be fitted with a fire relay that will turn the entire unit off when a fire signal is received. A phase failure relay shall be fitted to each unit and shall monitor high voltage low voltage, phase failure and floating neutral. A laminated wiring and control logic diagram shall be provided for each unit. Dirty filter indication lights shall be fitted to the switch board to indicate if the filters require cleaning. Provision shall be made for remote control of the unit and must be able to interface with BACnet or similar BMS interface logic. The controls on the unit itself must have full diagnostic capabilities for each main component of the unit itself. Each plenum casing shall be fitted with vapour proof LED lights with a light switch on the inside near the door opening to the associated plenum.

Two spare plug fan assemblies shall be kept on site as critical parts for the high lift pump station and low lift pump station.

42.7.15 Chilled Water Generators (Air Cooled)

Chillers shall be of the standard factory assembled packaged type and the design, materials and finish shall be of a reputable make approved by the Engineer. If an imported product, the tenderer shall be able to prove that such products are well represented in the Republic of South Africa with a qualified technician in the area of installation.

The chiller shall use the latest energy efficiency technology and shall comply and be certified by Eurovent and AHRI. Must have a minimum net EER rating of 3.00 and ESEER rating of 4.00 tested in accordance with EN 14511-2013.

Only R134a or R410a refrigerants will be accepted.

Condenser coils shall be manufactured from copper tubes with mechanically bonded aluminium fins or micro channel construction. The coils shall also be factory fitted with corrosion protection.

Chillers shall be complete with refrigerant piping, one or more screw / scroll compressors, one or more evaporators, one or more air cooled condenser, control panels with separate refrigerant and power control sections, frame, compressor drive and full refrigerant charge. A crank case oil heater is required where oil comes in contact with refrigerant. These heaters will remain energised when the compressor stops.

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

The refrigeration circuit shall comprise of refrigeration pipe work, expansion valve, liquid line solenoid valve re-changeable filter drier, sight glass (above the operating level of the liquid condenser), liquid line shut off valve and a hot gas muffler.

The minimum capacity controls for each chiller shall be in 25% increments to 100%.

The fouling factors used when selecting chillers shall not be less than the following:

- Condenser tubes : 0,0176 m² °C/kW
- Chiller tubes : 0,009 m² °C/kW

Each evaporator shall be of the direct expansion shell and tube design. Seamless copper tubes roller expanded into the tube sheets shall be employed for refrigerants. The evaporators, refrigeration piping and associated water piping shall be insulated with a minimum of 20 mm polyurethane foam.

Water connections shall be flanged.

All compressors shall be screw type for the high lift pump station and scroll compressors for the low lift pump station and all compressors shall be fitted with lifting eye bolts or fixing points for eye bolts. Any equipment and other parts with a mass greater than 25 kg shall be fitted with a lifting hook or fixing points for eyebolts.

All critical components such as the compressors and evaporators shall be easily accessible for maintenance and removal without major dismantlement of other equipment and piping.

Condenser fans shall be variable speed directly driven and be selected for a low noise level. Fans shall have aerofoil-shaped-blades and be fitted with aerodynamically designed casings. Fan motors shall be totally enclosed fan cooled and suitable for a three phase, 4 wire electrical supply. Fan guards shall be fitted.

All control and starter panels shall be weatherproofed (IP54). All panels shall be factory wired and machined mounted in the factory and shall contain soft motor starters, control switches safety cut-outs and micro-processor capacity controls. Each control panel shall have power and refrigeration controls in separate compartments. The power cubicles shall have independent access doors.

The following protection devices shall be included and shall be fully automatic and shall shut down the chiller in the event of: Low chilled water temperature, low evaporator temperature, low chilled water flow, high refrigerant discharge pressure (Manual reset), low refrigerant suction pressure, high motor winding temperature, high oil temperature, low oil temperature, low oil pressure (manual reset), voltage fluctuations, phase reversal and phase failure. A touch screen LCD user interface shall indicate the operation of any of these above-mentioned devices and for quick diagnostics.

The following instrumentation and control devices shall be provided: suction pressure gauge for each compressor, discharge pressure gauge for each compressor, oil pressure gauge for each compressor, crankcase heater control, overcurrent relay, pump-down relay, anti-recycle compressor protection relays and an anti-cycling timer to limit the number of starts to three per hour.

The refrigeration control panels shall contain refrigerant and oil pressure gauges, low and high temperature and pressure controls, control relays and indicating lights for all temperature and pressure safety controls and overload relays where specified, over-current-limit relays, must be provided to reduce compressors capacities to within the motor current selection.

The air cooled chillers for the low lift pump station shall have a factory assembled / built in dual VSD pump hydronic module with associated expansion tank from the same supplier as the chiller.

All chillers shall have a single power connection for ease of installation and maintenance and all compressors shall be fitted with enclosures.

Provision shall be made for remote management of the chillers and must be able to interface with BACnet or similar BMS interface logic. The controls on the unit itself must have full diagnostic capabilities for each main component of the unit itself.

A terminal strip for starting signals and relays for all indicating lights shall be provided on each chiller.

Chillers shall be wired for automatic restart through an anti-recycle timer after power failure is rectified.

42.7.16 Chilled Water Treatment and Filtration

The chemical treatment system for all chilled water systems shall perform the following functions:

- Inhibit corrosion, inhibit formation of scale, protect system against algae growth, and 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. Concentration of chemicals in pipe systems shall be in accordance with suppliers' recommendations.

Closed 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.

Each chilled water system shall have a separate dosing pot to introduce chemicals into the suction side of the pump. The dosing pot shall be easily accessible and shall be adequately sized and rated for the working pressure of the system. Pipework with isolating valves shall connect the dosing pot to the system in such a manner as to ensure circulation through it. The pot must also be fitted with a feed funnel, feed isolating valve, air vent cock, flow and return isolating valves and drain valves.

42.7.17 Water Pumps

The Contractor shall be responsible for the sizing of the pumps to handle the required water flow against the calculated total head pressure and shall have an operating efficiency greater than 75%.

The pumps duties specified is only provisional and the system resistance shall be recalculated by the Contractor when the air conditioning equipment is selected and ordered by the Contractor.

Pumps shall be of the non-overloading, volute, centrifugal type. Volute casing shall be cast iron (or cast steel) selected to withstand 1,5 times operating pressures (dynamic plus static pressure). Casing shall have axial suction and radial discharge nozzles and shall be fitted with renewable case wear rings of spun cast iron. 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 impeller is to be cast bronze radial type, overhung and is to be dynamically balanced.

Shafts shall be chrome or stainless steel of sufficient diameter to withstand all stresses imposed and with a critical speed well above the maximum running speed. Pumps are to be fitted with mechanical seals unless otherwise specified.

Water pumps shall be supplied as complete sets by their suppliers, incorporating pumps, bronze impellers, motors, drives, bedplates, stainless steel drip trays, etc., factory assembled and dispatched to the project complete in all respects.

The net positive suction head (NPSH) required by the pump shall at design conditions shall not be more than 0.5 times the positive head available at the pump suction with system operating at anticipated maximum delivery and temperature.

Pumps shall be directly coupled to an electric motor which shall be of sufficient capacity to operate over the entire range of the pump (as determined by installed impeller size) without exceeding the name plate power rating.

Coupling between motor and pump shall be by means of a flexible coupling "Fennerflex" or equal and approved. The coupling shall be provided with a removable galvanized sheet steel coupling 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 pumps 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 and verify the system resistance (including pressure drops through all components) in order to establish the pump heads. The pumping heads as indicated in the schedule of capacities are a guide for tendering purposes only.

All bedplates shall be of fabricated mild steel with surfaces on which the pump, motor, gearbox, fan etc. is mounted. All bedplates shall be stress relieved after welding but before machining. Each bedplate shall be provided with approximately eight horizontal jacking screws with locknuts for each unit mounted thereon to assist in aligning the pumps and motors, etc. All bedplates shall be thoroughly cleaned, prepared and painted with one coat of Anodite red oxide primer to finishing coats being applied. It will not be necessary to dowel equipment in place, provided the jacking screws specified above are fixed and locked. Where equipment is delivered completely assembled on a bedplate, these items of equipment shall be removed from the bedplate prior to installation. The bedplates shall first be installed, levelled, lined up and packed to ensure that there is no twist or distortion therein. The machines shall then be installed on their bedplates and the final alignment carefully checked and adjusted until it is to the entire satisfaction of the Client. Minor corrections to the alignment of machines may be carried out using thin shims between the machinery feet and the machined surface of the bedplate. This applies particularly to electric motors. A maximum level error of 20 seconds of arc, or as decided by the Client, will be allowed.

The pump supplier is to sign-off the installation and confirm pump installation and alignment. A suitable sized galvanised drainpipe shall be installed to the nearest drain point from the pump assembly.

One spare pump set shall be kept on site as critical parts for the high lift pump station and low lift pump station.

42.7.18 Chilled Water Pipework, Fittings and Insulation

(a) Piping and Pipe Fittings

All piping shall be ungalvanized steel piping. Piping from sizes DN50 to DN150 shall be SANS 62 Medium piping, sizes DN200 to DN600 shall be SANS 719 Gr B 6 mm wall piping and sizes DN650 to DN800 shall be SANS 719 Gr B 8 mm wall piping. All ends shall be bevelled.

All components used shall be chosen from fully catalogued products and shall be of a high standard of manufacturer and well-known brand. Documentation submitted by the Contractor shall include selection tables and/or pressure drop data for the expected range of operation conditions. Full documentation of all components and calculations shall be submitted for approval at the same time showing all detailed pressure loss and velocity calculations under full and minimum load conditions. Where pipe sizes are not indicated on the drawings, pipes shall be sized for a maximum water velocity of 3.0 m/s and a maximum pressure drop of 10 m per 100 m of piping.

Valves of one manufacturer shall be used as far as possible. Screwed valves to be used up to and including 50 mm and flanged valves from 65 mm and over. Screwed valves shall have screwed ends to SANS 1109. Flanged valves shall have Class 150 SABS 62/719 flanges.

The Contractor shall make adequate provision for union or flanged connections to facilitate the dismantling of piping. All welding shall be done by a coded welder as certified by an approved authority in terms of SANS 10044. Flange joints shall include Klingerite gaskets or equivalent. The bolt lengths shall be compatible with flange, washer and insertion ring thicknesses to ensure that after the flanges have been connected and the bolts tightened, no bolt protrudes more than two to three threads from a nut and no bolt is short of the end of a nut. No cutting of bolts is allowed. All bolts and nuts shall be Hexagon ISO metric and shall be electroplate-galvanised.

Long radius bends shall be used wherever possible, elbows only being permissible where limited space dictates their use. Reductions in pipe sizes shall be affected with reducing sockets, bushing reducers not being permissible.

Due allowance shall be made for the thermal expansion and contraction of the pipes as the result of changes in temperature. Allowance for expansion shall be at least 13 mm per 30 metre of pipe length in the case of chilled water pipes. Suitable expansion joints shall be provided in the water piping to accommodate the expansion and contraction of the pipes without imposing stress on the piping or equipment. All expansion joint shall be suited to the applicable working pressures. If necessary flexible connectors shall be installed to bridge expansion joints in the structure.

Low points in piping shall be provided with drain valves with hose unions. These valves so located that the entire piping system can be completely drained. High points in piping shall be provided with automatic air vent valves with integral check valves. Each air vent shall be preceded by a stop valve and the outlet shall be piped to the nearest drain ensuring visible discharge.

Eccentric reduction sockets shall be used where necessary on horizontal pipes if required and concentric reduction sockets on vertical pipes.

A sufficient number of isolating valves shall be installed to enable repairs to be carried out to any one section of the system without necessitating the shut-down and draining of other sections. It shall be possible to isolate and remove any component requiring regular inspection, cleaning or removal, without draining the entire system. At least one detachable joint is required in each 10 m section of piping. No joints shall be concealed within walls and floors.

Hand wheel operated valves shall be closed clockwise, and the hand wheel shall be of suitable diameter to allow tight closure by hand. Use of valve spanners will not be permitted. Indicators showing "Open" "Closed" shall be provided.

Strainers shall be of the angle or Y-type and mounted between isolating valves. The screens shall be removable for cleaning purposes. Bolted end covers shall incorporate drain plugs. Strainers shall be of at least the same size as the piping in which they are installed. Screens shall be bronze or stainless steel with the following perforations of which the effective free area is at least 3 times the cross sectional area of the pipe:

Strainers size	Perforation size
20 - 50 mm	1.0 mm
65 - 150 mm	1.5 mm
200 - 300 mm	2.0 mm
above - 300 mm	3.0 mm

Copper Alloy Gate valves shall be in accordance with SANS 776, cast iron gate valves to SANS 644 and cast steel valves to SANS 191. Gate valves shall have rising stems and wedge gates with back seats to allow repacking under pressure.

Globe valves shall confirm to EN13789. The discs shall be free to rotate and readily removable from the valve stem and renewable. Valves shall permit control of flow rate from full flow to complete shut-down. Valves shall be suitable for repacking of stem gland under pressure.

Check Valves shall be bronze screwed, swing check type, bronze seats, or cast iron body flanged solid, cast iron flap with bronze trim and bolted cover to SANS 1551.

At all equipment connections to vibrating equipment flexible connections need to fitted. All flexible connectors shall have flanged joints and be capable of a 16 bar or 1.5 times the system working pressure whichever is the higher value. Copper earthing straps shall be fitted over all flexible connections and shall be carried out in accordance with the standard wiring regulations.

(b) Insulation

All piping shall be clean, dry and free of grease, loose rust and scale before any insulation is applied. The insulating material shall fit tightly around the pipework.

The following insulating material shall be accepted:

- Pre-formed glass wool sectional lagging with a minimum density of 80kg/m³.
- Pre-formed poly-isocyanurate (PIC) rigid closed cell foam insulation with a minimum density of 32kg/m³.
- Pre-formed closed cell elastomeric insulation with a minimum density of 48kg/m³.

All insulating material shall have a minimum fire rating Class 1 as per SANS 10177.

The required insulating material thickness for the associated pipe sizes are as follow:

Pipe Size (mm)	Thickness of Insulation (mm)
15 to 40	25
50 to 80	40
150 to 200	40
300 and larger	40

Bends, pipe fittings and components shall be cleaned, firmly wrapped with 25 mm mesh galvanised wire netting and then plastered with a TPH Plaster scrim cloth and 2 coats 0.6 mm mastic 2415 (blue).

The insulation shall be installed with a continuous vapour tight seal. The vapour seal shall be continuous at pipe supports. All vapour joints to have an overlap of 50 mm.

Where insulation is exposed to the weather or where protection against mechanical damage such as in plant rooms is required, it shall be covered with 0,6 mm galvanised, aluminium or stainless steel sheet metal. Where cladding is exposed the weather or is used in a wash-down area, all joints and sealed pop rivets shall be carefully sealed with silicone sealer. Sheet metal sleeved sections shall overlap not less than 25 mm and 10 mm at longitudinal and transverse joints respectively. The transverse lap shall be such that the higher section always overlaps the lower section.

Where pipe supports are located, hardwood or rubber blocks are to be incorporated which are to be suitably vapour sealed in conjunction with the associated insulation.

(c) Buffer Tanks

The buffer tank shall be a standard product from a recognized supplier. Each closed water system shall be connected to a buffer tank. The buffer tank shall consist of a steel shell rated for 1.5 times the working pressure in the chilled water system, but not less than 690 kPa. The tank shall be installed in accordance with the manufacturer's instructions. Pipe weight shall not rest on the tank. The buffer tank shall be insulated, vapour proofed and metal clad.

42.7.19 Control Panels

All switchgear and distribution boards shall generally be manufactured in accordance with Clause 39.11.1 and shall be of the metal clad surface type, with a framework, which is electrically continuous and which shall be properly bonded to earth.

The boards shall be equipped with hinged steel doors adequately braced each with a flush lock and two keys. All boards shall have an Epoxy Powder Coat finish. Switches, push-buttons, and indication lamps and gauges shall be so installed that they remain fastened to the doors when the doors are opened.

All boards, which are to be mounted outdoors, shall be weatherproof and guaranteed by the manufacturers for such outdoor operation. The boards shall be labelled in accordance with Clause 39.5.2.27 – Labelling.

All wiring in distribution boards shall be labelled to ease the later tracing of circuits in accordance with Clause 39.1.4.3. Local lock-out isolators shall be installed no more than 1 m from the fans when remote control panels / switches are used.

42.7.20 Ductwork

All ductwork shall be manufactured according to SANS 1238: 2005 Standard Specification for Air Conditioning Ductwork. Unless otherwise specified or noted, ductwork casings and plenum chambers shall be made of galvanised sheet metal.

Air conditioning ducting manufactured from galvanized sheet metal shall be insulated as follows, unless otherwise specified:

Low and medium pressure supply and return air ducts in roof voids under sheet metal roofing	25 mm internal Insulation
Low and medium pressure supply and return air ducts in ceiling voids under concrete slabs	25 mm external insulation
High pressure ducting	25 mm external insulation
Ducting exposed to weather (external)	25 mm internal insulation and ducting must be painted to spec.
Ducting supplying high risk areas such as hospital theatres and isolation rooms (Internal and External Ducting).	25 mm External insulation (Internal) 25 mm External Insulation protected by sheet metal cladding on all four sides (External)

The maximum air velocity for internal insulation is 15 m/s. Internal insulation shall be FIBRE GLASS SONIC LINER (glass fibre insulation faced with a woven glass fibre layer) glued to the exposed surface. The minimum requirements for the insulating material are:

- Thermal conductivity = 0,037 W/m deg K at 0 deg C
- Density = 24 kg/m³

Spigots to diffusers and grilles need not be insulated unless such spigots are longer than 1000 mm in which case they will be considered to be ducts. External insulation shall be DUCT WRAP with a foil laminated covering reinforced with bi-directional mineral fibre yarn with the same or better conductivity as specified above. The insulating material and liner at heaters shall be protected, for a distance of 500 mm upstream and 1000 mm downstream of the heater. If ducts are internally insulated, the membrane shall be folded over the opening edges and shall be sandwiched between the spigot and the duct when fixing the spigot to the duct.

Spigots to grilles shall have 100 mm, 45° shoes unless the Engineer approves straight spigots. Where spigots have to be cut through stiffeners, or where cross breaking of ducts causes excessive malalignment of spigots, a stiffener shall butt into one side of the spigot in the case of spigots with a width (dimension in direction of air flow) of less than 400 mm and onto both sides of the spigot if the width exceeds 400 mm.

The spacing in bends of which the throat radius exceeds 100 mm, shall be selected using Figure B.1 – Turning vane spacing selection chart in Annex B, in the SANS 1238.

Access panels shall be 500 x 500, similar to TROX Type BS. Access panels installed in internally insulated ducting shall be of double wall construction. Each panel shall be hinged or fitted with a latch on all sides.

All ducting joints on the outside of the buildings shall be sealed with a reinforcing waterproofing mesh membrane, coated with an acrylic paint and painted with a UV resistant silver metallic paint ("Lap and Pap").

All duct sections shall be identified by duct sequence erection numbers which shall also appear on the duct layout drawings. The flow direction shall be marked on each duct section.

Ducts which are not painted shall be thoroughly cleaned and all markings removed once approved.

The flexible duct connectors shall be Clim or Europair and shall be for heavy duty, low pressure systems and extra heavy duty for high pressure systems. Flexible joints exposed to the weather, shall be protected by means of galvanised sheet metal covers. The butt joints of the flexible material shall be glued and stitched. All flexible joints shall be fitted with a copper earthing strap.

Duct connections to mixing boxes, fan air terminals and diffusers shall be of spiral aluminium flexible ducting. Flexible ducts longer than 1000 mm shall be insulated. Flexible ducts shall not have more than two 90°, long radius bends and shall these not flatten or distort. Flexible ducts shall not be longer than 1,5 m. The flexible ducting shall be fire rated in accordance with SANS 10177-3 and shall comply with municipal fire.

42.8 PAINTING AND CORROSION PROTECTION

Where not indicated otherwise in this Section, corrosion protection of cabinets, enclosures, materials and Plant shall be as specified in the Section 37 – Painting and Corrosion Protection, Schedules and Drawings.

Any damaged galvanised coatings or corrosion protection coatings shall be repaired in accordance with Section 37 – Painting and Corrosion Protection. All steelwork, piping, lagging, etc. supplied under this Contract shall be painted as follows except if galvanised.

All exposed metal parts, materials and Plant items such as pumps, belt guards, all piping, pipe lagging, fittings, dampers, fans, coils, motors, pumps, packaged units, control panels, steelwork, exposed ducts and lagging, expansion tanks, make-up tanks, cooling tower, unit shelters, etc. shall be cleaned, primed, and finished in a high quality two pack epoxy plus top coat of re-coatable polyurethane, except if specified to be anodised, galvanised or epoxy power coated.

All Plant shall be generally painted as indicated in SANS 10140 - Identification Colour Marking.

42.9 INSTALLATION AND OPERATING REQUIREMENTS

42.9.1 General

All Plant shall be installed and erected flush, level and square as required. No Plant shall be damaged during the installation. Damaged Plant shall be replaced at the Contractor's expense. All installed Plant shall be securely fixed and fastened, taking into account the life span, the weight and the local conditions. The installations shall, at all times, comply as a minimum to the manufacturer's specification and guidelines.

42.9.1.1 Building Works

The Contractor shall install all wall and floor sleeves for louvres, ductwork, pipework, conduit as required for the installation of the HVAC systems.

42.9.2 Power Supply and Electrical Installation

42.9.2.1 General

The Main Contractor shall provide 50 Hz power points in close proximity to the positions shown on the Drawings or as required by the final installation position of the HVAC systems. The power supply shall terminate in a suitable wall isolator from where the control panel and switches as applicable and HVAC Plant shall be wired. The electrical installation shall include for all cabling, conduits, cable racks, trays, switchgear, panels, distribution boards, etc., necessary for the satisfactory operation of the HVAC system.

Plant intended for outdoor installation shall be rated IP65 and for indoor use IP55.

42.9.2.2 Wiring

Wiring of the Plant shall be carried out by the Contractor in surface work in the pump room, VSD Rooms, Low- and Medium- Voltage Rooms, UPS room, HVAC room and Battery room and concealed work in the Control Room, PLC and Server Rooms, Staff Facilities and Guard House.

All electrical material and installation work shall be as required in Section 38 – Electrical General and Section 39 – Electrical Plant and Installation.

The wiring system shall be as specified in Clause 39.1.7.

42.9.2.3 Conduit and Accessories

Conduit and accessories shall be in accordance with Clause 39.1.5.

42.9.2.4 Low Voltage PVC Cables

LV cables with PVC insulation shall conform to the requirements of SANS 1508-3: 2007 as amended.

42.9.2.5 Labelling

Numbering and labelling shall be as required in Clause 38.27 (Labelling and Numbering).

42.9.2.6 Cable Trays

The Contractor shall supply and install all cable trays or ladders as specified or as required by the cable routes including the necessary supports, clamps, hangers, fixing materials, bends, angles, junctions, reducers, T-pieces, etc.

The cable trays shall be as required in Clause 39.1.4.8 (i) Cable Racks and Trays.

42.9.2.7 Earthing

The whole installation shall be efficiently earthed to the satisfaction of the Engineer, the Inspector of Factories, the Supply Authority, and strictly in accordance with the Code of Practice for the Wiring of premises as required in Clause 39.1.12 (Earthing and Lightning Protection). Any points proposed as earthing points by the Contractor shall first be approved by the Engineer before connection.

42.9.3 Multi and Split Type Air Conditioning Units

Indoor and outdoor units shall be mounted in terms of the manufacturer's recommendations in the positions shown on the Drawings.

All units shall be designed and installed so as to provide ease of access for inspection, cleaning and maintenance of all components in the system of the unit. The units shall have a neat appearance, shall be vibration free and shall meet the specified noise ratings.

The Contractor shall be a qualified installer of the VRV/F system manufacturer and must supply the technicians training certificates for the specified manufacturer to the engineer prior to Installation. The VRF systems and all its components shall be installed as per the manufacturers' recommendations.

The mounting bracket to the remote control shall be securely fixed to a wall, in close proximity to the light switch.

The outdoor units for the split type system shall be installed at low level to enable safe maintenance on the units, at a height no less than 300 mm above finished floor level (a.f.f.l.), but no higher than 1 m above finished floor level, measured from the bottom of the unit. The units shall be installed on galvanised Unistrut-type cantilever brackets, complete with anti-vibration mountings and associated fittings as sold by Cabstrut or similar approved. The condenser shall have a free space of at least 200 mm between it and the supporting wall.

The outdoor units for the multi-split type system shall be mounted on concrete or galvanised steel plinths at least 300 mm above finished floor level (a.f.f.l.), with anti-vibration pads under the unit. If steel plinths are used, anti-vibration pads shall be installed between the plinth feet and the floor. There shall be at least 500 mm clear space around each outdoor unit for ease of access and maintenance unless more space is required by the unit's manufacturer's specifications.

Mounting brackets for "Under ceiling" and wall mounted units shall be approved by the Engineer. "Cassette" and "In-ceiling" units shall be supported from the roof structure and not by the ceiling grid. All indoor units shall be installed using a spirit level. Indoor units shall be fixed with at least four supports and the supports shall be full threaded rods with at least 10 mm diameter or as per unit manufacturer's specifications. Dual nuts shall be used to secure the indoor units on the supports. Cassette units shall only be installed as a second fix item (i.e. after the ceiling grids / plastered ceiling has been installed). The Contractor shall be held liable if the cassette units do not line up with the other co-ordinated services. All indoor units shall be covered with plastic during construction phase.

Communication wires may not be grey of colour. The communication cables shall be a different colour than the data cables installed in the building for ease of tracing and future maintenance.

42.9.4 Refrigerant Piping

The indoor and outdoor units must be interconnected with refrigerant piping in terms of the supplier's recommendations. The Contractor shall note that the distances between the indoor and outdoor units to ensure that the piping is correctly sized.

All piping through walls shall pass through sleeves which shall be properly sealed after installation. Piping installed through sleeves shall be continuous / without joints.

Refrigeration Grade hard drawn seamless, dehydrated, de-oxidised copper tubing shall be used, unless otherwise specified by the unit manufacturer. The sizing of refrigeration piping shall be in

strict accordance with the unit manufacturer's specification. All refrigerant piping must be filled with nitrous oxide gas during welding (0.02 MPa) and flushed with nitrous oxide gas (0.5 MPa), after all welding has been completed and before charging with refrigerant gas as per manufacturers specifications. Charging connections shall be provided at the compressor.

All mechanical fittings and joints in the refrigerant pipe must be accessible for leak testing without the damaging of any structure or system.

All refrigeration lines shall be insulated, separately with "ARMAFLEX" Class O, K value of 0.037 W/m.k at 20°C or a similar approved product. The wall thicknesses of the insulation shall be:

PIPE DIAMETER	**THICKNESS**
Ø 6.35 – 15.88 mm	≥13 mm
Ø 19.05 – 34.93 mm	≥ 19 mm
> Ø 34.93 mm	≥ 25 mm

All refrigeration piping and wiring external to the building or in visible positions shall be installed in galvanised steel wiring channels with removable cover plates or protected by means of 0.6 mm galvanised cladding. In concealed spaces and ceiling voids piping and wiring shall be fastened to a perforated / wire mesh galvanised cable tray or other acceptable means approved by the Engineer. The last section of ≥500 mm length of copper piping to the indoor unit may be unsuspended. Refrigerant piping in cable trays shall be fastened to the cable trays with velcro straps of at least 10 mm in width and may not compress the insulation at any point around the refrigerant piping. All pipe insulation exposed to the weather or in visible positions shall be installed in galvanised steel wiring channels with removable cover plates or protected by means of 0,6 mm galvanised cladding. All refnet joints, headers, branches, etc. shall be installed with the manufacturers supplied insulation boxes / covers. All refnet joints, headers, branches, etc. shall be installed as per the manufacturer's requirements and according to good installation practice. No bends (hard or slow bends) before and after the refnet joints, headers, branches, etc. are allowed closer than 500 mm.

When refnet joints, headers, branches, etc. is installed horizontally, the maximum allowable tilt is ±7,5°. The refrigerant piping shall be marked tape / spray / paint every 3 m with the following colours:

- Heat Recovery (3 Pipe):
  - Liquid Supply : Blue
  - Hot Gas Supply : Red
  - Return : Yellow
- Heat Pump (2 Pipe):
  - Supply : Blue
  - Return : Yellow

The refrigerant pipe lengths between the outdoor unit and the HR/BS unit shall be strictly according to the manufacturer's specification.

The refrigerant pipe lengths between the HR/BS unit and the indoor units shall be strictly according to the manufacturer's specification. The HR/BS units are to be located inside the ceiling voids of the passages. The HR/BS unit's height may not exceed 300 mm. HR/BS units are to be located as close as possible to the indoor units it is serving. No refrigerant piping bends (sharp or slow bends) are allowed closer than the 500 mm to a BS Box, distribution box, MCU box, etc. A straight piece

of refrigerant piping, ≥500 mm, before and after a BS Box, distribution box, MCU box, etc. shall be installed as per good installation practice.
The pressure tests and vacuum of the piping shall be witnessed by the manufacturer's technicians and by the Engineer. The pressure tests shall be done for a minimum of 24 hours at a pressure specified by the manufacturer. A photo report of each pressure tests performed shall be supplied to the engineer and shall also be included in the O&M Manual. A photo report of each systems vacuum performed shall be supplied to the engineer and shall also be included in the O&M Manual. The technician from the supplier shall witness all required tests and must supply a commissioning report to the Contractor for each system commissioned. These commissioning reports shall be included in the O&M Manuals.

The Contractor shall be registered as a Competent Practitioner in terms of the "Pressure Equipment Regulations" and "the communique for SAQCC GAS".

42.9.5 Air Handling Unit

All air handling units shall be installed on anti-vibration mountings and flexible joints shall be used to connect to the supply and return air ducting to prevent vibration transfer from the unit.

The installation of the air handling units shall comply with the installation recommendations by the supplier.

42.9.6 Air Cooled Chillers

All units shall be installed on anti-vibration mountings to prevent vibration transfer from the unit to the surroundings.

The Contractor shall ensure that the connecting piping is adequately supported so that no strain is imposed on the chiller.

The Contractor shall be responsible to size and select the circulation pumps and expansion tanks to ensure adequate operation is achieved as specified in this document and drawings.

The installation of the chillers shall comply with the installation recommendations by the supplier.

The chiller installation shall be checked and verified by a certified technician from the supplier.

42.9.7 Water Piping

The water piping shall be installed according to the routes indicated on the relevant drawings. The piping shall be arranged and installed to ensure that there is enough head room, does not obstruct walkways, does not interfere with maintenance and keeps access to valves unobstructed. Piping shall generally be installed as close to the parallel or perpendicular lines of the buildings, as the required gradients permit.

The system shall be complete in all details and provide for all valves and accessories necessary for satisfactory operation. All valves shall be labelled using the same numbers shown on the drawings.

The relevant piping drawings issued are schematic only and does not indicate the final positions of the pipes and valves. All final dimensions must be checked on site and shop drawings shall be submitted for approval.

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

Pipes shall generally be installed to slope and be fitted with riser pipe Anti-drain loops and anti-siphon pipes to prevent the system from draining back to ponds, cooling towers on Thermal storage tanks during normal operation, cycling on power failure

Plug open ends of piping, drains, fittings and equipment connections during installation to keep system free of rubble, dirt and other foreign matter. All piping systems shall be flushed out properly to ensure cleansing, prior to the operation of the plant.

Horizontal support spacing, unless indicated otherwise on drawings shall be as follows:

NOMINAL PIPE DIAMETER	DISTANCE BETWEEN SUPPORTS
Up to 15	2.5 m
20 to 40	3.5 m
50 to 80	4.5 m
100 to 150	6.0 m
200 to 300	7.5 m
350 to 600	7.5 m

In addition to the spacing set out above, supports shall be fitted within 1 meter from bends or fittings and at locations of concentrated loads. Piping shall be supported in such a manner that loads imposed on the building structure are evenly distributed. Anchors, guides, expansion joints and loops must be provided for proper control of thermal movement to prevent undue strain on equipment and in piping. Hangers and supports shall allow adequate adjustment. Multiple supports for pipes of differing sizes shall be spaced at intervals to the requirements of the smallest pipe.

Sleeves shall be provided to the Building Contractor to build into the walls where pipes pass through brick and concrete walls and slabs. Sleeves shall extend the full depth of construction including final finishes. Sleeves shall be galvanised steel, not less than 1,6 mm, with a diameter at least 10 mm larger than the O.D. of the pipes or flanges in the case of welded flanged piping.

The Contractor is responsible to ensure that sleeves are correctly positioned, and adequate provision shall be made to fix sleeves to shuttering. Sleeves in fire walls shall be packed with high density glass fibre and fitted with wall plates on either side. Sleeves in exterior walls and roofs and waterproof floors shall be waterproofed by means of epoxy resin and wall sleeves shall be fitted with wall plates on either side. Sleeves through floors and roofs shall protrude at least 75 mm above the top of the floor or roof covering to facilitate weatherproofing.

Piping systems shall be tested by means of a hydraulic pump to twice the operating pressure of the system or, where it is not permissible due to the maximum allowable piping working pressure, the piping shall be tested to a minimum of 1500 kPa in order to verify that no water leaks are present. All instrumentation or other equipment which could be damaged during the pressure test, shall be isolated or removed from the pipe systems. The duration of the pressure test shall be 2 hours, after which no water leaks shall be visible and no pressure drop shall be occur after corrections have been made for changes in ambient temperature. The pressure test shall be completed before insulating or painting the pipes. If leaks are found, welded connections shall be cut out and rewelded and screwed joints shall be dismantled, cleaned and reconnected. Rectified pipes shall be retested.

Buffer tanks and pump sets shall be installed in accordance with the supplier’s recommendations.

After completion, all piping systems shall be flushed and cleaned out in accordance with CIBS: Commissioning Code: Series W: Water Distribution Systems.

The Contractor shall allow for 1% of the welded pipe joints to be X-rayed or cut for examination purposes. If any of the welds prove unsatisfactory, the Contractor shall be called upon to test further welds and to re-weld rejected welds at his own cost.

42.9.8 Ductwork

All ductwork Drawings are schematic. All ductwork shall be erected according to standards as set down in SANS 10173: 1980 - Standard Specification for Air conditioning Ductwork.

Galvanised and stainless steel ductwork shall not be fitted with any copper or copper alloy parts unless the junctions between ductwork and such parts are so insulated that electrolytic inter-action is prevented. The Contractor shall ensure that maximum head room is maintained, especially in Plant rooms. All transverse joints, duct stiffening, beading, seams etc. must conform to the SABS standard as applicable. All intake and discharge ducting shall have neat wire mesh screens fitted to their ends where louvres are not required.

42.9.9 Drain Piping

Each outdoor unit shall be equipped with a condensate drain pan. Condensate drains shall be installed from the various indoor units to the nearest drain point. All condensate drain piping shall be at least 22 mm dia. hard drawn Class 0 copper tubing, 25 mm dia GMS or 25 mm dia uPVC for up to 3 units only. Where more than 3 units share a drain piping shall be at least 54 mm dia. hard drawn Class 0 copper tubing, 50 mm dia GMS or 50 mm dia uPVC (This includes down pipes). Drain piping shall be supported at 2,0 m intervals with a fall of at least 1:80. A T-piece for a vertical venting pipe of 200 mm shall be provided close to the unit in the same piping as the rest of the condensate drainage system. Provision shall be made for all heat pump units to drain the condensate of the outdoor unit to the nearest drain point. All indoor units shall be fitted with drain pumps being able to pump at least 500 mm high. Easy access to drain pumps shall be provided and the locations of these drain pumps shall be indicated on the as built Drawings. The condensate drainage pipe shall be filled with water after installation to check for any leaks. The Contractor shall provide proof of this test to the Engineer before practical completion can be obtained.

The Contractor shall install unions in drain piping pipe cleaning purposes.

Drain points provided are indicated on the Drawings. If additional drains are required, the Contractor shall indicate within 12 weeks after award of the Contract, the number and location of additional drain points. Where no drain points are indicated, the Contractor shall route drains to the nearest gully or open drain.

All drainpipes shall be provided with a mesh to prevent rodents from entering the building through the drain pipes.

All drain piping shall be chased into the walls and drain by gravity.

42.9.10 Control Panels

42.9.10.1 General

Panels and boards shall be factory pre-wired so that the only "on site" connections to be made will be the main connection, the supply to the motor, and the control system connections to the terminal block if applicable.

42.9.10.2 Low- and High-Lift Pumping Stations - Pump Rooms

The control panel shall be installed in the Pumping Station Control Room. The panel shall feature:

a) a main isolating “ON/OFF” switch;

b) a “SYSTEM OFF/RUN” selector switch;

c) a yellow “SYSTEM OFF” indicator lamp;

d) a green “SYSTEM RUN” indicator lamp; and

e) red “FAN 1 FAULT” and “FAN 2 FAULT” indicator lamps.

An ammeter graduated to a suitable scale shall be fitted on at least one phase of each fan, and shall be installed in the panel next to the relevant switchgear. The fan start method shall be Controlled with a VSD.

There are two axial fans, per supply system, each delivering 100% of the outside air supply to the high- and low lift pump rooms. In the case that the lead axial fan stops / trips, the lag axial fan shall automatically start up without any manual intervention.

42.9.10.3 Low- and High- Lift Pumping Stations - Low and Medium Voltage Rooms, Battery room and Ablutions

The fans in these rooms and areas shall be switched on and off by means of a manufacturer-approved switch, installed locally in an accessible location, preferably on the outside of each room. The switch shall only have two positions, “on” and “off”. The fan start method shall be direct online. Local lock-out isolators shall be installed no more than 1 m from the fans when remote control panels / switches are used.

There are two axial fans, per supply system, each delivering 100% of the outside air supply to the high- and low lift pump rooms. In the case that the lead axial fan stops / trips, the lag axial fan shall automatically start up without any manual intervention.

42.9.10.4 Low- and High-Lift Pumping Stations – HVAC and VSD Rooms

The air handling units shall have a built-in user interface with BMS output compatibility in BACNET or similar format. To enable quick parameter viewing from sensors and error / alarm signals on the unit itself.

The chillers shall each have a built-in touch panel user interface with BMS output compatibility in BACNET or similar format. To enable quick parameter viewing from sensors and error / alarm signals on the unit itself and associated accessories.

The smart control panel shall be installed in the Pumping Station Control Room. The panel shall feature:

a) Chiller Information:
    i) Run indication;
    ii) System Error information / Alarm;
    iii) Chilled water supply and return temperature; and
    iv) Chilled water supply and return pressure.

b) Air Handling Unit Information (Unit 1 and 2):
   i) Run indicator;
   ii) System error information / Alarm;
   iii) Air supply and return Temperature;
   iv) Chilled water supply and return temperature; and
   v) Chilled water supply and return pressure.

c) Pump/s (Pump 1 and 2):
   i) Run indication;
   ii) Off indication;
   iii) Trip Indication / Alarm; and
   iv) Water pressure before and after the pump/s.

The control / monitoring system shall have the capability to send all information mentioned above to multiple remote locations via a BACnet or similar BMS interface.

The plant manager shall be provided with all the necessary control modules, interfacing modules, interconnecting wiring and sensors to perform the required function. All software required to be included.

Flow switches must be provided in each chiller circuit to confirm water flow before the chiller start is initiated.

There are two chillers each delivering 100% of the cooling load to the VSD room. The chillers will swap lead-lag to ensure that both chillers have the same operating hours. In the case that the lead chillers stops or has an issue, the lag chiller will automatically start up without any manual intervention. The chilled water pumps shall operate on the same principal. A warning signal shall display for the chillers and pumps on all local and off site control panels if any error occurs.

The EC plug fans in the air handling units shall ensure that the supply air to the VSD room remains constant. In the case that one plug fan breaks down, the other plug fans shall ramp up as far as possible to accommodate the lost capacity. A warning signal shall display on all local and off site control panels if any error occurs.

42.9.11 Operating Requirements

42.9.11.1 Low- and High-Lift Pumping Station Pump Rooms

The fans shall be “on” permanently under normal operating conditions. The stand-by fans shall turn on automatically if the primary fans trip.

42.9.11.2 Low- and High- Lift Pumping Station: Low- Medium- Voltage, Battery Room and UPS Room.

The fans shall be “on” permanently under normal operating conditions. The UPS air conditioning units shall be “on” permanently under normal operating conditions. The stand-by fans shall turn on automatically if the primary fans trip.

42.9.11.3 Low- and High- Lift Pumping Station: VSD Room

The air handling units, pumps and chillers shall be “On” permanently under normal operating conditions. The stand-by chiller shall turn on automatically if the primary chiller trips.

42.9.11.4 Low- and High- Lift Pumping Station: Staff Facilities

The air conditioning units shall be manually controllable and shall be switched on during normal operating hours when the associated areas are occupied. The server and UPS air conditioning units shall be “on” permanently under normal operating conditions. The outside air and extraction fans shall be “on” permanently under normal operating conditions.

42.9.11.5 Guard House

The air conditioning units shall be manually controllable and shall be switched on during normal operating hours when the associated areas are occupied. The server air conditioning units shall be “on” permanently under normal operating conditions. The fans shall be “on” permanently under normal operating conditions.

42.9.12 Notices

The Contractor shall supply and install all notices required in terms of the Occupational Health and Safety Act, Act of 1993, and its regulations.

42.10 TESTING AND COMMISSIONING

42.10.1 General

All HVAC Plant shall be tested and commissioned in accordance with the requirements set out below and as per the requirements stated in Clauses 48.3 and 48.4.

The Contractor shall record all measurements taken during testing and shall undertake the necessary adjustments until the Engineer is satisfied with the results.

The Contractor shall notify the Engineer 14 days in advance of any tests to be conducted on Plant and the installations together with a Method Statement / Test Procedure for approval.

42.10.2 Inspections and Testing

42.10.2.1 Inspections

All Plant shall be subject to inspection and testing by the Engineer in accordance with the requirements specified in Section 28 – Mechanical General and at the manufacturer’s premises before despatch in accordance with Clause 28.25 (Inspection, Quality Control and Testing).

42.10.2.2 Testing

42.10.3 Duct Testing

The installed ducts shall be tested in accordance with SANS 10172: 2003 - The Installation, Testing and Balancing of Air-conditioning Ductwork.

42.10.4 Commissioning

Commissioning of the HVAC systems shall be in terms of the following codes:

a) Air Distribution Systems: SANS 10173: 2003: Code of Practice for the Installation, Testing and Balancing of Air Conditioning Ductwork;

b) Refrigeration Systems: CIBSE: Commissioning Code: Series R: Refrigeration Systems;

c) Control System: CIBSE: Commissioning Code: Series C: Automatic Controls; and

d) Water Distribution Systems: CIBSE: Commissioning Code: Series W: Water Distribution Systems.

The Contractor shall inform the Engineer what time allocation has been allowed for commissioning purposes. This must be reflected on the Construction Programme.

42.11 STANDARDS AND CODES OF PRACTICE

Any ambiguity between this Section and these standards shall be brought to the attention of the Engineer in writing who shall review the ambiguity and submit his written clarification in each instance.

The following Standards and Codes of Practice are relevant to this work:

a) Occupational Health and Safety Act, 1993 (Act 85 of 1993) as amended;

b) Local Government Act 1998 (Act 10 of 1998 (Gauteng)) as amended and the municipal by-laws and any special requirements of the local supply authority;

c) Fire Brigade Services Act 2000 (Act 14 of 2000) as amended;

d) National Building Regulations and Building Standards Act 1996 (Act 29 of 1996) as amended;

e) Electricity Act 1996 (Act 88 of 1996) as amended; and

f) National Building Regulations and Building Standard Act, 1977, (Act No 103 of 1977) as amended.

South African Bureau of Standards

SANS 460:20011	:	Plain-ended solid drawn copper tubes for potable water.
SANS 1453:2011	:	Copper tubes for medical gas and vacuum services.
SANS 10400	:	The applications of building regulations.
SANS 10103:2008	:	The measurement and rating of environmental noise with respect to annoyance and speech communication.
SANS 10140	:	Identification colour marketing.
SANS 10142	:	The wiring of premises Part 1 – Low-voltage installations.
SANS 10147:2014	:	Refrigerating systems, including plants associated with air-conditioning systems.
SANS 10173:2003	:	Installation, testing and balancing of air-conditioning ductwork.
SANS 1238:2005	:	Air-conditioning ductwork.
SANS 1507-3:2007	:	Electric cables with extruded sold dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 3: PVC Distribution cables.

British Standards Institution

BS 476-10:2009 : Fire tests on building materials and structures.

European Standards

EN779 : Particulate air filters for general ventilation - Determination of the filtration performance.

42.12 OPERATION AND MAINTENANCE MANUALS

Submission of O&M Manuals shall be as required under Section 48 – Tests on Completion.

In addition to the requirements of Clause 48.4.4.3, these Manuals shall contain the following information:

a) A comprehensive description of the installation; and
b) Operating Instructions:
    i) Starting and stopping instructions;
    ii) Prestart checks; and
    iii) Plant running checks.

The following information shall be provided in full for each item of Plant:

a) General information - Description, Make, Model Number, Name and Address of Supplier, Manufacturer, etc.;
b) Design information - Design Data Sheet containing all design and selection parameters, calculations, selection curves, etc.;
c) Settings and values recorded during commissioning;
d) Test certificates, inspections certificates;
e) Manufacturer’s Brochures and Pamphlets;
f) Maintenance Data and Schedules - The lapse of time between services and the description of the service required of each part, lubrication requirements, etc.; and
g) Detailed contact information of suppliers.

Maintenance of Plant

Proposed maintenance actions and schedules to be considered and included as applicable in the Operating and Maintenance Manual are included in Annexure 42/1.

42.13 SPARE PARTS REQUIREMENTS

The Contractor shall list and price the spare parts considered to be necessary as required for the continued operation of all mechanical, electrical and electronic Plant based not only on a reliability analysis of the Plant, but also on the reliability and availability of local suppliers of spare parts. The lists shall also include all long lead maintenance items and special maintenance tools that will be required during the maintenance of the plant by the Contractor. The lists of additional critical spare parts must be submitted to the Engineer prior to achieving RFTO.

The total amount for spares derived from for each part of the Works shall be carried forward to the Bill of Quantities. A provisional sum will be allocated in the Bill of Quantity for the complete list of spare parts as listed by the Contractor.

42.14 MEASUREMENT AND PAYMENT

The rates tendered under this Section shall not include for the general obligations, Contractor's Equipment and work deemed to be covered by the items provided in Section 1 – General.

42.001 Design and documentation — Unit: lump sum (Sum)

The rates tendered shall include for full compensation of all costs incurred in the preparation of the design and calculations, detail workshop drawings for all systems, specifications, schematic diagrams, electrical drawings and wiring diagrams, layout drawings, operation and maintenance instructions, programmes of work (manufacture on site) and any other works as specified for the design of the complete installation. Payment will only be effected after the design and associated documentation has been approved by the Engineer.

Measurement and Payment for the preparation and submission of O&M Manuals shall be covered under Clause 48.11 of Section 48 – Tests on Completion and paid elsewhere.

42.002 Supply and deliver to Site — Unit: number (No) or metres (m); or lump sum (Sum)

The rates tendered shall include full compensation for the supply and delivery of the Plant to Site including the:

a) Supply of raw materials and bought-out items and associated Plant items (i.e. cabling and electrical panels);

b) Fabrication, manufacture and assembly;

c) Application of finishes (painting and corrosion protection);

d) Trial erection and dismantling;

e) Quality assurance and quality control;

f) Inspection and Factory Acceptance Testing (including attendance on inspections and tests witnessed by the Engineer);

g) Type and routine tests;

h) Preparation and packing for transport;

i) Transport from place of manufacture to site;

j) Insurance, etc. during transport;

k) Loading and unloading;

l) Storage under appropriate conditions from date of delivery until commencement of erection; and

m) Any other work as specified.

Payment will be made per unit. Payment will only be effected after full compliance of the Plant items with this Section and associated documentation has been approved by the Engineer.

42.003 Installation of Plant **Unit: number (No) or metres (m); or lump sum (Sum)**

The rates tendered shall include for the full compensation for the installation of the Plant on Site including the:

a) Provision of all labour, transport, materials and Temporary Works necessary to install the complete works;

b) The installation of all auxiliary Plant items, electrical cables panels, etc. necessary for the operation of the installation until taken over by the Employer;

c) On-site quality assurance and quality control, inspection, testing (including attendance at tests witnessed by the Engineer);

d) The putting into service of the complete installation of the Plant; and

e) Any other work as specified.

The rates shall also include for all pre-commissioning testing and the provision of equipment therefore including all disruptions to installation caused by such testing.

Payment will be made per unit. Payment will only be effected after full compliance of the Plant items with this Section and associated documentation has been approved by the Engineer. Measurement and Payment for Test on Completion shall be covered under Clause 48.11 of Section 48 – Tests on Completion and paid elsewhere.

42.004 Spares **Unit : Provisional sum (PS)**

The cost of spares, considered to be necessary by the Contractor other than spares required by the Employer, delivered to Site and handed over will be paid as a lump sum. A Spare Part Schedule by the Employer is available in Section 48 – Tests on Completion, The spares identified by the Contractor are to adhere to Clause 42.13 Spare Parts Requirements.

The payment for specific spare items required by the Employer shall be made per item listed in the Commissioning and Trial Operation parts of the Bill of Quantities. Payment Item 48.007 is relevant in this regard.

Payment for spares identified by the Contractor as per Clause 42.13 and approved by the Engineer, shall be made from the provisional sums allowed for this in the Bill of Quantities. The rates provided for these spares shall provide for the manufacture, supply, delivery to Site and handing over of the spares ordered and shall include permanent packing for long term storage. The spares shall be manufactured at the same time as the installed items.

ANNEXURE 42/1
PROPOSED MAINTENANCE ACTIONS AND SCHEDULE

Daily Maintenance Actions

The air-conditioning units and ventilation systems will run both during working hours and continuously. The status of these systems must thus be monitored by observation on a daily routine as follows.

Ventilation systems:

- Are the systems running and is the operation quiet?
- Is the pressure loss over filter banks acceptable and within parameters?

Air-conditioning units:

- Does the unit perform and maintain temperature?
- Is the temperature in the areas concerned satisfactory and within specification?
- Is the condensate drains working properly?
- Is the pressure loss over filter banks acceptable and within parameters?

These daily checks shall be logged at the facility, i.e. by the Pump Station Superintendent or his designated representative and the maintenance personnel.

Monthly Maintenance Actions

VENTILATION SYSTEMS	
REFERENCE NUMBER	**ACTION**
V-1	Inspect air intake for blockages
V-2	Check all accessible ducts for leakages, damage, and damaged supports
V-3	Clean filters
V-4	Check electric motor running temperature
V-5	Check electric connections for tightness
V-6	Check operation of relief air grilles and check that they are not blocked
V-7	Check for motor noise and check bearings
V-8	Check for leaks on canvas collars

AIR-CONDITIONING UNITS	
REFERENCE NUMBER	**ACTION**
S-1	Clean filters, replace if required
S-2	Inspect air intake and discharge for blockages
S-3	Check all refrigerant, drainage and water pipes for damage and leaks
S-4	Check sight glass: clear or flush gas
S-5	Carry out visual inspection of condenser coil for blockages and correct operation of fans
S-6	Carry out visual inspection of evaporator coil for blockages and correct operation of supply fan
S-7	Check enclosure for damage
S-8	Check electric motor running temperature
S-9	Check electric connections for tightness
S-10	Test thermostat and control operation
S-11	Clean condensate tray and test drainage for proper operation
S-12	Check cooling and heating cycle

Note: The monthly actions shall include the activities of the daily maintenance actions.

Biannual Maintenance Actions

VENTILATION SYSTEMS	
REFERENCE NUMBER	**ACTION**
V-1	Inspect air intake for blockages
V-2	Check all accessible ducts for leakages, damage, and damaged supports
V-3	Clean filters
V-4	Check electric motor running temperature
V-5	Check electric connections for tightness
V-6	Check operation of relief air grilles and check that they are not blocked
V-7	Check for motor noise and check bearings
V-8	Check for leaks on canvas collars
V-9	Clean fan blades and check for unbalance
V-10	Clean exterior casing
V-11	Clean all grilles
V-12	De-rust, neutralise and touch up paint work
V-13	Check vibration mounts of fan and tightness of mounting bolts

AIR-CONDITIONING UNITS	
REFERENCE NUMBER	**ACTION**
S-1	Clean filters, replace if required
S-2	Inspect air intake and discharge for blockages
S-3	Check all refrigerant, drainage and water pipes for damage and leaks
S-4	Check sight-glass: clear or flush gas
S-5	Carry out visual inspection of condenser coil for blockages and correct operation of fans
S-6	Carry out visual inspection of evaporator coil for blockages and correct operation of supply fan

AIR-CONDITIONING UNITS	
REFERENCE NUMBER	**ACTION**
S-7	Check enclosure for damage
S-8	Check electric motor running temperatures
S-9	Check electric connections for tightness
S-10	Test thermostat and control operation
S-11	Clean condensate tray and test drainage for proper operation
S-12	Check filter / dryer
S-13	Check superheat and functioning of expansion valve
S-14	Check operation of HP and LP switches
S-15	Check operation of controllers
S-16	De-rust, neutralise and touch up paint work
S-17	Check cooling and heating cycle
S-18	Clean evaporator and condenser coil chemically
S-19	Clean all filter frames and seals
S-20	Check fan motor and compressor current
S-21	Check and test overload settings
S-22	Lubricate all bearings
S-23	Check water pump running temperature
S-24	Check water pump pressures
S-25	Clean all Y strainers
S-26	Test chilled water chemical concentration
S-27	Test all chilled water balancing valves

Note: The above biannual actions include the activities of the monthly maintenance actions.