HOUSE 251

CONSTRUCTION & TENDER DOCUMENTATION

HEATING VENTILATION AND AIR CONDITIONING (HVAC) TECHNICAL SPECIFICATION

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1.INTRODUCTION

This document specifies and describes the supplies, services and engineering, and construction Works which are to be provided and any other requirements and constraints relating to the manner in which the Heating Ventilation and Air Conditioning (HVAC) system contract is to be performed.

1.1.PURPOSE

The purpose of this document is to describe the minimum requirements for engineering, drawings, procurement, manufacture, quality control & assurance, supply, delivery, installation, commissioning, testing, training, and maintenance and handing over of Heating Ventilation, Air Conditioning and Refrigeration at House 251.

1.2.DEFINITIONS

Definition	Description
Acceptance	The Employer accept the condition or design but does not take responsibility from the Contractor
Approval	Written agreement or authorization by Employer. All requests for approval must be submitted in writing and any proposed deviation from specified requirements must be fully justified and agreed by Employer.
Contractor	Refers to the corporation appointed to perform the engineering, procurement, and construction Works required for the project.
Design freeze	Is a binding decision that defines the whole product, its parts or parameters and allows the continuation of the design based on that decision (no further changes can be made to the design, it is cut-off for the engineers)
Employer	Refers to House 251 who will be represented by the Facilities Management division throughout the duration of the Project.
Interface	Interface in these document means either to hard wired or software interaction between the Contractors and/or other Works
Heating, Ventilating, and Air Conditioning (HVAC)	Relates to Systems that perform processes designed to regulate the air conditions within buildings for the comfort and safety of occupants. HVAC Systems condition and move air to desired areas of an indoor environment to create and maintain desirable temperature, humidity, ventilation and air purity.
Maintenance	Maintenance can be defined as the function of keeping components or equipment in, or restoring them to a serviceable condition so that they comply with design and statutory requirements and Employer standards. Maintenance includes the cleaning, removal of contaminants and waste, correct adjustment and setting, tightening, testing, fixing, refill, lubrication, rust prevention, touch up, refrigeration charge, servicing, inspection, replacement, re-installation, troubleshooting, calibration, condition determination, repair, modification, overhaul and rebuilding of equipment. Maintenance can be either preventative or corrective of nature.
Maintenance Management	Maintenance Management can be described as the management (planning, organising, leading and control) actions needed to ensure effective maintenance execution to provide the most efficient and optimum availability (capable of being used) and reliability (consistent quality) of the equipment installed.
Specification	The document/s forming part of the contract in which the methods of executing the various items of work to be done is described, as well as the nature and quality of the materials to be supplied and it includes technical schedules and drawings attached thereto as well as all samples and patterns
System/s	A set of components working together as parts of a mechanism or network in an organised manner or method such that the requirements of the System are achieved.
The Client	The end user will be House 251 who will be represented by the Facilities management Division throughout the duration of the Project.
Unequipped spare	A functional unit that does not house any electrical components, but is intended to be used in future by retrofitting/modifying the functional unit.

1.3.ABBREVIATIONS

Abbreviation	Description
AC	Alternating Current
BMS	Building Management System
BS	British Standard
CD	Compact Disc
C&I	Control and Instrumentation
CM	Corrective Maintenance
COP	Coefficient of Performance
DC	Direct Current
DWG	AutoCAD drawing, vector format
DX	Direct Expansion
EN	European Standards
FAT	Factory Acceptance Testing
FRA	Failure Report Analysis
FDS	Fire Detection System
GA	General Arrangement
HBS	Hardware Breakdown Structure
HMI	Human Machine Interface
HTM	Health Technical Memorandum
HVAC	Heating, Ventilating, and Air Conditioning
IEE	The Institution of Engineering Engineers
ISO	International Organisation for Standardisation
LED	Light Emitting Diode
LCC	Life Cycle Cost
LPA	Low Pressure Air
LV	Low Voltage
MCC	Motor Control Centre
MTTF	Mean Time To Failure
MTTR	Mean Time To Repair
MV	Medium Voltage
O&M	Operating and Maintenance
OEM	Original Equipment Manufacture
OH&S	Occupational Health and Safety
PBS	Plant Break Down Structure
PFD	Process Flow Diagram
P&ID	Process Instrumentation Diagram
PM	Planned Maintenance/Project Manager
PPM	Parts Per Million

Abbreviation	Description
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
QCP	Quality Control Procedure
RAM	Reliability, Availability and Maintainability
RCM	Reliable Centre Maintenance
RH	Relative Humidity
SANS	South African National Standards
SAT	Site Acceptance Testing
SLA	Service Level Agreement
TBC	To be Confirmed
TBF	Time between failures
USB	Universal Serial Bus
V	Voltage
VRS	Variable Refrigerant System

2.HEATING VENTILATION AIR CONDITIONING & REFRIGERATION SCOPE OF WORK

The Heating, Ventilating and Air Conditioning (HVAC) scope of works, as detailed in this specification document, Bill of Quantities and accompanying drawings; comprise of the engineering, the provision of all labor including materials and Contractor's equipment, manufacturing, supply, delivery, off-loading, hoisting, erection, testing, balancing and commissioning to serve, guarantee and maintenance after final completion of the Heating, Ventilating and Air Conditioning (HVAC) Installation.

The engineering, quality control, inspections, plant and material selection, preparation of installation drawings, testing, balancing, commissioning and preparation of operating and maintenance manuals, are to be managed and executed by the Contactor in a systematic manner as follows:

a) Engineering;
b) Plant and material selection;
c) Installation drawings;
d) Plant installation;
e) Testing, balancing and commissioning Documentation;
f) Quality control
g) Operating Instruction and Maintenance Manuals; and
h) Inspection Record Cards/Checklists and final hand-over

The following design outdoor and indoor conditions were used to validate and verify the HVAC design, in terms of expected environmental conditions and sizing & selection of the plant and material for HVAC system.

The outdoor design conditions for HVAC are based on the Weather Bureau data. The mean maximum temperature (DB) for summer and mean minimum temperature for winter is taken as a design condition. The Weather Bureau does not list temperature and associated relative humidity (RH) as one set of data. The Maseru (House 251) climate conditions are as follows:

a) Summer: Ambient Temperature = 34^{o}C DB
b) Winter: Ambient Temperature = -10^{o}C DB
c) The estimate terrain elevation above sea level is 1600 metres

The operating hours for the building are envisaged to be between 04h00-22h00 and 24 hours Monday to Saturday for comfort.

The Heating, Ventilating and Air Conditioning (HVAC) installation is required for House 251 to perform the following:

a) **The site shall be equipped with a new heat recovery system that will be able to control the ambient conditions to 22 ± 2°C.**
b) **All existing split units shall be decommissioned**
c) **All R22 refrigerant shall be collected and disposed of in accordance to Section 608 of the Clean Air Act.**

The Heating, Ventilating and Air Conditioning (HVAC) works including the following:

a) Variable Refrigerant System (VRS) together with matching ventilation system to service club house, sports hall and gym areas as indicated by accompanying drawings.
b) Sports hall is to be serviced by two central ducted package air conditioning unit as indicated by the accompanying drawings as well as a VRS system at only one area of the building with small height.
c) Natural and mechanical ventilation are to service the foyer/Circulation area/waiting areas, ablution, kitchen, general stores, and other general areas.
d) Associated Electrical Works for complete HVAC system.
e) Associated Controls and accessories for complete HVAC Works.
f) Associated building and Civil Works for complete HVAC Works.
g) Interfacing with fire detection system.
h) Testing, balancing and commissioning of the complete HVAC Works.
i) Provision of Painting and corrosion protection for complete HVAC Works.
j) Provision of operation & maintenance manuals
k) Plant Codification & Labelling and provide new where required for the complete HVAC Works.
l) The Contractor makes provision for spares and maintenance support as per the requirements set out in this document.
m) The Contractor is to execute maintenance and maintenance management under the supervision of Employer for a period of 12 (twelve) months from the date of Taking over of the Works. The minimum intervals for the Contractor to be onsite for inspection and maintenance after taking-over of Works are to be 3, 6, 9 and 12 months respectively.

The accommodation required for Heating, Ventilating and Air Conditioning (HVAC) is as follows:

a) Variable Refrigerant System (VRS) outdoor units/plants are to be located on the roof slab and be placed on steel frames or lets of the units.
b) Packaged air conditioning units on steel frames shall be located above the Gym building and on the roof slab link between the Club House and Sports hall.
c) All indoor units are to be mounted against internal room walls or be supported onto roof slab/s or trusses.
d) All ducting and mechanical ventilation fans are to be mounted against internal room walls or be supported onto roof/s or trusses, slab/s or purpose made frames.

2.1.HEAT RECOVERY SYSTEM

2.1.1.General

The Heat Recovery system will control flow of refrigerant through the indoor units, by means of an electronic expansion valve fitted in each indoor unit. It will have the following features:

1) The Heat Recovery system must utilise a dedicated discharge line in addition to the liquid and suction pipes to the indoor units. The dedicated discharge line is required to maintain a higher degree of usable heat output in comparison to a two pipe Heat Recovery VRF system.
2) The Heat Recovery system will have inverter controlled fan motors to allow the system to accurately respond to head pressure control requirements.
3) The system must be able to vary evaporating and condensing temperatures based on ambient temperatures and/or load to ensure optimum seasonal efficiency and comfort. Or alternatively fix the evaporating temperature for continual very high off coil temperatures.
4) Part load conditions must be met by a combination of change of compressor speed and change in refrigerant temperature at a suitable reaction speed which is set at the condenser on commissioning.

5) The Heat Recovery systems will have a minimum of 50 step inverter fan control to allow the system to accurately respond to head pressure control requirements.

6) The compressor shall respond to control frequencies from 60 to 402Hz to provide stepless capacity control.

7) All condenser fans must be capable of at least 78 Pascal's of external static pressure.

8) The refrigerant must be distributed by the use of a refrigerant networking system (Refnet) to ensure low pipe pressure losses as well as keeping the require pipe work installation space and material used to a minimum compared to other parallel pipe work systems.

9) The changeover of indoor units will be provided by Branch Separator units (BS – boxes). Each BS-box will be responsible for changeover of indoor units connected to it. The system must have the possibility to use multi type BS-boxes, to provide the design flexibility. Multi type BS-box will allow the connected indoor units to change the operation mode independently.

10) Changeover of an indoor unit from Heating to Cooling must not prevent any other indoor unit on a different BS box port from providing continuous capacity by ensuring that pressure equalisation is performed within the BS box and not across the whole system.

11) The system will have the ability to sustain refrigerant piping lengths of up to 165m (equivalent piping length has to be at least 190 meters) with a level difference of 90m between fan coil units and condensing unit, providing connection ratios are suitable. The system shall be capable of having up to 1000m of refrigerant pipe work installed. The system shall be capable of having up to 90m from the first refnet to the furthest indoor unit, providing manufacturer system design guidelines are used. The elevation between the highest and lowest indoor units must be able to be extended up to 30 meters.

12) The system must be able to adjust capacity depending on the load requirements and outside temperature to ensure that the efficiency is optimised and responsiveness maintained.

13) The system must be able to operate a continuous heating during defrost system on single as well as multi-unit installations resulting in no cold air dumping.

14) The system has to smoothly operate at ambient temperatures ranging at least from -5°CDB to +43°CDB in cooling and down to -20°CWB and up to +15,5°CWB in heating. The system operation must be possible outside above mentioned limits, unless safety devices are activated.

15) The system will operate with Refrigerant R410A, being a zeotropic blend constituted of a maximum of two different refrigerants providing a maximum temperature glide of less than 0.17K to avoid fractionation problems.

16) The system will have the capability to automatically charge the correct volume of refrigerant during commissioning and, if automatic charging has been utilised, the system must also have the ability to self-diagnose refrigerant containment for maintenance and service purposes. The unit shall be capable of carrying out automatically the calculated required additional refrigerant charge necessary to operate the system within its optimum efficiency. This cycle shall be completely automatic and provide a warning to the service technician to indicate when charging has been completed or the charging cylinder is empty. The refrigerant cycle shall not rely upon float valves, level switches or weighed input of the refrigerant. The calculated refrigerant charge shall be retained within the memory of the outdoor PCB as a reference for a refrigerant containment check which can be carried out as required to verify the correct refrigerant charge remains within the system. The automatic refrigerant charging and containment check facilities shall be capable of being used at any time during the life of the system for any alterations or service operations which may be required.

17) In the event of compressor failure, the system will allow emergency operation of its other compressors in order to maintain 8 hours of interim capacity whist spares are sourced.

18) Systems containing multiple outdoor units shall sequentially cycle its start-up sequence to ensure equalised compressor operation to extend operating life and reduce lifecycle cost.

19) In the outdoors units it is preferable to have a 7 segment decimal display, displaying detailed error codes, stage of the start-up procedure as well as function and operating data of the system. For the commissioning of a system and in order to properly set all necessary data and values for the optimum operation of it, it is recommended for the starting-up the use of special software provided by the manufacturer of the system. The establishing of the values and the programming should be possible even offline.

20) The system shall have the capability to monitor and log data in a critical memory which will store and provide 5 minutes of real time operational data prior to any system failure. This information provides the system with “Black Box” data recording capability which can be used by a qualified service technician to perform efficient and precise interrogation.

21) Reclaimed refrigerant shall be (administratively) allocated to the VRV heat recovery outdoor unit covering the full amount of the refrigerant factory charge. The refrigerant reclamation consists in a regenerative process of the refrigerant recovered from existing installations. The quantity and quality of refrigerant must be confirmed by independent audit. Refrigerant quality is audited to the AHRI700 ‘as-virgin’; standard. Reclaiming and reusing refrigerants avoids the production of virgin gas. The whole refrigerant reclaiming process (recovery, reclaiming and charging) must be made solely inside European Union’s borders, guaranteeing a small carbon footprint of the whole process.

2.1.2.Equipment manufacturer

The equipment manufacturer must be fully certified and registered to comply in the areas of CE, Eurovent, ISO9001 and ISO14001. The equipment manufacturer shall be responsible for the manufacture of the compressor, refrigerant oil and refrigerant used within the system to maintain integrity of design and optimise efficiency and reliability of equipment.

2.1.3.Testing and certification.

All equipment shall be run tested in accordance with the following procedures prior to leaving place of manufacture:

1) A choke test carried out on the refrigerant piping to detect obstacles.

2) The pipework shall be tested to 38bar.

3) Electronic leak testing shall be carried out to ensure maximum system refrigerant containment.

4) System vacuum test to 2 Torr

5) Refrigerant test to within 0.3%

6) Electrical tests shall include flash testing at 1440V AC to ensure that current leaks above 5mA are detected, megger test at 500V DC to ensure resistance levels are above 10 mega Ohm and earth continuity tests.

2.1.4.System components features

2.1.4.1.Outdoor unit features

2.1.4.1.1.Outdoor unit physical appearance

The outdoor unit must be suitable for outdoor installation. The shell/casing of the unit will have to be made of enamelled stainless steel sheet, with polyester thermal powder coating (minimum 70μ) for high protection in environment near the seaside. The units shall be air-cooled type incorporating heat exchanger coils manufactured from copper tubes and aluminium fins. The air-cooled heat exchanger of the outdoor unit will have to have undergone appropriate treatment for protection and long life efficient operation against atmospheric corrosion. Specifically, the aluminium fins will be coated with a layer of acrylic resin and on top covered with a hydrophilic film or any other material which will provide minimum 5 to 6 times greater resistance to acid rain and salt corrosion. The bottom of the unit will have a sheet of stainless steel for protection against oxidation.

2.1.4.1.2.Outdoor unit mechanical features and components

The outdoor units will be able to deliver cooling capacities ranging from 8HP (22,4kW) and up to 20HP (56,0kW) in a single shell/housing. A combination of two or three outdoor units will be possible in order to have systems with cooling capacity reaching 54 HP (150,0 kW). No limitations on possible combinations will be accepted while the most appropriate one will be decided primarily for operating at the best possible seasonal efficiency. Aforementioned cooling capacities will have to be clearly mentioned in the manufacturer’s official technical documentation and literature and will have to be calculated, based on the following conditions:

- Indoor room air temperature: 24^{o}CDB / 19^{o}CWB.
- Ambient air temperature: 35^{o}CDB.
- Equivalent piping length: 5,0m.
- Height difference: 2m.

2.1.4.1.3.Compressors

In the outdoor unit there will be either one or two compressors in separate shells, so in case one fails it will not be necessary to replace both. The outdoor units will have axial fan(s) DC inverter driven, air-cooled heat exchanger, piping, wiring and automation, factory-installed electronic expansion valves, oil separator, accumulator at the suction side of the compressor, high & low pressure sensors, protection thermostats, fuses, protection against overcurrent, protection for overloading of the inverter, liquid and gas stop valves and solenoid valves, timers and all the necessary sensors and protection equipment to ensure continuous, safe and smooth operation.

The outdoor unit - and consequently the whole system - will keep on operating even if one compressor is turned off (emergency operation). In case of a multi-outdoor unit system it will be possible to isolate one module, while the rest of the system will continue to operate even if delivering reduced capacity. This ensures continuous air conditioning of the premises, until the cause of the issue seizes to exist.

Outdoor units should have a specific function and appropriate devices to prevent refrigerant in liquid phase to return to the compressor. This ensures the specified density of the oil and therefore the adequate lubrication of the compressor. This function increases the efficiency of the system and extends the lifespan of the compressor.

Compressors will have to be hermetically closed scroll type with integrated motor and sound absorbing jacket. They will have a DC inverter driven motor and be able to continuously change the frequency, resulting in a change to the volumetric refrigerant flow from the compressor, in order to accurately and fast respond to the required load. The change in frequency should be done incrementally, but in enough steps so the change of delivered capacity can be approximated as linear. The minimum number of capacity steps will have to be no less than 100. The motor windings will have to be specially constructed, in order to achieve the safe and smooth operation to avoid hazards due to the continuously changing of frequency and voltage. The compressors will be protected by an electrical crankcase heater to prevent oil condensation at low ambient temperatures.

The oil supply in the compressor will have to be on the high pressure side, ensuring optimum lubrication of all moving parts. Therefor a separate lubrication system will not be required for the moving parts of the compressor, since the oil in the centre of the crankshaft will be transported across the surface of the rotating parts from the centre to the perimeter. This optimizes the performance of the compressor and minimizes stress and wear, extending its lifetime. The compressors' motors will have a cooling system using compressed gas, to avoid sudden changes in temperature resulting in significant stresses on winding and bearings.

Compressors will alter the rotation speed linearly and consume energy in accordance with cooling and heating loads, ensuring operational autonomy and independent temperature control in each room. The two DC inverter compressors will vary their speed separately controlling the volumetric flow more accurately, with lower power consumption, resulting in higher efficiencies at all loads and connection ratios.

For protecting the compressor from frequent start-stops, there will be an appropriate timer.

2.1.4.1.4.Oil recovery system

The oil recovery from the piping network and the indoor units has to be achieved by the use of a microprocessor. The oil will be recovered at least once every eight hours, via a special oil recovery function, ensuring smooth operation of compressors.

2.1.4.1.5.Fans

The fan motor(s) of the outdoor unit will have to be DC inverter to further increase energy savings, to more accurately adjust the fan speed and reduce noise. The setting of the fan speed will result in precise control of system's performance in accordance with the requirements of indoor and ambient conditions. The DC inverter fan motors will automatically adjust the rotation speed – thus the air flow -

and have at least 120 different steps. Each fan will be separately controlled in order to further increase the accuracy of system control.

The impeller will be made of plastic and with a special configuration to achieve greater air flow with low noise level. Outdoor units will have a protective cover over the fan to guard against accidents and to avoid foreign objects entering the units. It will be special design and construction to minimize the external static pressure drop of the fan.

Fans will have a high external static pressure setting in order to reach at least 78 Pa. This will allow the installation / connection of duct(s) for greater flexibility during installation. In case of an outdoor unit with two fans, then each fan will have the ability to be separately ducted.

2.1.4.1.6.System control and functions

All indoor units to be connected to a system must be independently controlled depending on the requirements of each room. The indoor units will be connected to the outdoor unit via the wiring and refrigeration piping network. The wiring cables are not required to be shielded, but the installer will have to ensure that it will not be closer than 5cm to power cables.

The system's operation has to be based on pressure sensors and thermostats, which via a specially designed integrated circuit will control the frequency of the compressor motor (inverter) by varying the compressor's speed resulting in changes to the refrigerant's volume and temperature.

The result, combined with ambient temperature and building's load requirements, will always deliver the necessary capacity while maintaining optimum efficiency.

The system will have the ability to perform capacity control from down to 9% and up to 100% of the nominal capacity. The capacity delivered by the system should match the building's load. This way the system will consume the minimum required energy, at the highest possible efficiency.

The room temperature for each room must be controlled by a microprocessor, where processing of the various parameters and the corrective settings are proportional and according to the integral - differential method of regulation.

- Parameters; set temperature and return air temperature for the differential control, gas and liquid refrigerant temperatures for controlling the superheat
- Corrective settings; opening of the expansion valve, fan speed

2.1.4.1.7.Variable Refrigerant Temperature

The system has to automatically adjust the evaporating and the condensing temperature in order to always deliver the exact capacity for the building's load, with the highest possible efficiency. In parallel, it must be possible to also set a target refrigerant temperature. This way the delivered capacity will be ambient temperature dependant thus having very high seasonal efficiency. In addition, it has to be possible to operate the system with at least three different set refrigerant temperatures. Higher evaporating temperatures will result in less dehumidification indoors, while the system will deliver mostly or even only sensible capacity. The adjustment of the evaporating and the condensing temperature will have to be easily field set, without any optional accessories prior or after the commissioning of the system.

Ambient temperature dependant variation of the refrigerant temperature – evaporating and/or condensing is required, and results in even greater energy savings and optimal seasonal efficiencies, as per latest directives of the European Union.

It should also be possible to fix the evaporating temperature at different values in order to have the system operate with different Sensible Heat Factors. This way and depending on the indoor relative humidity the supply air temperature can vary (e.g. higher), thus increasing comfort levels through less cold air supplied in the rooms. At the same time relative humidity levels can be maintained within the comfort zone according to international standards and guidelines.

2.1.4.1.8.Continuous Heating During defrost

The VRV units should incorporate a function that guarantees continuous comfort during defrost cycles as defrost takes place regularly in order to increase efficiency of the system and protect the outdoor units from heat exchanger breaking down.

In order to avoid cold drafts and also the absorption of heat from the rooms, the indoors will not be used as the evaporator during defrost. The outdoor unit must have a special heat exchanger that will

act as the evaporator during defrost. In case of multi-outdoor systems, the defrost of the outdoor heat exchanger will take place in a consecutive way, by means of defrosting completely each heat exchanger one after the other.

For single-module systems the most preferred technology for the special heat exchanger will the one of using a phase changing material. This material will provide the necessary heat for the defrost cycle, while ensuring that any residual capacity of the unit will be provided in the indoor units for continuous heating.

2.1.4.1.9.Branch Selector units (BS-boxes) features

There shall be 2 types of BS-boxes to allow the design flexibility. Single port BS-box will allow the connected indoor units to change the mode simultaneously. Multi-port BS-box will allow the connected indoor units to change the operation mode independently. Single port BS-box must not exceed 210 mm in height to be available to be installed in limited ceiling space. Multi-port BS-box must not exceed 300 mm in height for the same reason. Both types of BS-boxes must be factory pressure tested and must not require piping caps cutting in order to save labour.

All single port Branch Selector boxes for heat/cool changeover must be fully sealed within a metal container eliminating any need for an external condensate drain. Multi-port BS-boxes should be capable of having any number of unused free ports capable of allowing additional indoor units of a size 140 class to be added at a later date without any loss of capacity.

Multi-port BS-boxes must have the possibility to unite 2 ports to allow the connection of large capacity indoor units (up to 10HP/28 kW cooling capacity).

Single port BS-boxes should have the additional solenoid valve to lower the evaporation temperature at the outdoor side if required to enable the connected indoor units to provide cooling under low ambient temperature (up to -20 0 C) for technical cooling purposes. This mode should be activated by additional setting. Single type BS-boxes should have sound pressure rating of no more than 31dBA under stable conditions.

2.1.4.2.INDOOR UNITS

2.1.4.2.1.High-wall units

DESCRIPTION AND MECHANICAL FEATURES

The unit casing shall be manufactured from heat resistant plastic. The casing colour shall be White N9.5. The front panel will be flat with return air from the top of the unit. The back plate and the support frames shall be manufactured from galvanised steel plate. The heat exchanger coils will be manufactured from copper tubes and aluminium fins. It shall have electronic expansion valve to control refrigerant flow rate in response to the load variation in the conditioned space. The expansion valve shall be controlled by an integral computerised PID control system to maintain correct room temperature. The fan shall be multi blade cross flow type, statically and dynamically balanced to ensure low noise and vibration free operation. The fan motor must be brushless DC inverter type to reduce the energy consumption. The condensate shall be drained from the unit using suitable tube and run directly to a main drainage point.

KEY CHARACTERISCTICS

All maintenance functions must be able to be performed from the front of the unit. Piping connections will be possible from either side or the back of the unit.

FUNCTIONS

The units must have the ability to control the louvers by remote controller and fix them at different angles. The number of positions must be at least 5.

The units must be able to be operated by wired or wireless remote controllers (by designer choice), available wired controllers must be available in 2 types at least (simplified and fully functional) to allow the design flexibility. The units must have the automatic restart function and multi-tenant ability.

ADDITIONAL OPTIONS

Adapters for remote control and monitoring must be available as options to allow integration with other types on engineering equipment. Remote temperature sensor (wired or wireless) must be also available as an option to allow the correct temperature control if installation situation does not allow

using the built-in sensor or remote controller sensor. The suitable drain pump must be offered as an additional accessory by manufacturer

2.1.4.2.2.Round Flow Cassettes

DESCRIPTION AND MECHANICAL FEATURES

The unit casing shall be manufactured from galvanised steel plate and shall be fully insulated. The use of a polystyrene only construction for the outer casing will not be acceptable. The heat exchanger coils will be manufactured from copper tubes and aluminium fins. It shall have electronic expansion valve to control refrigerant flow rate in response to the load variation in the conditioned space. The expansion valve shall be controlled by an integral computerised PID control system to maintain correct room temperature. The fan shall be DC for LOT 11 compliance of the dual suction multi blade type, statically and dynamically balanced to ensure low noise and vibration free operation. The indoor unit shall contain temperature sensors, to control the unit's heating / cooling output. The air filters shall be incorporated within the unit and shall be mould resistant washable resin net type

KEY CHARACTERISTICS

The unit must have a 360° Airflow pattern with reduced velocity and all round air distribution pattern to avoid hot and cold spots and to ensure uniform airflow. It shall have 23 possible airflow patterns to provide installation flexibility and cold draft absence despite the place of installation. A condensate lift pump shall be provided within the unit and shall be capable of discharging at a height of at least 850 mm above the drain outlet. The unit must sit no deeper than 204 mm within the ceiling void for class 20-63, 246mm for class 80 & 100 and 288mm for class 125.

FUNCTIONS

The low profile dedicated decoration panel shall be provided for each unit. The decoration panel shall incorporate the return air grille and supply air louvers. A facility shall be provided to automatically swing the supply air louvers or lock them at a desired angle between 20 0 and 60 0 to ensure even distribution of the airflow. The decoration panel should also be available in white with white louvers and black with black louvers. The decoration panel shall be manufactured to allow free passage of tempered air in all eight directions. Each flap must be controlled individually, with the ability to close 1 or 2 flaps to enable installation in the room corners.

The unit must have the ability to be disconnected from power supply without stopping of the whole system for repairing or parts replacement.

ADDITIONAL OPTIONS

There must be possibility to use the following optional accessories which can sufficiently improve user experience if customer requires so:

1) A floor sensor that can detect the average floor temperature and adjust the air flow to ensure even temperature distribution between the ceiling and the floor.
2) A presence sensor that detects the presence of people within a room and adjusts the set point if no one is detected in the room. It must also direct the air flow away from individuals within the room based on a four zone system.
3) A self-cleaning decoration panel that once a day automatically collects dust from the filer into the dust chamber, which can later be emptied by a vacuum cleaner attachment. This improves the unit energy efficiency be reducing the airflow resistance, and thus reduces the running costs. Also, this makes maintenance easier and reduces disruption whilst maintaining the unit. The self-cleaning panel is available in white and black colouring.
4) A designer panel that can be used in spaces with high aesthetics requirements. The designer panel covers the suction mesh, which contributes to increase aesthetic quality of the indoor unit. The suction of the air is coming from the sides of the suction area, not in the centre. It is available in white and black colouring.

2.1.4.2.3.Four way blow Cassettes

DESCRIPTION AND MECHANICAL FEATURES

The unit casing shall be manufactured from galvanised steel plate and shall be fully insulated. The use of a polystyrene only construction for the outer casing will not be acceptable. Facility shall be provided for duct connection for introduction of fresh air to the unit and branch ductwork from the unit. The heat exchanger coils will be manufactured from copper tubes and aluminium fins. It shall have

electronic expansion valve to control refrigerant flow rate in response to the load variation in the conditioned space. The expansion valve shall be controlled by an integral computerised PID control system to maintain correct room temperature.

The fan shall be DC for LOT 11 compliance of the dual suction multi blade type, statically and dynamically balanced to ensure low noise and vibration free operation and give excellent low draught characteristics. The air filters shall be incorporated within the unit and shall be mould resistant washable resin net type. The condensate shall be drained from the unit using suitable tube and run directly to a main drainage point. A condensate lift pump must be provided within the unit and will be capable of discharging 750mm above bottom of the unit

KEY CHARACTERISCTICS

The unit must be full flat to the ceiling protruding no more than 8mm. The unit must also be able to fit and be installed within a standard ceiling tile. The surrounding ceiling tiles must be able to rest on a slight lip (5mm) to allow correct/ accurate ceiling alignment.

FUNCTIONS

The low profile dedicated 4-way air discharge decoration panel shall be provided for each unit. The decoration panel shall incorporate the return air grille and supply air louvers. A facility shall be provided to automatically swing the supply air louvers or lock them at five adjustable settings.

The panel must be available in two colours (silver and white) to fit into as much design environments as possible.

ADDITIONAL OPTIONS

There must be possibility to use the following optional accessories which can sufficiently improve user experience if customer requires so:

- A floor sensor that can detect the average floor temperature and adjust the air flow to ensure even temperature distribution between the ceiling and the floor.
- A presence sensor that detects the presence of people within a room and adjusts the set point if no one is detected in the room. It must also direct the air flow away from individuals within the room based on a four zone system.

2.1.4.2.4.Ceiling concealed units (Medium Static)

DESCRIPTION AND MECHANICAL FEATURES

The unit casing shall be manufactured from galvanised steel plate and shall be fully insulated. The use of a polystyrene only construction for the outer casing will not be acceptable. Facility shall be provided for duct connection for introduction of fresh air to the unit and branch ductwork from the unit. The return air to the unit shall be through the back of the unit as standard. A facility shall be provided for alternative return air position through the underside of the unit. The heat exchanger coils will be manufactured from copper tubes and aluminium fins. It shall have electronic expansion valve to control refrigerant flow rate in response to the load variation in the conditioned space. The expansion valve shall be controlled by an integral computerised PID control system to maintain correct room temperature. The fan shall be DC to comply with LOT 11 and dual suction multi blade type, statically and dynamically balanced to ensure low noise and vibration free operation. Supply and return air grilles, properly sized for minimum pressure drop at rated air volume, should be supplied by others. The return air should be ducted back to the indoor unit in insulated galvanised sheet steel ductwork. Return air path will be possible from either the bottom or the rear of the unit. The condensate shall be drained from the unit using suitable tube and run directly to a main drainage point. A condensate lift pump shall be provided within the unit and shall be capable of discharging 625 mm above the bottom plate of the unit. The air filter must be included with the units and must be removable and washable and have a mould proof coating.

KEY CHARACTERISCTICS

The units shall be no more than 245 mm in height. The units must have ESP at least 150 Pa for the whole line-up to enable operation with sufficiently long ducts. The units must have sound pressure level of no more than 34 dBA for biggest models.

FUNCTIONS

The units must be able to be operated by wired or wireless remote controllers (by designer choice), available wired controllers must be available in 2 types at least (simplified and fully functional) to allow the design flexibility. The units must have the automatic restart function and multi-tenant ability.

The units must have the ability to alter the External Static Pressure (ESP) from the controller during commissioning and automatically at installer's choice, to avoid the insufficient air flow if the real installed ducting differs from the designed one.

ADDITIONAL OPTIONS

Adapters for remote control and monitoring must be available as options to allow integration with other types on engineering equipment. Remote temperature sensor must be also available as an option to allow the correct temperature control if installation situation does not allow using the built-in sensor or remote controller sensor.

2.1.4.2.5.Ceiling concealed units (High Static)

DESCRIPTION AND MECHANICAL FEATURES

The unit casing shall be manufactured from galvanised steel plate and shall be fully insulated. The use of a polystyrene only construction for the outer casing will not be acceptable. Facility shall be provided for duct connection for introduction of fresh air to the unit and branch ductwork from the unit. The return air to the unit shall be through the back of the unit as standard. A facility shall be provided for alternative return air position through the underside of the unit. The heat exchanger coils will be manufactured from copper tubes and aluminium fins. It shall have electronic expansion valve to control refrigerant flow rate in response to the load variation in the conditioned space. The expansion valve shall be controlled by an integral computerised PID control system to maintain correct room temperature. The fan shall be of the dual suction multi blade type, statically and dynamically balanced to ensure low noise and vibration free operation. The fan motor must be brushless DC inverter type to provide energy efficient operation. The condensate shall be drained from the unit using suitable tube and run directly to a main drainage point. A condensate lift pump shall be provided within the unit and shall be capable of discharging 625 mm above the bottom plate of the unit. The air filter must be included with the units and must be removable and washable and have a mould proof coating.

KEY CHARACTERISCTICS

The units shall be no more than 300 mm in height. The units must have ESP at least 200 Pa (5-12,5 kW units) for the whole line-up to enable operation with sufficiently long ducts. The units must have sound pressure level of no more than 40 dBA (low fan speed) for biggest models.

FUNCTIONS

The units must be able to be operated by wired or wireless remote controllers (by designer choice), available

wired controllers must be available in 2 types at least (simplified and fully functional) to allow the design flexibility. The units must have the automatic restart function and multi-tenant ability. The units must have the ability to alter the External Static Pressure (ESP) from the controller during commissioning; the steps to select ESP must be no less than 13. This is required to avoid the insufficient air flow if the real installed ducting differs from the designed one.

ADDITIONAL OPTIONS

Adapters for remote control and monitoring must be available as options to allow integration with other types on engineering equipment. Remote temperature sensor must be also available as an option to allow the correct temperature control if installation situation does not allow using the built-in sensor or remote controller sensor.

2.2.VARIABLE REFRIGERANT SYSTEM (VRS) GENERAL SPECIFICATION

The VRS system is to be factory assembled, factory charged, factory run tested of mentioned capacities, air-cooled, direct expansion type central air conditioning system consisting of one or more VRS condensing units (outdoor) and one or more evaporator (indoor) units. The system is to comprise of all accessible compressors, air cooled condenser, steel base for mounting the above components, refrigeration piping/circuit, fittings, valves, refrigerant and oil, controls and ancillaries.

The VRS system is to facilitate the operation and control of individual rooms and be able to cater for partial load of which can be as low as 10% of the total load. All outdoor units of the system are to be suitable for operation with 380V±10%, 50Hz, 3Ph, 4 wire AC supplies. All indoor units shall be preferable be suitable for operation with both 230V±10%, 50Hz, single phase supply or 380V±10%, 50Hz, 3Ph, 4 wire AC supplies.

The VRS system is to be of the inverter two or three pipe system and each system/zone is to be based on air cooled outdoor unit/s connected via a single refrigerant circuit, comprising gas and liquid pipework up to individual branch selectors. The indoor units are to be connected via two or three pipe system to the respective individual branch selectors.

The operation of the VRS system is to be through independent wired remote controllers and through HVAC central controller as specified. The complete VRS system units are to be capable of interfacing with motion sensors (motion detector) that are provided by others.

The contractor is responsible for the connection of all power requirements for the successful operation of the mechanical equipment between the electrical isolators provided by others and all the equipment specified in this document.

Fan delivery is not to decrease more than 10% when filter dirty. The operation point is to be in stable part of curve.

The units are to operate continuously without damage or malfunction for the following range of conditions at local altitude:

a) Indoor Unit: Entering Air Dry Bulb Temperature: 18ºC to 28ºC
   Entering Air Wet Bulb Temperature: 13ºC to 20ºC
b) Condensing Unit: Entering Air Temperature: -5ºC to 50ºC

A “low ambient” condensing control is to be incorporated in the unit if specified as such in the schedule.

Safety protection is to be provided for the fan motors as follows, unless otherwise specified:

a) Single phase motors: Thermal overload protection.
b) Three phase motors: Combined thermal overload and phase failure protection.

Fan motors are to be non-overloading at any operating point of their performance curves.

The system components and casings are to be designed for a service life of at least 15 years for local conditions based on a 12-hour daily operation. All components which may come in contact with water (rain, condensate, sweating of compressor, etc.) are to be protected against corrosion in order to obtain the desired service life.

Mounting brackets, bolts, hangers etc., to be of galvanised steel. Exposed brackets/hangers/supports are to be painted with a suitable paint for that environment.

The unit cabinet are to have the following minimum requirements:
a) Deflectors to be available on exposed split units to deflect the airflow in any direction or to concentrate the flow of air as required.
b) Service panels are to be provided to give access to compressor, fans, controls and electrical connections. No special tools to be required to remove these “easily removable” panels.
c) Cabinets to be constructed from fully galvanised sheet-metal powder coated to an approved colour.

The unit coils shall have the following minimum requirements:
a) The indoor unit coil to be aluminium fins mechanically bonded to seamless copper tubes. The fin spacing to be greater than 2mm. Ensure no “water carry over” during any operation condition.
b) The outdoor coil must be hail-proof.
c) Coil and refrigerant piping to be protected from freezing in ambient temperatures down to -5^0C.

The refrigerant piping system is to have the following minimum requirements:
a) The necessary traps to be installed in the refrigerant lines to ensure oil return for applications where the outdoor unit is installed higher than indoor unit in accordance to manufacturers installation manuals.
b) Flare connections to be used at the indoor and outdoor unit.
c) Three way valves with service port are to be installed at the outdoor unit for connection of standard refrigerant pressure gauges.
d) Fit a filter in the liquid line with a sight glass and moisture indication thereafter.
e) Provide facilities for charging the units with refrigerant and measuring the refrigerant pressures of the unit using standard refrigerant gauges.
f) Units which are not pre-charged are to be evacuated to a vacuum of not less than 4mm Hg before charging.

g) The insulation for the refrigerant piping to be of the “ultra-violet resistant” type. Insulation exposed to outside weather to be finished off with ultra-violet resistant plastic tape or paint.

Drainage of condensate from the units to be collected by the following means:

a) A pan of sufficient size to catch all condensate which may emanate from the unit.
b) Drainage via gravity feed from this pan to a suitable connection; or booster pump assisted drainage where indicated on the relevant drawings or in the accompanying schedule.
c) The drain pan to be fabricated from PVC piping.
d) Drain piping to be fixed and routed to the nearest suitable drain point to ensure positive drainage.
e) Drain piping to be resistant or protected against weather elements or people traffic.

The electrics and controls are to have the following minimum requirements:

a) All electrically powered elements within the unit to have an adequate resistance to earth, with due regard to the possible condensation of moisture and comply with statutory requirements.
b) Interconnecting wiring from the outdoor unit to the indoor unit is to be via conduits or suitable special cable.
c) Power supply from the local isolator is to be protected against the elements by means of conduit or suitable cable.
d) Confirm adequacy of the power supply at equipment submission stage.
e) A manual override facility is to be provided on the indoor unit if a remote wireless temperature/ control unit is offered.

The Contractor is to submit with his tender certified performance tests of capacity and power consumption at either ISO conditions or local conditions by the SANS or a similar organisation. Performance to be based on the actual mounting details and location where installed. Performance testing of each unit to be done in a certified “on line” test facility. The minimum tests are to include compressor running amps, entering and leaving temperatures, a leak test, the heater amperage, all controls for function and calibration of thermostat. All results to be properly recorded against the serial number of the unit and signed off by the responsible person for quality.

2.2.1.Condensing Unit (Outdoor Unit)

The condensing units are to be capable of providing cooling and heating within the ambient range of -5°C to 50°C DB. The system must be self-intelligent to run on low outdoor ambient conditions for better power consumption irrespective of number of indoor units in operation.

The condensing unit is to be capable of assessing the requirement of liquid refrigerant volumetric flow of each evaporating unit at all times by means of a sophisticated microprocessor controller and generating the required total volume of refrigerant liquid for supply to the evaporator units.

The condensing unit is to be a factory-assembled unit housed in a sturdy weatherproof casing constructed from rust proof galvanized powder coated steel panels. The unit must be completely factory wired tested with all necessary controls. The noise levels of the unit are not to be more than 70dB (A) measured horizontally 1 m away and 1.5 m above base level. The sound data should be measured in accordance with SANS applicable standard.

The compressors are to be hermetically sealed Inverter driven variable speed type scroll or rotary type, with multiple steps of capacity control capable of changing the capacity in accordance to the cooling or heating load requirement. All condensing units are to be provided with multiple compressors and be able operate at part load in case of failure to other compressor. The outdoor units are to employ a system of equal run time for all the compressors.

The condensing units are to be filled with low noise, aero-spiral design fan with grill for spiral discharge airflow to reduce pressure loss and be fitted with DC fan motor to better efficiency. The unit is to be capable of adequate external static pressure and be designed to operate safely when connected to multiple fan coil units.

The condenser coil is to be air cooled type with copper tubes and aluminium fins. The condenser coils are to be constructed out of copper tubes mechanically bonded to aluminium fins to form a cross fin coil. The surface of the condenser coil is to be coated with anti-corrosion resin film to prevent deterioration due to coastal climate.

The refrigeration circuit is to have liquid and gas shut off valve or solenoid valve at condenser end. The refrigerant control is to be through the Electronic Expansion Valve (EEV). The following safety devices are to be provided as minimum shall to ensure safe operation of the system:

a) High pressure for inverter switch;
b) Fan drive overload protector;

c) Over current relay for inverter;
d) Inverter overload protector;
e) Short re-cycling guard timer;
f) Fuse crankcase heater, Fusible plug; and
g) Auto re-starts on power supply interruption

The units are to be equipped with a highly efficient oil separation system to ensure stable operation with long refrigerant piping. High efficiency oil separation is to be fitted to the discharge side of the compressor together with factory oil equalisation system which must be factory assembled and tested.

The VRS condensing units are to be located in open on a terrace with adequate clearance from nearby objects to ensure unobstructed air flow and easy approach for maintenance.

The condensing units are to be installed onto the concrete plinth or against the outside by means of channel frames with stainless steel bolts/chemical anchors. Vibration eliminators are to be installed between the condensing unit frames and the supporting brackets.

2.2.2.Duct-able Indoor (Evaporating Units) Units

The units are to be supplied complete with coiling/heating coil, fan assembly, refrigerant ping and refrigerant controls and safety devices. The unit coils are to be made of copper tubing having extended aluminium fins. The tubes are to be mechanical expanded for positive bonding between tubes and fins. The coils are to be fed with liquid refrigerant through electronic expansion valve and distributor.

The unit fans are to be statically and dynamically balanced and designed for silent operation at required airflow rates against specified static pressure. The units are to have high static fan for duct-able arrangement. The units are to be equipped with three speed fan motors capable of controlling the airflow to low, medium, high speed. The filters are to be of MEVR 8 washable synthetic media type arranged for convenient cleaning and replacement.

The unit casing is to be of light weight galvanised steel plate, duly power coated for weather protection and sufficient service area provided all around the units. The drain pan is to be fabricated out of heavy steel metal sheet. The units are to be equipped with built-in drain pumps; suitable for vertical lift of 750 mm.

2.2.3.Cassette Type Indoor Units

The units are to be supplied complete with cooling/heating coil, fan assembly, refrigerant ping and refrigerant controls and safety devices. The cassette units are to be installed between the bottom of finished slab and above false ceiling. The cassette units are to be installed such that the bottom is flush with the ceiling and no air gaps are to be visible around the face plate. Sufficient service area is to be provided all around the unit.

The unit casing is to be of light weight galvanised steel plate, duly power coated for weather protection. The drain pan is to be fabricated out of heavy steel metal sheet. The units are to be equipped with built-in drain pumps; suitable for vertical lift of 750 mm.

The cassette units are to be insulated with sound absorbing thermal insulation material similar or equal to polyurethane foam or polyester sheet. The noise level of the unit at the highest operating level is not exceed 40 dB (A), at vertical discharge of 1.5 m from the grill of the unit. The cassette units are to be supplied with suitable decorative panels. The filters are to be of MEVR 8 washable synthetic media type arranged for convenient cleaning and replacement.

The cassette units are to be equipped with three speed fan motors capable of controlling the airflow to low, medium, high speed.

2.2.4.High Wall Mounted Type Units

The high wall mounted type units are to be supplied complete with direct expansion coils, electric motor, fan, insulated sandwiched drain tray and junction for electrical connections. The housing of unit is to be light weight powder coated galvanized steel. Noise level should not be more than 40 dB (A) at medium speed at 1.5 m distance.

The fans are to be of the dual suction multi blade type, statically and dynamically balanced to ensure low noise and vibration free operation. The units are to be equipped with three speed fans capable of

controlling the airflow to low, medium, high speed. The filters are to be of MEVR 8 washable synthetic media type arranged for convenient cleaning and replacement.

2.2.5.Controls and interlocking

The entire VRF/VRV system is to have microprocessor controls with an automatic monitoring function to indicate piping and cabling errors. The microprocessor is control speed or switching or by pass of compressors, condensers, fans, and liquid management including proper oil return and stable and safe operation of system. The microprocessor is to have a pre-set memory, which shall not be erased on power failure. The entire VRF/VRV system is to have automatic restart in case of mains failures.

Precision temperature control is mandatory with Electronic Expansion Valves adjusting to load fluctuation and operating load fluctuation to maintain ± 0.5° C of set point with Proportional-Integral-Derivative (PID) control Algorithm.

All units are to be equipped with individual hard wired controllers for operation and control. All units are to have self-diagnostic function to pre-warn of failure or problems with function codes. Power to the control system is to be generated inside the units from common power supply.

2.2.6.Hard Wired Controllers

Individual areas are to have hard wired controllers for controlling individual units. The controller must have large crystal display screen, which displays complete operating status. The controllers must be able to individually program by timer for operation start and stop within a maximum of 72 hours.

The controllers must be equipped with thermostat sensor in the remote controller that will make possible more comfortable room temperature control. The controllers must be able to monitor room temperature & pre-set temperature by microcomputer & can select cool/ heat operation mode automatically. The controllers must constantly monitor malfunctions in the system & must be equipped with a “self-diagnosis function” that let know by a message immediately when a malfunction occurs. Controlled units are to have digital indication of temperature along with setting and other functions such as ON / OFF switch, timer, operation of the fans, swing of louvers and other operation modes as desired including diagnostics.

The contractor is to make an allowance for connecting each fan coil unit in each zone to its own controller. The controllers are to be installed against the wall (surface mount), with control wiring to the ceiling void installed in PVC trunking. Each controller is to be clearly marked to indicate the unit number corresponding to the working drawing. Controllers are to be set to switch on per end-user requirements. The controller must be able to be overridden for after-hours operation.

The units are to be provided with an adjustable temperature controller with an adjusting range of 19-24ºC. The sensitivity of this temperature controller is to be such that it controls in a differential band of 2ºC (adjustable 1 to 4ºC, factory set at 2ºC), 1ºC on either side of the set points. The temperature controller is to be clearly marked in which way to adjust the room temperature. The temperature controller is to switch on the heater or compressor automatically in accordance with the load.

2.2.7.Central Remote Controller

The complete VRS system is to be provided with controls which area capable of interfacing with a HVAC Central Controllers via BACnet or LonWorks or Modbus adapter to enable the monitoring and control of the entire air conditioning system, set working parameters of all indoor units and the VRF/ VRV outdoor unit from this HVAC Central Controllers. The interfacing with a HVAC Central Controllers should make it be possible to control several number of indoor units and change fan speed and angle of swing flap individually and in group.

The central remote controller unit is to be equipped with self-diagnosis for easy and quick maintenance and service. The remote controller is to memorize the latest malfunction code for easy maintenance. The controller is to be equipped with a battery back-up and a real time clock. It should be possible to control several number of indoor units and change fan speed and angle of swing flap individually and in group.

Central Controller is to be compactable to connect with Fire Detection System and Building Management System (BMS) of standard makes.

2.3.GENERAL SPECIFICATIONS FOR FANS

Fans shall be of reputable manufacturer. The manufacturer shall be in possession of certified performance rating of fans. The test method and results should be in agreement with ISO 5801 or AMCA 210.

Safety protection is to be provided for the motors as follows, unless otherwise specified:

a) Single phase motors: Thermal overload protection.
b) Three phase motors: Combined thermal overload and phase failure protection.

The allowable maximum downtime for fans is to be so installed that replacement is not to take longer than 2 hours when executed by qualified building maintenance staff.

The contractor is to submit service, maintenance, troubleshooting and testing instructions in order to obtain acceptance approval. Documentation is to be indexed in accordance with the equipment part of the Operating & Maintenance Manuals.

Fans are to be provided complete with standard flanges.

Bearings are to be of the permanently lubricated type.

Air flow arrow indicators to be installed for each fan unit.

Motor rating is not to be less than the maximum power required by the fan at any operating point between zero and break off capacity.

Fan casing is to be insulated with high density acoustic insulation to limit break out noise to the occupied space.

The fan motor is to be provided with manually adjustable speed controller (where required) to deliver the specified air quantity.

The contactor is to install fan assemblies in accordance with manufacturer's recommendations.

Contractor is to supply the necessary field-testing instruments and detailed description of field testing arrangement to prove a capacity/performance measurement accuracy of ± 5% for the Fan Acceptance Testing (FAT). Certified test results are to be plotted on the official published and certified equipment performance graph/table to confirm that claimed performance is achieved. The various tests as required by the Quality Management System are to be demonstrated and accessible to the Employer at all times for monitoring.

2.3.1.Centrifugal Fans

Centrifugal fans are to be of the multi-bladed type with forward or backward curved blades, dependent on delivery air pressure requirements. The bearings may be of the sleeve, ball or roller type, but they must be selected and fitted for quiet operation, as recommended by the bearing manufacturer. The impellers and casings are to be rustproof to prevent corrosion.

The fans are to be direct drive type or belt driven and the motor must be of standard type that shall be easily replaceable and may be either sleeve or ball bearing type. Maximum speed of the motor is to be 1450rpm, unless it specified otherwise in the detailed specifications

2.3.2.Propeller Fans

Propeller fans are to be of the ring-mounted type when operating without ducting, and of the diaphragm-mounted type when mounted in ducting.

The bearings are to be of the sleeve type, except where the shaft of the fan is mounted vertically, when ball or roller bearings shall be used. Where fans are handling moist air, all components of the fan and motor are to be suitable for operation in saturated atmospheres.

2.3.3.Axial Fans

Fans are to be of direct driven suitable for mounting at any angle and mounted on vibration isolation mountings.

Impellers are to be of genuine aerofoil design and incorporate an adjustable blade pitch feature facilitating factory or site resetting of fan duty. Hubs and blades are to be die cast in aluminium silicon alloy materials, assembled with high tensile zinc plated steel bolts and nuts. Complete units are to be statically and dynamically balanced.

The fan casings are to be hot dip galvanised after manufacture. Standard casing lengths are to cover the overall length of the impeller and motor assemblies. External terminal boxes are to be provided on the casings of fans fitted with standard totally enclosed motors. Where flameproof motors are fitted electrical connections are to be integral with the motors and external connections are not be provided.

2.4.REFRIGERANT PIPING

New refrigerant piping is to be used for this installation and the contractor is to allow for adequate piping in both sizes of refrigerant piping. Each refrigerant pipe set is to be installed in its own trunking or on cable trays. The trunking is to be cleaned after the completion of the installation. The contractor is to ensure that the installation on the inside of the building is neat and of good workmanship nature.

The refrigerant piping on the outside of the building is to be installed in galvanized trunking of at least 100 x 76mm. The galvanized trunking is to run the entire outside distance from the condenser unit to the indoor unit and no refrigerant piping or drain piping is to be visible inside the room.

Refrigerant piping between indoor and outdoor units located above false ceilings are to be supported along its entire length by a galvanised perforated cable tray of sufficient size to allow pipe work to be neatly laid out and insulated. The cable tray is to be supported clear of fixing surface by galvanised brackets allowing air space between cable tray and mounting surface.

Where piping and insulation is exposed to damage, a galvanised sheet metal cover having a minimum thickness of 0.8mm shall be neatly formed and secured to the cable tray brackets. Joints are to be lapped by a minimum of 30mm and to have a minimum clearance of 10mm over insulation.

The suction line pipe size and the liquid line pipe sizes are to be selected according to the manufacturers specified outside diameter. All refrigerant pipes are to be properly supported and anchored to the building structure using steel hangers, anchors, brackets, and supports which are to be fixed to the building structure by means of inserts or expansion shields of adequate size and number to support the load imposed thereon.

The refrigerant piping interconnecting to indoor & outdoor units is to be made out of hard/soft copper tubes, in brazed construction. The refrigerant line sizing is to be designed to achieve minimum pressure drop and avoid oil return problem. The pipe sizes and connections are to be designed such that the evaporator units do not face back pressure due to the functioning of the evaporator next to it.

All refrigerant piping for the air-conditioning system is to be constructed from soft seamless up to 19.1 mm and hard drawn copper refrigerant pipes for above 19.1 mm with copper fittings and silver soldered joints. The refrigerant piping arrangements are to be in accordance with good practices within the air conditioning industry, and are to include charging connections, suction line insulation and all other items normally forming part of proper refrigerant circuits.

The thickness of copper piping is not to be less than mentioned below:

Table 1: Thickness of refrigerant copper piping

Pipe Size (OD) in mm	Wall thickness in mm
54.10	1.5
41.28	1.3
34.93	1.3
28.58	1.2
22.22	1.0
19.05	1.0
15.88	1.0
12.7	0.8
9.52	0.8
6.35	0.8

The refrigerant piping suspended from the roof slab are to be supported by trapeze hangers manufactured from galvanised mild steel angle iron, suspended from the slab by threaded rods. The threaded rods are to be screwed into expanding anchors in the slab. The refrigeration piping running along the walls shall be clamped to cable tray sections fixed to the wall. The maximum support spacing for refrigerant piping is to be as follows:

Table 2: Maximum Support Spacing for refrigerant piping

Pipe Size (OD) in mm	Maximum Support Spacing (mm)
0 to 15.9	1500
15.9 to 25.4	2000
25.4 to 41.3	3000
41.3 and up	4000

The refrigerant piping system is to be selected satisfy the following:

a) To minimise loss of lubricating oil from compressor at all times.
b) To ensure lubricating oil return to compressor, at the same rate at which it leaves under all load conditions.
c) To prevent lubricating oil being trapped in system.
d) To prevent liquid refrigerant from entering the compressor during operation and shutdown.
e) For minimum pressure drop and noise generation. The suction, discharge and liquid lines are to be sized so that the pressure drops do not cause a change in saturation temperature of refrigerant greater than 1.1 degrees C in each respective line.
f) For handling the specified capacities from 100% down to minimum load at specified suction and discharge/condensing temperature.

Refrigerant piping accessories and connections are to be selected to ensure no leakage from refrigerant piping system during its operational life.

Refrigerant piping system is to be complete with all necessary isolating valves to enable repairs and maintenance to be carried out on any one section of the system.

The refrigerant accessories are to be so connected and installed into the refrigerant piping system such that, either a sub component replacement or total removal and reinstallation of the accessory does not take longer than 2 hours by qualified refrigeration mechanics.

The refrigeration piping system, including accessories, thermal insulation, hangers, supports and vibration isolators shall be selected and installed to give a minimum working life of 15 years under normal building service conditions.

All joints in copper piping shall be sweat joints using low temperature brazing and or silver solder. Before joining any copper pipe or fitting, its interiors shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints. The entire refrigerant piping system is to be subjected to a leak pressure test with a suitable gas, e.g. clean dry air or nitrogen. It is permissible to add system refrigerant to enable leakages to be more easily detected.

Prior to carrying leak pressure test, the Contractor verifies by examination of the various parts of the components of the system that the test pressure to which they were subjected at the manufacturer's works, are adequate for the required duties.

The Contractor shall incorporate a safety valve or rupture disc in the piping system. Rupture discs are to have a specified and certified bursting pressure at a specified temperature and marked accordingly on the disc.

The system is to comply with the Safety Code for Refrigerant Piping ASA B31.35–1962, with the requirements of ASME, with Occupational Health and Safety Act as amended, and with local authority's by laws.

The refrigeration piping is to be stored and handled on site to prevent dirt from entering piping system. Open ends are to be plugged.

Where required for connection to gauges and control devices, tubing not larger than nominal 10mm may be type K soft (annealed) with flared tube fittings suitable for high pressure.

Accessories connected to copper tubing are to have solder type ends or flanged ends and soldered flange adaptors.

Piping is to be installed so as to allow for expansion and contraction. Suction and discharge lines are to be installed so that the first point of support is 6 pipe diameters in each of three directions from the unit.

System vibration isolation shall be in accordance with Sound and Vibration Control requirements.

Thermal insulation of suction line is to be in accordance with insulation requirements.

Piping is to be installed parallel or perpendicular to building construction, while maintaining the required gradients.

All necessary pressure gauges are to be installed in refrigerant lines to check pressures and temperatures for load monitoring function of various accessories and possible blockages of strainers.

Isolate accessories requiring regular inspection, cleaning and removal by shut off valves to enable this without pump down of the entire refrigeration system.

Liquid receivers are to have the following minimum requirements:

a) Each receiver is to have sufficient capacity to hold all refrigerant in the system to which it is connected, except that in plants having two or more separate refrigerant circuits, cross connected by pump out piping.
b) The receiver is to have sufficient capacity to hold all refrigerant in the largest circuit. Receiver capacity is to be based on not over 85% of its internal volume being occupied by liquid. Receiver is to be complete with liquid level indication.

Liquid Suction Interchanger is to have the following minimum requirements:

a) Heat exchangers for field assembled systems are to be the standard products of a reputable manufacturer. Field fabrication of heat exchangers is not permitted.
b) Heat exchangers for field assembled systems are to be of the shell and tube, shell and coil or double tube type. Tubes are to be seamless copper, plain or with integrally formed fins. Shells are to be welded steel, conforming to the requirements of the latest edition of the Mines and Works Act or the Machinery, Factories and Building Work Act and Regulations, covering pressure vessels. Gas passages are to be arranged so as to prevent trapping of oil. Liquid gas heat exchangers for Refrigerant 12 are to have sufficient surface to ensure heating the gas to not less than 18.5 degrees C at the outlet. Liquid pressure drop is not to exceed 21 kPa and gas pressure drop not to exceed 3.5 kPa.

Refrigerant driers are to have the following minimum requirements:

a) Refrigerant driers for field assembled systems are to be of the angle type with removable cartridges that can be renewed without disturbing pipe connections. Driers are to have brass or steel bodies and solder joint connections. Bonnets are to be flanged and bolted. Cartridges are to be charged with dry silica gel or activated alumina, held securely in place without restraining normal expansion, and provided with suitable means for distributing the refrigerant evenly through the charge. Unless otherwise indicated driers are to be installed in liquid lines close to the receiver outlets and be provided with valves on the inlet and outlet connections. Valve bypasses are also to be provided unless the driers are of a type guaranteed by the manufacturer to operate indefinitely without dusting of the desiccant or appreciable increase in pressure drop. Install a liquid sight glass and moisture indicator of the colour change type in the liquid line, close to each drier.
b) Select each drier so that the pressure drop through the drier does not exceed 14 kPa when operating at full connected evaporator capacity.
c) Drier cartridges are not to be installed until after pressure and vacuum tests have been completed but immediately prior to charging.

Thermostatic Expansion Valves shall have the following minimum requirements:

a) In field assembled systems, each evaporator circuit is to be provided with a thermal expansion valve of the gas charged type.
b) Valves are to have external equalizer connections, external superheat adjustments with seal caps and solder joints or flanged pipe connections.
c) Valves are to move from fully open to fully close with not more than 3 degrees C superheat change. Superheat setting is to be 6 °C at full load. Each valve is to be provided with an external strainer, regardless of any internal strainer that may be incorporated in the construction. Strainers are to be as specified under “Refrigerant Strainers”.

Oil Separators shall have the following minimum requirements:

a) Each reciprocating compressor having suction and/or liquid mains more than 15 m long is to be equipped with a discharge line oil separator.
b) Separators are to be made of welded steel and have an effective impingement type separating element, an oil sump and a float operated return trap connected to them to return oil to the compressor automatically.

Refrigerant stop and shutoff Valves shall have the following minimum requirements:

a) Refrigerant stop valves generally are to be of the back seating key operated, sealed cap type. Valves which are opened and closed in regular operation are to have pack-less type hand wheels.

Refrigerant strainers shall have the following minimum requirements:

a) Refrigerant strainers are to be of the angle type, cleanable without disturbing pipe connections. 40 mm N.B. strainers and smaller are to have brass bodies and solder joint connections. 50mm N.B. strainers and larger are to have brass or rust proofed steel or iron bodies and flanged connections. Connections are to be flanged and bolted.
b) Screens are to be bronze with perforations not larger than 0.25 mm for liquid lines and 0.5 mm for gas lines. The free area of each screen is not to be less than 5 times the area of the strainer inlet pipe.

Charging valves are to be located in the liquid line between the receiver shutoff valve and expansion valve.

Provide external gauge connections at inlet and outlet of condenser, evaporator coil and compressor to enable evaluation of system pressures at commissioning and for normal maintenance inspections.

All gauges are to be connected to the refrigerant piping system through isolating shut off valves.

Liquid indicators are to be of sight glass – double port with seal cap type – of full size in the main liquid line before the thermostatic expansion valve.

The solenoid valves are to have manual override to enable the system to continue to operate in case of solenoid coil failure.

Vibration Isolators (flexible connectors) are to have the following minimum requirements:

a) Suction and discharge lines from the compressor are to be fitted with flexible connectors of the bronze braided hose type, having sweatends, to fit over copper tubing having the same size as the line in which they are installed.
b) Locate flexible connector as close as possible to the compressor and parallel to the compressor shaft. It shall not be subjected to compression or extensions.
c) For refrigeration installation utilising a remote air cooled or evaporative condenser, hot gas mufflers shall be used to remove pulsations from the hot gas discharge and thereby reduce noise and vibration from the piping system. The hot gas muffler must be installed to prevent accumulation of oil.

The complete refrigeration piping system is to be pressure tested with dry nitrogen and leak test carried out. Test pressure to be maintained for 24 hours with no loss in pressure. Complete system to be evacuated and proved to be free of moisture. System is to stand for a minimum of 12 hours with no change in Vacuum. System to be liquid charged on high side following purging of connections to the estimated total charge. Minor adjustment to charge is to be carried out during the 12-hour test run. The following method is recommended for pressure leak testing:

a) Use a mixture of nitrogen & trace refrigerant in conjunction with one of the following suitable leak detection methods: Acceptable leak test methods include, Liquid submersion testing, soap bubble leak detection, fluorescent leak detection & electronic leak testing or any acceptable standard.
b) Pressurise the complete system with dry nitrogen & leak test using any acceptable method.
c) Having ensured there are no leaks using A or B above, the system must be pressurised to a safe test pressure. Observe over a period of time, relative to the size of the system that no pressure drop occurs, having due regard to temperature variation throughout the system.
d) After determining that there are no refrigerant leaks when the system is pressurised, the system must be evacuated to remove moisture & air. Evacuation must be deep evacuation method, or triple evacuation using dry nitrogen only as the moisture absorber. To be witnessed by *Employer's* representative.
e) DEEP VACUUM METHOD: Pull a deep vacuum to a pressure of less than 13 Pa absolute (100 microns of mercury). After isolation the vacuum pump, allow the system to stand for 60 minutes to ensure the vacuum is maintained at or below 16 Pa absolute (120 microns of mercury), OR

f) TRIPLE EVACUATION METHOD: Use a vacuum pump to pull a vacuum to a pressure of at least 260 Pa absolute (2,000 microns of mercury). Break the vacuum with dry nitrogen & allow the system to stand. Re-evacuate the system & repeat the procedure twice more, breaking the vacuum each time with dry nitrogen.
g) The final evacuation should be held for twelve hours with no loss of vacuum. After the system has been evacuated the vacuum pump should be isolated from the system and as guide, with constant ambient conditions' the vacuum should not rise above 13 Pa absolute (100 microns of mercury) in one hour. A greater rate of rise may indicate a leak. Absolute vacuums should be measured using accurate measuring equipment selected for the specific application.

Expansion valves and solenoids are to be stripped before welding refrigerant pipes so as to avoid overheating and associated damage to seals, or they are to be kept at constant temperature by means of damp rags.

Should the refrigerant piping run longer than normal, the amount of refrigerant oil is to be increased in the pipe system as per the manufacture's specification.

2.5.DRAINAGE OF CONDENSATE

The indoor unit's condensate is to be drained by both gravity and condensate lift pumps via PVC drain piping to the nearest gullies. U-traps will be installed in the Polyvinyl Chloride (PVC) drain piping to prevent odours being drawn back into the units.

Each air conditioning unit is to be provided with suitable PVC or Galvanised drain piping that shall rise to maximum allowable height in accordance with manufacturer's specification, so as to create the correct trap arrangement.

The drain piping on the outside of the building is to be extended to the water gutter that runs around the building. Each drain piping set is to have a suitable P-trap depth.

The contractor is to allow for adequate PVC or Galvanised drain piping for each air conditioning unit. The first two meters of the drain piping from the indoor unit are to be covered with non-drip tape to ensure no condensation around the drain pipes on the inside of the building. The drain piping is to be supported every two meters by mean of brackets.

2.6.DUCTING

The ducting system is to comply in all the respect with SANS 1238-Standard specification for Air-conditioning ductwork and SANS10173 and Code of practice for the Installation, testing and balancing of Air Conditioning Ductwork and be manufactured and supported according to SMACNA Duct Construction Standard.

The low pressure ducting is to be utilised in systems where external pressure is below 400Pa. The medium pressure ducting is to be used where external pressure is higher than 400 but not exceed 1000Pa and above 1000Pa a high pressure ducting is to be installed

Ducts, when installed, are to run in straight lines, without winding or twisting.

Ductwork is to be designed for uniform airflow with minimum number of bends, restrictions and abrupt changes in section.

Double thickness turning vanes are to be fitted to all square bends to reduce air turbulence and pressure loss.

Duct dimensions and routes are detailed on project specification and drawings. The contractor is to check all dimensions when preparing shop drawings and check all critical dimensions, if possible by site measurement, to make sure that the ducts will fit and not foul other services.

The Contractor will be required to co-ordinate with others to ensure equitable sharing of service reserves and to ensure that the building contractor is notified timeously of any accesses required through ceilings or walls for balancing or servicing of this system. Any building work resulting from the air-conditioning contractor's default in this respect will be for the air-conditioning contractor's account.

Duct joints in plant rooms, masonry shafts and at wall or floor penetrations are to be flanged. Duct sections that pass through walls are to be of heavier gauge and/or braced to ensure there will be no distortion of the duct when it is built in or grouted.

Ductwork is to be stiffened with cross-breaks, be free from drumming and supported at spaces not exceeding 3000 mm. Hangers, saddles, rods, etc. for hanging ductwork is to be of rigid construction, to Employer's approval.

Spigots to diffusers and grilles are to be long enough to ensure uniform air velocity across the spigots at the diffusers or grilles.

Flexible ducting is to be of circular in form with either a steel helix covered externally with approved material or be of all metal interlocking spiral construction. The ends are to be suitable for securing to sheet metal spigots with securing bands which must be easily removable for possible maintenance requirements to adjacent equipment. Flexible ducts are to be suitable for the system temperature and pressures and be non-combustible.

All supports and fixing accessories are to be provided. Ducts supports are to be in accordance with SMACNA. Employer prefers cadmium plated or galvanised mild steel threaded rods with angle iron or uni-strut which does not deflect visibly.

2.7.WELDING

Welding is to be carried out by skilled welders who are in possession of a current certificate of competence Grade II issued by an approved authority, in accordance with SANS 10044.

All welds are to be fully penetrated in accordance with SANS 10044 – Class `C' unless otherwise agreed to by Employer.

Contractors will be required to prove the quality of pipe joint welds, at their own cost by having 10% of the joints, radiographed as nominated by Employer. Should any of the welds prove unsatisfactory in terms of fault limitations; the contractor will be required to radiograph all welds and repair defective welds as required.

Either the electric arc or the oxy-acetylene method may be used.

The preparation of surfaces, edges and ends of plates are to be free from irregularities and shall where practicable, be formed by machining. Where flame cutting has been used, the burnt edges are to be dressed back to the parent metal by grinding. Any welding carried out on burnt or rough surfaces will be rejected by Employer and the Contractor shall grind out all the weld metal deposited thereon.

Welding work may be held in position before and during the welding by bridges, lugs, etc., however no stresses are to be transmitted onto the completed weld after their removal. Tack welds used for assembly must be completely removed by chipping or grinding prior to the execution of the main-weld. Every precaution is to be taken to avoid distortion or inherent stresses during and/or after the welding.

No welding is to be carried out on wet surfaces; if moisture is apparent, the surfaces must be thoroughly dried prior to welding. Furthermore, no welding is to be undertaken external to a protective shelter during periods of strong wind or other adverse weather conditions. During welding operations no pneumatic tools etc., shall be used which may cause vibrations to the component being welded.

Full penetration is to be provided for all highly stressed welds and back-gouging is to be carried out. Before further welding commences, the gouged seams are to be cleaned, inspected and approved by Employer.

When the general hydraulic tests of the completed systems are carried out, each weld is to be lightly hammered whilst pressure is maintained. If any leaks occur, the portion of the weld near the leak is to be cut out and re-welded. Should a considerable portion of the welded joints made by a particular welder be found to be defective due to faulty workmanship, all such welds shall be cut out and re-welded by another welder whose work has proved satisfactory.

2.8.INSULATION

All insulation materials are to be in close contact with the surface to which it is applied and all joints are to be sealed ensuring that the edges of the sectional material are in close contact with one another over the insulated surface.

Application of insulation is to be by specialists whose specification shall be submitted for approval.

The complete chilled water system is to be insulated including piping, fittings, valves, etc. Chilled water pipework is to be insulated with sectional glass fibre effectively vapour sealed. The pipework is to be supported by bands applied outside the insulation. Shaped wooden blocks of the same thickness as the insulation must be used at these points to carry the weight of the pipes. Galvanised sheet metal cladding fixed with metal strips is to be applied to the chilled water pipes. Fittings, valves, etc., are to be insulated with hard setting cement fibre mix, trowelled smooth and level with the adjoining insulation and cladding.

All air conditioning air ducting (supply, return, outside air and flexible connection) is to be insulated as required by detailed specification. Ventilation ducting generally do not need insulation unless passing through hot not accessible areas.

Where internal duct insulation is specified 25 mm sonic duct liner is to be used. The lining is to comprise a medium density fibre glass blanket faced with a black heavy weight glass cloth. Mechanical fasteners are to be used with spacing's in accordance with SANS 1238. Where external insulation is specified the duct not exposed to view is to be rapped with aluminium foil and ducts exposed to view shall be double cladded.

The insulation is to be applied with suitable adhesive and securely fixed to the metal surface. The metal strips are to be applied at every duct support to secure the insulation and shall not compress the insulation material. Adhesives and sealants used in ducting for fixing insulating material and sealing duct joints are not to be readily combustible or produce excessive smoke or toxic gasses.

The insulation is to assure continuity of vapour seal to avoid condensation and corrosion of ducts

The insulation material is to be non-combustible according to BS 476 Part 4 but may have a surface thickness not thicker than 0,8 mm resulting in a class 1 spread of flame to BS 476Part 7 or have an index of performance to BS 476 Part 6 not greater than 15.

2.9.PAINTING AND CORROSION PROTECTION

For speedy recognition and warnings; the plant, contents of pipelines, moving machine parts and other accident potential areas are to be identified by painting them in identifying colours in accordance with Code of Practice SANS 10140 and identification colours numbered as given in SANS 1091. The following colours are to apply:

Table 3: Identification colours

Equipment or Plant	Colour Code
Condenser water pipework	Grass Green H14
Chilled water pipework	Strong Blue F11
Potable water pipework	Brilliant Green H10
Air pipework	Arctic Blue F28
Valves and fittings	As associated pipework
Valve wheels	Black
Base plates	Black
Ducting	Navy light Grey G35
Pumps	Grass Green H14
Fans	Navy light Grey G35
Motors	Navy light Grey G35
Drains	Black
Drain Tundishes	Black
Middle rail and supports	Teak
Belt guards	Light Orange B26
Duct heaters	Light Orange or lagged
Cable trays	Galvanised
Packaged equipment	As manufactured
Junction boxes	Navy light Grey G35
Actuators	Light Orange B26
Stainless steel equipment	No painting – polished

The existing stations need to continue using existing colour coding system as per SANS 10140-3.

Ductwork (except for those exposed to outside air) is not to be painted over the whole length but identifications is to be placed at all junctions, service applications, bulkheads, wall penetrations, at both sides of dampers, and at any other place where identification is regarded as necessary.

External ductwork is to be corrosion protected and painted.

All pipework is to be painted over the whole length of the pipework and treated to resist corrosion.

All ferrous materials and equipment are to be provided at manufacturer's works with a protective primer which is to be made good during construction. After erection materials and equipment is to be thoroughly cleaned, degreased and given a priming undercoat and two finishing coats suited to the application. Where ferrous pipes, etc., are to be insulated they are to be given one coat of red oxide zinc rich primer prior to application of insulation.

Galvanised materials which require painting is to be thoroughly cleaned and degreased, given a primer and two finishing coats.

Ducting for the battery room ventilation is to be specially treated as follows:

a) Ducting within battery room (should be avoided if possible)
b) Supply air ducting externally painted with acid resistant paint
c) Extract air ducting externally and internally painted with acid resistant paint

2.10.NOISE LEVELS

Noise levels in the air-conditioned areas are to be as specified in SANS specification when measured at a point 1,5 m above floor level and at 1m from any air terminal. The dBA level shown will be accepted on site tests providing there are no predominant frequency components audible.

The noise levels in ventilated areas are not to exceed background noise level and shall be limited to 85dbA.

2.11.HVAC ELECTRICAL AND ELECTRONICS WORKS

The complete electrical installation associated with the HVAC system including all wiring between equipment, control boards and alarm panels form part of this contract.

The electrical works is to be carried out in compliance with the requirements of SANS 10142-1 (The wiring of premises Part 1: Low-voltage installations).

No electrical wires or cables must be allowed to come into contact with piping and not manned properly.

2.11.1.HVAC Electrical Works Responsibility Matrix

The Contractor's HVAC discipline is responsible for the detailed design; plant and material selection; installation and as built drawings; testing, and commissioning documentation; operating instruction and maintenance manuals of the complete HVAC related Electrical Works.

The Contractor is to submit the detail design for the HVAC electrical scope for acceptance. Employer is to review the designs submitted by the Contractor and sign it off for acceptance.

The Contractor is responsible for the design of the HVAC electrical scope and provides the following, as a minimum:

a) 400/380V AC HVAC Electrical Distribution Panels
b) Power, Control Cabling and Racking

The selection and application of all the electrical equipment is to be in accordance with the current Employer's relevant standards referenced on the technical specification.

The complete HVAC are to be provided with 1 x power distribution board panel fed by 1 x set of power cables (single feed) in each area or zone.

The HVAC related Electrical Works responsibility matrix between Contractor's Electrical and HVAC discipline is as detailed in Table below.

Table 4: HVAC Related Electrical Works Schedule

Description of work	Responsible Discipline		
	Employer	Contractor's Electrical discipline	Contractor's HVAC discipline
1. HVAC technical specification for electrical works	X		
2. Essential (standby diesel generator) and normal power cabling to 380V AC HVAC Electrical Distribution Panels		X	
3. Detailed Design of HVAC related Electrical Works			X
4. Plant and material selection; installation and as built drawings; Testing, balancing and commissioning Documentation; Operating Instruction and Maintenance Manuals; and Inspection Record Cards/ Checklists			X
1. Supply and install 380V AC HVAC Electrical Distribution Panels with circuit breakers, contactors, isolators, indication lamps, pushbuttons, door interlocking handles, ammeters, selector switch, auto/manual etc.			X
2. Supply and Install and terminate power cables on the new 380V AC HVAC Electrical Distribution Panels and connect incoming cables to medical gas and vacuum services equipment			X
3. Allocate the spare circuits on the selected boards to supply the new 380V HVAC Electrical Distribution Panels. And equip the spare unequipped circuits.		X	
4. Terminate the power cables on the allocated spare circuits on the selected 380 V boards to supply the new 380V AC HVAC Electrical Distribution Panels.		X	
5. Electrical cable / wiring, Cable ladders and trays, power and control cabling and racking, joint kits, earthing, hangers and mounting arms, risers and droppers measured as elbows etc. and isolators ending within 1meter reach to HVAC equipment and its controls.			X
6. Testing and commissioning HVAC related Electrical Works	X	X	X

2.11.2.HVAC Control and Instrumentation Works Responsibility Matrix

The Contractor's HVAC /Electronic discipline is responsible for the detailed design; plant and material selection; installation and as built drawings; testing, and commissioning documentation; operating instruction and maintenance manuals; and inspection record cards/checklists of the complete HVAC standalone equipment controls (which are capable of interfacing with Building Management System).

The HVAC controllers are to be designed to utilise standard sensors, transducers and actuators for the industry which has been field tested within the last two years.

The HVAC controllers is to have a capability to communicate with the standard equipment supplied such as compressors and vacuum pumps to enable monitoring of performance of the components and allow for subsystems to be tested, logged and commanded at the central operator's terminal.

Field controllers are to operate independently of the central/main control panel and each redundant plant is to have dedicated sensors and actuators. The communication bus is to be BACnet, LonWorks or Modbus.

Each HVAC is to be provided with centralized/main controller (HVAC Control Panel) capable of interfacing with Building Management System (BMS).

The HVAC related controls and fire detection Works responsibility matrix between Contractor's Electronic/Fire discipline and medical gas and vacuum services discipline is as detailed by table below.

Table 5: Division of HVAC Related Controls and Fire Detection Works Schedule

Description of work	Responsible Discipline	
	Contractor's Electrical discipline	Contractor's HVAC discipline
1. Detailed Design of HVAC standalone equipment controls including plant and material selection; installation and as built drawings; Testing, balancing and commissioning Documentation; Operating Instruction and Maintenance Manuals; and Inspection Record Cards/Checklists.		X
2. Provision of fire relay interface in HVAC equipment and electrical boards	X	X
3. Testing and commissioning of HVAC response to fire detection alarms for each zone.	X	X

2.11.2.1. General Requirements for Stand-alone Controller

Every care is to be taken to protect material, either fixed or unfixed, from damage, ingress of dust, water and moisture. All panels are to be totally enclosed; dust, damp and vermin proof.

The control system is to be designed for location in mechanical plant rooms at maximum temperature 40ºC.

The system is to be designed to provide continuity and correct operation during abnormal conditions caused by over voltages, electromagnetic induction, spiking input/output and any other "normal" interference found in commercial buildings through switching of fluorescent lights, operation of other control equipment, operation of welding machines, somewhere in the building, etc.

The stand-alone controllers are to have the following:

a) Stand-alone field gear.
b) Local processors.
c) Peripheral devices.
d) Terminal controllers.
e) Programmable system controllers.
f) MCC start/stop monitoring.
g) Sub-system interface panels with other services.
h) Touch screen operator terminal.

2.11.2.2. Stand-alone Controller Level of Interface

The system is to be designed to utilise only standard sensors, controllers, transducers, actuators, for the industry which have been field tested for at least 2 years.

The control system is not to only incorporate its own sensors and controllers where applicable, but must also use the standard instrumentation, sensors and control equipment supplied as "standard" on equipment such as chillers, so that the performance of all the components of a subsystem can be test logged and commanded at the central operator's terminal.

All actuators, operating valves, dampers, etc., controlling the capacity of components and/or subsystems are to be equipped with manual operators to maintain control during power failure or interruption. It must be impossible to use the manual operator when the power is switched on. If the actuator is switched back to automatic control the manual operator knob is to be automatically dis-engaged.

All interfaces between sensors, components, relay boards, capacity controllers, etc., are to be via plug in terminal factory pre-tested strips in the Motor Control Centres (MCC's) or interface panels.

The accuracy of the sensors, controllers, outstations and management level are to be of such a standard that the discrepancy (measuring error) between actual and measured value never exceed 2% of the operating range specified on the detailed specification.

2.11.2.3.Control Points

Digital outputs are to provide electrically maintained signal to operate low voltage relays for starting and stopping subsystems.

Digital inputs are to monitor volt free contacts in MCC's via interface strips or interface panels.

The specialist BMS manufacturer is to provide suitable actuators for valves, dampers, etc., to carry out the following:

a) Analogue control signals.

b) Pulse counting signals. Modules shall read pulse signals up to 32 kHz

2.11.2.4.Instrumentation

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

Test instruments are to be checked for accuracy by the manufacturer or by an approved laboratory with certificates being submitted prior to site tests, showing the degree of accuracy.

2.11.2.4.1.Temperature Indication

All direct reading thermometers and temperature reading devices are to have an accuracy of 0.5^{o}C and a range of –10^{o}C to 50^{o}C, unless otherwise specified, with graduation being in steps of 1^{o}C.

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

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

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

The sensor element is to be at the centre of the pipe.

2.11.2.4.2.Pressure Indication

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

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

All differential dial pressure gauges are to have an accuracy of 2% and to be not less than l00 mm diameter. Zero pressure reading is to be in the centre, and the range of scale on either side is to extend to 150% of the maximum operating pressure, with provision being made for individual pressure reading.

2.11.2.4.3.Relative Humidity Indication (hygrometers)

Hygrometers are to have an accuracy of 5% in the range of 20% to 100% relative humidity.

2.11.2.4.4.Flow Meters

Liquid flow is to be measured by means of an in-line orifice, or Venturi tube and differential pressure gauge normally calibrated in litres per second 5% accuracy.

The Contractor provides all permanently installed instrumentation necessary for logging and monitoring of status and performance of equipment and components.

In addition, a handheld digital electric instrument, measuring temperature and humidity is to be provided at handover for use by the Employer.

2.11.2.4.5.Moisture Indication in Refrigeration Circuit (sight glass)

A sight glass/moisture indicator is to be installed in the refrigerant circuit of each chiller and/or condensing unit. The indicator is to be suitable to read the recommended moisture levels of the refrigerant used.

2.11.3.Checking of System Compliance with Specification

The certified test results are to be plotted on the official published and certified equipment performance graph/tables to confirm that claimed performance is achieved.

No handover of system will take place without submission to and acceptance by the Employer of this formal handover report.

The Contractor provides all permanently installed instrumentation necessary for logging and monitoring of status and performance of equipment and components.

3.PROCUREMENT

3.1.PLANT AND MATERIAL

3.1.1.Quality

The Contractor is not to use Plant or Materials which are generally recognised as being unsuitable or otherwise to be avoided for the purpose for which they are intended.

Only components of high reliability are to be utilised, with a proven operating history, to enable the Plant to achieve required reliability and availability. Plant and Material design, engineering and manufacture to accord with the best modern practice applicable to high-grade products of the type to be furnished, so as to ensure the efficiency and reliability of the Works and the strength and suitability of the various parts for the Works.

Plant and Materials withstands ambient conditions and the variations of temperature arising under working conditions without distortion, deterioration or undue strains in any part.

All parts are made accurately, and where practicable, to standard gauges so as to facilitate replacement and repairs. Like parts are interchangeable.

No repair of defective Plant and/or Materials are to be permitted without the Employer’s approval and any such repair, if approved, are to be carried out to the satisfaction of the Employer.

The Employer is free to specify hold and witness points during the installation and on site testing stages of the project. The Contractor issues preliminary notification of such hold and witness points as per agreed schedule to the Employer, and confirms such hold and witness points at least seven working days prior to the activity.

Typical hold points are listed below:

a) Design Review
b) Factory Acceptance Test
c) Delivery to Site
d) Erection
e) Site Acceptance Test
f) All manuals and drawings (in the specified format)
g) Commissioning

In addition to maintaining appropriate inspection and test records to substantiate conformance to requirements, the following records are safely stored for a minimum period of seven (7) years following the final completion of the Works:

a) Construction, layout and component approvals
b) Type and routine test certificates
c) Construction drawings and approvals

After this period, the Contractor offers these records to the Employer (in writing) and obtains a disposal instruction.

Documentation regarding quality procedures is submitted as per agreed schedule after Contract Award. The Employer is review and comment on the acceptability of these documents in a time frame as per the requirements of the contract for contractual correspondence. If controlled copies of these documents have been submitted to the Employer, then the controlled copy numbers may be quoted in the submission.

3.1.2.Plant & Materials Provided “free issue” by the Employer

None.

3.1.3.Contractor’s Procurement of Plant and Materials

The Contractor is to take all necessary steps to ensure that all Plants and Materials are adequately protected against damage during shipping, transport and storage.

3.1.4.Spares and Consumables

The Contractor provides as part of the operating & maintenance manual, a recommended parts list as well as a proposal for the execution thereof:

a) The Employer is responsible for procurement of recommended spares.
b) The Contractor is responsible for ensuring that consignment spares are available in time of need.

Each recommended spare part is to be uniquely identified with a part number, which can be cross referenced to a part list and associated drawing. The Employer prefers that support from the OEM is available locally in South Africa.

3.2.TESTS AND INSPECTION BEFORE DELIVERY

The Employer carries out quality inspections at own discretion. The Employer is to inspect and approve stages of manufacture of all equipment necessary to ensure the correct quality of equipment as prescribed in the approved project quality plan.

All inspections and testing to be performed in accordance with the Quality Control Procedure (QCP) developed by the Contractor after approval by the Employer.

The Contractor is to provide facilities for inspection of all items of equipment at the place of the manufacture and this requirement is to be extended to all Sub-contractors and suppliers. All material labour or assistance, tools, gauges, articles or apparatus that the Employer may require for the purpose of testing, gauging and inspection, are to be provided by the Contractor. The Contractor is to provide all such facilities for testing and the contract price is to include for this.

The Employer reserves the right to reject items that do not conform to the Employer’s requirements. When the plant has passed the test referred to in this specification, the Employer is to furnish to the Contractor a certificate or endorse the Contractor’s test certificate to that effect. Examination by the Employer is not to relieve the Contractor from the responsibility of carrying out all tests which may be necessary to ensure the required standard of manufacture or from any obligations in terms of the contract.

The achievement of adequate standards during the tests at the place of manufacture, if performed, is only the first requirement. The final criterion is the performance onsite, and any of the requirements which prove defective due to bad workmanship or material are to be replaced forthwith by the Contractor at his/her own cost on the instruction of the Employer.

The following tests are conducted by the Contractor and are to be witnessed by the Employer at the manufacturer’s Works or Contractor’s premises as a minimum requirement:

a) Visual inspection of the equipment.
b) Review of the certification requirements.
c) Functional tests of the systems and controls including starting & stopping procedures.
d) Inspection of paint work and corrosion protection.
e) Verification that all components are delivered to the Contractor’s premises.
f) Verification that all power plugs is correct.
g) Verification that components installed is correct.

h) Verification that all labels are correct.
i) Phase rotation.

3.3.MARKING PLANT AND MATERIAL OUTSIDE THE WORKING AREAS

All Plant and Material paid for by the Employer must be clearly labelled as being the Employer's property.

3.4.CONTRACTOR'S EQUIPMENT (INCLUDING TEMPORARY WORKS)

The Contractor provides the following in order to complete the Works:
a) All scaffolding required.
b) All crane hires if required.
c) Any equipment necessary to complete the Works.
d) Lifting facilities.

The Contractor supplies, installs, maintains and removes all temporary construction facilities and utilities necessary to provide the Works.

4.PLANT AND MATERIAL STANDARDS AND WORKMANSHIP

4.1.DESIGN OF EQUIPMENT

The minimum general HVAC equipment design criterion that is to be met is as follows:
a) The equipment is to be designed to facilitate efficient manufacture, inspection, transportation, installation, maintenance, cleaning and repairs.
b) The equipment is to be designed to ensure safe and satisfactory operation for at least 15 years for under the conditions prevailing at House 251, Maseru in Lesotho.
c) The equipment is to be designed to prevent undue stresses being produced by expansion and contraction due to temperature change and other local natural and manmade conditions.
d) The equipment is to be designed to keep maintenance costs to a minimum.
e) The equipment is to be designed to comply with all the legal requirements in respect of safety and the prevention of environmental pollution.
f) The equipment is to be designed to satisfy any specific requirements contained in the relevant statutory codes and standards.
g) The equipment is to be designed for operation of 365 days per annum, 24hrs per day.
h) The equipment is to be designed such that all material from which the equipment is manufactured from is compatible with the intended duty and service conditions. All equipment is suitable treated and protected from corrosion.
i) After the design freeze, the information stated in the data sheets is to be fully complied with through the installation, unless otherwise agreed upon by both GDID & Contractor in writing.

4.2.EQUIPMENT REQUIRED TO BE INCLUDED IN THE WORKS

The Contractor is required to provide lifting facilities and other equipment required for the execution of the complete Works.

4.3.APPLICABLE STANDARDS AND CODES

Table 6: List of Applicable Standards and Codes

Number	Title
ISO 900	Quality Management Systems
OHSACT	Occupational Health and Safety Act 85 of 1993
ASHRAE 15	Safety Code for mechanical refrigeration
ASHRAE 62	American Society of Heating Refrigeration and Air Conditioning Engineers. Ventilation for acceptable indoor air quality
ASHRAE 55	Thermal environmental condition for human occupancy
ASHRAE 52/76	Standard test method for filters
ASHRAE G1	Guideline for commissioning of air conditioning system
BS EN 1171	Industrial valves - Cast iron gate valves
BS EN 12288	Industrial valves - Copper alloy gate valves
BS EN 13789	Industrial valves - Cast iron globe valves
BS EN 1983	Industrial valves - Steel ball valves
BS 8233	British Standard code of practice for sound insulation and noise reduction in buildings
BS 5720	British Standard Code of practice for mechanical ventilation and air conditioning
BS IEC 61882:2001	Hazard and Operability Studies (HAZOP Studies) – Application Guide
CIBSE Commissioning Code A	Air Distribution Systems
CIBSE Commissioning Code C	Automatic Controls
CIBSE Commissioning Code M	Commissioning Management
CIBSE Commissioning Code R	Refrigeration
CIBSE Commissioning Code W	Water Distribution Systems
NFPA 70	National Electrical Code
OHSACT	Occupational Health and Safety Act 85 of 1993
SANS 10400	The Application of the National Building Regulations
SANS 10108	The Classification of Hazardous Locations and the Selection of Equipment for Use in Such Locations
SANS 10103	The measurement and rating of environmental noise with respect to annoyance and to speech communication
SANS 61800	Adjustable speed electrical power drive Systems
SANS 10140-3	Identification colour marking Part 3: Contents of pipelines
SANS 10142-1	The wiring of premises Part 1: Low-voltage installations
SANS 10147	Refrigerating Systems including plants associated with air-conditioning Systems
SANS 10173	The installation, testing, and balancing of air-conditioning duct work
SANS 193	Fire dampers
SANS 1238	Air-conditioning ductwork
SANS 1287-1	Ventilation brattices and ducting Part 1: Flexible ducting
SANS 1287-2	Ventilation brattices and ducting Part 2: Brattices, unsupported

Number	Title
SANS 1424	Filters for use in air-conditioning and general ventilation
SANS 1551-1	Check valves (flanged and wafer types) Part 1: PN series
SANS 1551-2	Check valves (flanged and wafer types) Part 2: Class series
SANS 1849	Butterfly valves for general purposes
SANS 62	Steel pipes and fittings 150mmm and below
SANS 719	Steel pipes and fittings above 150mm
SANS 936 (BS5155)	Float valve
SANS 1123	Flanged fittings
SANS 564	Flanged gaskets of reinforced rubber
SANS 1056-3	Ball valves Part 3: Light duty valves
SANS 1551-1	Check valves (flanged and wafer types) Part 1
SANS 191	Cast steel gate valves
SANS 665-1	Wedge gate and resilient seal valves for general purposes
SANS 893-1	Legionnaires' disease Part 1: Risk assessment
SANS 893-2	Legionnaires' disease Part 2: The control of Legionella in water systems
SANS 10139	Fire detection and alarm systems for buildings – System design, installation and servicing

5.CONSTRUCTION

5.1.CONSTRUCTION OF HVAC WORKS

The construction of the HVAC system is to be undertaken in parallel with other House 251 construction activities during the complete duration of the execution of works. Hence, the installation of HVAC system is to be carried out in a systematically manner to ensure no interference or obstruction to other construction activities can be accommodated at any stage.

5.2.COMPLETION, TESTING, COMMISSIONING AND CORRECTION OF FAULTS

5.2.1.Work to be done by the Completion Date

The contract is deemed to be complete when the following have been completed in accordance with the relevant specifications:

a) The Plant is erected, and commissioned
b) Signed erection and safety clearance certificates.
c) The final as built drawings have been submitted.
d) All documentation has been submitted including testing reports and the associated certificates received. All Quality Control Plan (QCP) documentation received. Final draft of the technical, operating, maintenance manuals delivered.
e) The plant and all documentation, drawings are coded and labelled.
f) All special tools have been supplied.

5.2.2.Materials Facilities and Samples for Tests and Inspections

The Contractor provides all Materials, facilities and/or samples required for tests and inspections.

The Employer reserves the right to call for samples of equipment offered to inspect the workmanship as the work proceeds and either accept or reject the equipment or workmanship. The Employer’s

approval of the design, material and workmanship are to in no way reduce the Contractor's liability to provide a complete and proper working plant which is abreast with modern technology.

The Contractor must allow for control samples of the following which are to be approved by the Employer and are to be held in the site office to establish the quality standards:

a) Control sample of ducting to establish the ductwork quality standard.
b) Control sample of welded, insulated, and cladded piping to establish the pipework quality standard.
c) Air terminals

5.2.3.Commissioning

The complete HVAC system is to be commissioned and tested in accordance with requirements of Standard Quality Specification for Commissioning Guideline for all mechanical services, SANS and Chartered Institution of Building Services Engineers (CIBSE) codes or such other recognized commissioning procedure or code approved by the client or the equipment supplier's manual:

a) Air distribution systems
    i. SANS 10173: Code of Practice for the Installation, Testing and Balancing of Air Conditioning Ductwork, or
    ii. CIBSE Commissioning Code A: 2006 or latest revision
b) Automatic controls: CIBSE Commissioning Code C: 2001 or latest revision
c) Refrigerating Systems: CIBSE Commissioning Code R: 2002 or latest revision
d) Water Distribution Systems: CIBSE Commissioning Code W: 2010 or latest revision

The Contractor does comprehensive pre-commissioning, commissioning as well as quality monitoring on all the HVAC and its sub-systems and is to provide a report with the following details.

a) Demonstrate that the services were commissioned in compliance with SANS OR CIBSE Commissioning Codes or ASHRAE Commissioning Guideline for all mechanical services.
b) Include commissioning dates, records of all functional/commissioning testing undertaken, a list of any future seasonal testing, and a written list of outstanding commissioning issues.
c) Include the outcomes and changes made to the building as a result of the commissioning process, accounting for all the recommendations; and
d) Reference appended extracts of commissioning records for major plant and equipment.
e) Ensures that the correct performance of the equipment, safety of plant and personnel, and compliance with the Technical Information before commissioning of plant commences is achieved.

The commissioning procedure to be adopted is prepared by the Commissioning Authority. During commissioning the Contractor set the installation to work and competent personnel demonstrates and explain the operation and maintenance procedures for the installation and for each item of plant to the Employer. During commissioning if any item is found to be unsatisfactory the fault is rectified and/or new components fitted and commissioned by the Contractor at their own expense. The Contractor then rebalances and commission the system or part thereof affected at their own expense.

After successful completion of the commissioning and proof period of the installation and any maintenance materials as listed in the Specification and those normally supplied by equipment manufacturer are handed over, the maintenance period commences. Items of equipment which are of a specialist nature e.g. automatic controls etc. are to be commissioned by the manufacturer's representative who instruct the Employer on the function and proper operation of the equipment.

5.2.4.Start-up Procedures required to put the Works into Operation

No alterations or adjustments are to be made to the Works after functional checks are done without the Employer's written permission.

At this stage the following is to be achieved:

a) Installation and pre-commissioning completed.
b) Testing report and the associated certificates received.
c) Signed erection and safety clearance certificates.
d) Final draft of the technical, operating, maintenance manuals delivered.
e) All Quality Control Plan (QCP) documentation received.

5.2.5.Take Over Procedures

The Employer takes over the Works on the date of safety clearance of the HVAC system and its sub-systems in accordance with the sectional completion dates of the Accepted Program.

5.2.6.Performance Tests after Completion

All HVAC systems are to be subjected to performance tests under full working conditions as follows:

a) The Contractor is to supply the necessary field-testing instruments (thermometers and flow meters etc.) and detailed description of field-testing arrangement to prove a capacity/ performance measurement accuracy of ± 5% for equipment supplied.

5.2.7.Training and Technology Transfer

After completion of the contract, the Contractor is required to provide training and transfer system knowledge to the Employer by submitting documented Design Intent, As-built drawings, Operational and Maintenance Manual, Commissioning Records, Commissioning Report and by providing training on all the systems to the Employer's personnel to ensure that they have all the information and understanding needed to operate and maintain the features and systems in the various areas.

The Contractor is to provide on-site training and training material to the Engineers, Operators and Maintenance personnel prior to taking-over of the Works. The training is preferable to be offered during the commissioning and testing for a minimum of ten (10) personnel. The Contractor is to, prior to handing over of the Works, satisfy the Employer that maintenance, engineering and operational personnel are competent and adequately trained to maintain and operate the equipment supplied.

The training is to cover the following, however not limited to:

a) Information provided in the design intent report (including energy/environmental features)
b) Review of controls set up, programming, alarms and troubleshooting
c) Review of O&M manuals
d) Building operation (start up, normal operation, unoccupied operation, seasonal changeover, shutdown)
e) Measures that can be taken to optimise energy efficiency
f) Occupational health and safety (OH&S) issues
g) Maintenance requirements and sourcing replacements
h) Obtaining and addressing occupant satisfaction feedback
i) Development and creation of HMI mimics, logic and parameters

Steps for conducting On-site Training are to include:

a) Preparation
b) Introduction
c) Explanation
d) Demonstration
e) Practice Under Supervision
f) Conclusion

The operating and maintenance manual are to be available during the training of Employer's personnel. Employer's personnel are to be made familiar with the contents of that manual.

5.2.8.Operational Maintenance after Completion

After successful completion of the commissioning and proof period of the installation and any maintenance materials as listed in the Specification and those normally supplied by equipment manufacturer are handed over, the maintenance period commences. The Contractor is to execute maintenance and maintenance management under the supervision of Employer for a period of 12 (twelve) months from the date of Taking over of the Works.

The Contractor is to return to site following the issuing of the Taking over Certificate whenever is required or as defined by the detailed maintenance schedule submitted on Operating & Maintenance manuals. The minimum intervals for the Contractor to be onsite for inspection after taking-over of Works are to be 3, 6, 9 and 12 months respectively.

A report after each visit is to be submitted to the Employer in writing. The Contractor is to rectify such items in accordance with the requirements of the conditions of Contract. The Contractor is responsible for any faults that may arise during the guarantee and maintenance period and will be called out to repair such faults as required; therefore, it is important that a responsible/contact person and alternatives are to be provided as part of the Operating & Maintenance manual submissions.

The Contractor is to make all adjustments necessary for the correct operation of the plant and equipment for a period of 12 (twelve) months after the date of issue of taking-over certificate. The Contractor is to make good any faults due to inferior material or workmanship that may arise during this period. If during this period, the plant is not in working order for any reason for which the

Contractor can be held responsible or if the plant develops faults, the Contractor will be notified and immediate steps are to be taken by him to remedy the faults or to make any adjustments required. Should such faults occur so frequent as to become objectionable or should the equipment otherwise prove unsatisfactory during the above-mentioned period, the Contractor, if called upon by the Employer, is to replace at his/her own expense the whole or such parts thereof as the Employer may deem necessary, with apparatus to be specified by the Employer.

Final acceptance is to be taken once all the equipment has been replaced and the plant is in working order again. The Contractor is to confirm by means of instrumentation that the plant is delivering the same duty that it was at first acceptance. These readings and measurements are to be witnessed by the Employer.

5.2.8.1.Principles of effective maintenance and maintenance management

The following principles are to prevail to ensure effective maintenance management and maintenance of the medical gas and vacuum services facilities/equipment, namely:

a) The principle of disciplined configuration management/control is to be complied with during this period. The maintenance execution should apply strict control/discipline not to change/ alter the configuration status of the equipment without either approval by or notification of the change. The importance of managing the “as-built”, “operate-to” and the “maintain-to” information data packs (operation and maintenance manuals including maintenance schedules for each piece of equipment) of the equipment. Any discrepancies between the actual configuration and the information data pack information could lead to cost-inefficient maintenance (wrong information on equipment leads to wrong maintenance execution and therefore the operation and maintenance manual will be 100% correct.

b) The principle of applying optimum maintenance management and the desire to continuous improvement, learning from lessons of the past and wanting to apply intelligent maintenance management principles, should be accommodated as the driving force for maintenance management. The Contractor will therefore start with the built of each medical gas and vacuum services Systems history for future continuous improvement.

c) The sound principle of the maintenance Contractor having an independent quality assurance (QA), quality control (QC) and even an inspectorate service of the maintenance execution, where the Employer should only execute quality assurance (check a % of the QA and QC of the Contractor). It is therefore the responsibility of the Contractor to provide the Employer with maintenance QC lists and QA methods that are to be used during the one-year maintenance period.

d) Management information is of the utmost importance, especially in areas where huge sums of money are spent or where decisions are highly dependent on accurate information. Good performance measurement and management is highly dependent on accurate information (Maintenance report back information). The Employer will determine with the Contractor before Works completion, the maintenance information requirements and format that will be provided by the Contractor during the maintenance period.

e) Given the complexity/diversity of the medical gas and vacuum services equipment, it becomes obviously important to name and number the different System equipment to determine the exact maintenance history of each piece of equipment during the maintenance year and thereafter. The Contractor will therefore number each unit of each System in accordance the numbers that will be provided by the Employer before the Works commences.

f) Statutory regulations and GDID standards should be adhered to in the maintenance execution period in conjunction with the normal preventative and corrective maintenance actions. Where facility’s equipment is found, that does not comply to be rectified to create a working environment that is safe and without risk to safety and health.

g) Although the initial focus of maintenance management should be on optimising/reducing the maintenance-cost, the focus should shift to incorporate optimising/reducing of the entire operating cost and ultimately optimising/reducing the life cycle cost (LCC). The Contractor will therefore incorporate measurements such as “Coefficient of Performance” (COP) measurements as part of the year’s PM maintenance program. Other energy saving methods will be provided by the Employer to the Contractor to be included in Contractors PM schedule. Power consumption readings of each System provided with meters will be part of the Contractor’s monthly Planned Maintenance (PM) schedule.

h) Trade-off studies should continuously be analysed or conducted to ensure optimal use of preventative maintenance and corrective maintenance for each respective/individual situation (e.g. - more preventative, less corrective to increase item MTTF/MTTR).

i) Trade-offs regarding repair or replace decisions should continuously be made, as well as decisions on whether equipment/Systems should be phased out due to too high operating cost. Trade-offs involving decisions to purchase more reliable equipment with lower maintenance cost versus less reliable (also less costly) equipment with higher maintenance-cost will be executed.

j) A strategy will be developed by the Contractor regarding different standard levels of repair during the maintenance period in order to ensure focus/cost-effectively of the Contractor's service (supplier cost versus Contractor cost).

k) Re-commissioning of equipment after System breakdowns will be implemented as part of the Contractor's Corrective Maintenance (CM) procedure.

l) The Contractor will provide a maintenance service to the level defined in a quality plan (service level agreement standard). All the activities performed will comply with the required standard. The Contractor will supply procedures, documentation, and testing methods to support the committed level of service. The Contractor will have a documented process that verifies that all Beta Substation requirements (maintenance specification requirements and standards) are met. The PM and CM response times as required by Employer will be applied by the Contractor during the year maintenance period. Refer to Employer maintenance response times in accordance with the Service Level Agreement (SLA) between Contractors and Employer.

5.2.8.2.Service Level Agreement

The Employer expects the Contractor to at least meet the following service requirements however not limited to:

a) Ensure a continuous supply of conditioned air to all the facilities requiring conditioned air and that are fitted out with medical gas and vacuum services equipment.
b) Restore any interruption to conditioned air supply within the agreed restoration times.
c) Maintain an accurate database of all assets maintained.

5.2.8.3.Maintenance requirements after completion of Works

The Contractor is to be responsible for any failures as a result of the installation during this period.

A maximum response time of 2 hours will be allowed for all failures from the time the notification had been delivered to the Contractor.

The planned maintenance is to be execution in 3-monthly maintenance service, except if the OEMs recommend a different service interval; the later are to take preference. The Contractor will provide a PM schedule that will include the following:

a) Inspections time periods of applicable medical gas and vacuum services equipment/items including manufacturer's inspection requirements.
b) All medical gas and vacuum services equipment/items that require cleaning, removal of contaminants and waste, correct adjustment and setting, tightening, testing, fixing, refill, lubrication, rust prevention, touch up, refrigeration charge, servicing, inspection, replacement, re-installation, troubleshooting and calibration during a specific period e.g. weekly, monthly, 3 or 6 monthly, yearly or when required such as dirty filters, evaporators, etc. This is to include the manufacturer's maintenance requirements.
c) The schedule will be associated with PM guides/instruction list indicating the function to be executed and the material to be used for each piece of medical gas and vacuum services equipment that will be used by the Contractor during the one-year maintenance period. Each guide/instruction list will include the General instructions, Special instructions, Tools and materials to be used, List of codes/standards that are applicable to the equipment being maintained and Maintenance check points & maintenance execution including manufacturers maintenance requirements.
d) The Contractor will indicate all materials to be used for each instruction e.g. "Replace or clean filters if required" – Material required = Three (3) panel filters (600mm X 600mm X 50mm).

A process used to determine maintenance requirements of any physical asset in its operating context is to make use of the "Reliable Centre Maintenance" (RCM) process (RCM by John Moubray –

distributed by Butterworth-Heinemann) or similar. The RCM process entails asking seven questions about the asset or System under review, as follows:

a) What are the functions and associated performance standards of the asset in its present operating context?
b) In what ways does it fail to fulfil its functions?
c) What causes each functional failure?
d) What happens when each failure occurs?
e) In what way does each failure matter?
f) What can be done to predict or prevent each failure?
g) What should be done if suitable proactive task cannot be found?

To apply the above questions a table should be drawn up of each medical gas and vacuum services unit's component/item function, function failure, failure cause, failure consequences and proactive tasks. The Contractor will provide detail tables of each installed medical gas and vacuum services unit's items which will be discussed and agreed with the Employer before any maintenance tasks e.g. inspection period (e.g. daily inspections) or preventative maintenance tasks is taken up in the maintenance schedule (drawn up by the Contractor) that will be executed by the Contractor during the one-year maintenance period.

5.2.8.4.Maintenance information requirements

The Contractor will provide maintenance information on each PM and CM executed during the one-year maintenance period. The report template to be used for providing the required reporting will be agreed upon between the Employer and Contractor before execution of the maintenance & servicing commences.

All PM's are to be executed by means of Employer request number which is to form part of the procedure.

Although maintenance is executed on a unit/System more detail is required of that unit/System and specific detail is required of the components/items of that unit/System as follows:

a) Time reported or request/order generated
b) Time in - Time Contractor arrived on site
c) Time out - Time Contractor finished breakdown/complain
d) Total time spend on breakdown maintenance
e) Components/item description maintained
f) Was component/maintenance item:
    i. Repaired
    ii. Replaced
    iii. Inspected
g) Remarks on repair, replace or inspection and quantity/number of materials used
h) Power measured
i) Cooling capacity measured
j) COP (if applicable)
k) Cost of maintenance or servicing

5.2.8.5.Maintenance management

From information received on the PM`s and CM`s reports, logbook (produced by the Contractor) and Employer service requests, maintenance management will be executed by the Contractor in conjunction with the Employer. A maintenance meeting will be held once a month during the maintenance period where the Contractor, Employer will discuss all areas of the maintenance execution process, problems, maintenance information, and non-compliances and introduce maintenance management processes to be implemented by the Contractor during the maintenance period.

The following are some of the areas of maintenance on which maintenance management will be executed:

5.2.8.5.1.Improve maintenance cost-effectiveness

The capability to improve maintenance cost-effectiveness will be developed by all parties at the monthly maintenance meeting, based on the data received from the Contractor and Employer requests. The following minimum capability will be developed:

a) Failure Report Analysis (FRA). FRA will be done for each specific piece of equipment and the following analysis will be carried out:
    i. Time between failures (TBF), draw a process control chart of the TBF showing the MTBF, each TBF as recorded in sequential order and TBF control limits.
    ii. Monthly preventative and corrective maintenance times/cost. Draw a process control chart of the monthly time/cost showing average monthly time/cost spend on PM`s and CM`s.
    iii. Draw a process control chart of the downtime showing the average downtime; each downtime as recorded in sequential order and downtime control limits.
    iv. Draw a process control chart of the average availability, availability as calculated in sequential order and availability control limits.
    v. Identify those entire specific pieces of equipment of which the most recent TBF, monthly cost, downtime or availability is outside the control limits of the specific of generic equipment type or downtime is not within specified/contracted levels.
    vi. List the following for each of the above identified pieces of equipment for the most recent failure, as well as all previous failures:
        • All the failure descriptions
        • All the failure causes
b) Corrective Action (CA). From the FRA, the activity report obtained from the maintenance contractor, as well as standardisation considerations, one of the following actions will be taken for each of that equipment identified in the previous section a).:
    i. Don’t do any corrective action and monitor the performance of the specific piece of equipment.
    ii. Replace the specific piece of equipment or phase the equipment out.
    iii. Updates the “maintain to” info data pack (improve preventative maintenance such as more frequent lubrication etc. or specify a more realistic downtime values).
    iv. Do maintenance concept trade-off studies and update the maintenance concept (i.e. improve the lines of repair, maintenance processes, inventory levels/contents (e.g. filters), etc.).
    v. Carry out an equipment design/application analysis and/or a LCC analysis to determine whether it is cost-effective to change the equipment configuration (i.e. a different model/producer in need of more/less reliability, performance, capacity, etc.).

5.2.8.5.2.Replace identified equipment as soon as possible

This task comprises that specific part of maintenance improvement whereby it is determined as soon as possible that the existing equipment should be replaced by other or new identical piece of equipment, mainly due to a result of an analysis showing that the existing equipment requires excessive maintenance and excessive costs. The disciplined replacement needs to be managed together with its configuration control regarding series number and warranty control. The equipment database needs to be updated and controlled

5.2.8.6.Maintenance guide for three monthly service or as required

"Maintenance" or “CHECK” in the guide are to mean the efficient and effective examination, inspection, service, repair and replacement of components and parts of an air conditioning unit or System so that the air conditioning unit or System complies to the manufacturers, design and commissioning operational specifications and statutory/company requirements. This includes the cleaning, removal of contaminants and waste, correct adjustment and setting, tightening, testing, fixing, refill, lubrication, balancing, rust prevention, touch up and refrigeration charge of the air conditioning unit or System.

The guide indicates maintenance check points, components and items that are all applicable to the different medical gas and vacuum services units and Systems of the company. When maintenance is executed in accordance to the guide the maintenance check-points, components and items not applicable to the specific medical gas and vacuum services unit and System, are to be excluded from the service to be executed. The exclusion of any maintenance check points, components and items are to be the responsibility of the Contractor. Any error exclusions are to be the responsibility of the Contractor and no considerations are to be given to claims made by the Contractor for the rectification thereof.

6.AS-BUILT DRAWINGS, OPERATING MANUALS AND MAINTENANCE SCHEDULES

The importance of managing the "as-built", “operate-to” and the “maintain-to” operation and maintenance manuals including maintenance schedules for each piece of equipment is critical to the life of the plant. The operating & maintenance manuals are to be detailed enough to operate, maintain, dismantle, reassemble, adjust and repair plant & equipment.

6.1.AS-BUILT DRAWINGS

The Contractor is to provide “As Built” drawings based on the shop drawings embodying all modifications made during construction. The “As Built” drawings are to include general arrangement and sections of all plant and equipment including isometrics and P&ID’s or PFD’s. Safety, instrumentation, control and operation drawings are to also be included “As Built” drawings indicating the intended functioning, capacity data and control functioning of all Systems.

The As-Built drawing is to indicate all relevant plant coding and labelling. The determination of these codes and labels are to be done in accordance to the documents listed in this Technical Specification.

Two hard copies and one Soft copy of “As Built” drawings are to be submitted to the Employer for approval.

6.2.OPERATING MANUALS AND MAINTENANCE SCHEDULES

The Operating & Maintenance Manual must describe how the facility is to be operated and by whom, as well as the desired level of training and orientation required for the building occupants.

The operation and maintenance manuals are to consist of the following as the minimum:

a) List of Contents (Index)
b) Introduction
c) General description of the functions of each of the Systems including detailed description of each element of each System, how it functions, how it operates and how to maintain it and what attic stock or tools to carry.
d) Full as-built drawings and detailed drawings, brochures and catalogues for each System and each element of each System.
e) The format of the O&M documentation is to be A4 and is to be a specially bound document with hard cover and with metal ring binding. (All drawings folded into A4 format.)
f) The names addresses and telephone/fax numbers/email addresses of all responsible persons and manufacturers/suppliers are to be listed in the O&M document.
g) A full list with reference numbers are to be included to enable the Employers O&M staff to order materials and equipment.
h) Colour diagrams are be provided to illustrate the operation and function of each System with reference to the relevant as-built drawings or brochures of equipment. These diagrammatic drawings are to also indicate the locations of valves with their numbers.

7.DOCUMENT MANAGEMENT

7.1.DOCUMENT MANAGEMENT

All documents supplied by the Contractor are to be subject to Employer approval. The language of all documentation is to be in English. All documentation is to be controlled and managed in accordance with Employer’s Document and Records Management Procedure.

7.2.DOCUMENT IDENTIFICATION

The Contractor is required to submit the Vendor Document Submission Schedule (VDSS) as per agreed dates to the delegated Employer’s Representative. Employer will allocate document numbers on the VDSS and send back to the Contractor through the delegated Employer’s Representative. The VDSS is revisable and changes must be discussed and agreed upon by all parties. Changes in the VDSS can be additional documentation to be submitted, changes in submission dates or corrections in documentation descriptions, document numbers, etc. The Contractor’s VDSS is to indicate the format of documents to be submitted.

7.3.DOCUMENT SUBMISSION

All project documents must be submitted to the delegated Employer's Representative with transmittal note according to Project / Plant Specific Technical Documents. In order to portray a consistent image, it is important that all documents used within the project follow the same standards of layout, style and formatting as described in the Work Instruction. The Contractor is required to submit documents as electronic using Employer's electronic transmittal and hard copies and both copies must be delivered to the Employer's Representative.

The Contractor list all project soft copies and hard copies for submittal on the transmittal with the following metadata fields:

a) Title of the document
b) Document unique identification number
c) Revision number
d) Name of discipline
e) Reason for issuing/submission
f) Sender's details
g) Sent date
h) Recipient's details
i) Date received
j) Quantity of documentation referenced on the transmittal
k) Number of copies
l) Format/medium submitted (e.g. paper, CD/USB Stick, etc.)
m) Sender signature
n) Recipient signature, once submitted, to acknowledged receipt

The format of the final documentation handover will be specified in the Vendor Document Submittal Schedule. The Vendor Documentation Submittal Schedule (VDSS) specifies the following:

a) The limits of supply of the documentation, i.e. whether the documentation is provided / maintained by the Contractor or the Employer.
b) The type of documentation provided.
c) The software format (where applicable) in which the documentation is provided.
d) The stage in the project execution during which the documentation is provided as a deliverable.
e) The Contractor is to be responsible for planning the supply of the documentation during the various project stages and to provide the documentation in accordance with the Vendor Documentation Submittal Schedule (VDSS).

The documents are to be submitted to the Employer's Representative accompanied by the Transmittal Note. The Contractor submits all documentation to the Employer's Representative as well as the Project's Documentation Centre in the following media:

7.3.1.Soft Copy Transmittal

Electronic copies will be submitted to Employer's Documentation Centre via the Employer's Digital Transmittal space that will be setup for the project.

7.3.2.Bulk Submission

Electronic copies large for transmitting via SharePoint (>700MB) will be delivered on CD/USB Stick, large file transfer protocol and/or hard drives to the Project Documentation Centre.

7.3.3.Emails and other submission methods

Where applicable and contractually agreed, e-mail submissions can be used, as well as other submission methods employed in the relevant project e.g. Box; Norman Secure, etc.

7.3.4.Hard Copies

Two hard copies of documents are to be submitted to the Employer's Representative accompanied by the Transmittal Note.

7.4.DRAWINGS FORMAT AND LAYOUT

The creation, issuing and control of all Engineering Drawings will be in accordance to the latest revision of engineering drawing Standard. Drawings issued to Employer will be a minimum of two hardcopies and an electronic copy that is editable. The Contractor is required to submit electronic drawings in AUTOCAD format, and scanned drawings in pdf format. No drawings in TIFF or any other electronic format will be accepted. Drawings issued to Employer may not be “Right Protected” or encrypted. The Employer reserves the right to use these drawings to meet other contractual obligations. The Contractor is to include the Employer’s drawing number in the drawing title block. Drawing numbers will be assigned by the Employer as drawings are developed.

The Contractor submits all drawings in accordance with the requirements stipulated in the Employers Engineering Drawing Standard. Manufacturing of the equipment commences when drawings are accepted for construction, by the Employer. Two paper print, editable native CAD format (.dwg) and in .pdf format of each drawing are submitted to the Employer for acceptance as per agreed schedule before manufacturing of equipment commences, by the Contractor.

The Contractor submits a 3D Model in DWG format. The structure of the 3D model is to be according to the Plant Breakdown Structure. The 3D model is to clearly indicate all interfaces.

The Contractor submits all relevant drawings, documents and design information for approval before commencing any work. After the Employer accepts the drawings and design information, the Contractor is not allowed to depart from the accepted drawings in any way except when it is with the written consent of the Employer.

The Contractor is responsible for any error or deficiency in any drawings or documents supplied by him and for any loss, damage or expense arising out of such error or deficiency, notwithstanding that such drawing or document may have been accepted by the Project Manager.

Drawings are submitted to Employer in editable native CAD format (.dwg) and in .pdf format, after commissioning of the equipment. The drawings reflect any changes made during commissioning and are submitted as "As built” drawings.

The Contractor notes that all General Arrangement (GA) and detailed manufacturing and erection drawings become the property of the Employer. The Employer is permitted to purchase replacement parts off these drawings from the lowest cost suppliers.

7.5.CONFIGURATION MANAGEMENT

7.5.1.Plant Coding and Labelling

Coding and labelling of all Plant & Materials and documentation supplied is part of the Works and is the responsibility of the Contractor. The Contractor is to propose a plant and labelling system which is to be accepted by the Employer before any coding and labelling is to be undertaken.

7.5.2.Change Management

All Design change management is to be performed in line with the Employer’s Project Engineering Change Management Procedure and the Employer ensures that Contractor is provided with latest revisions of this procedure. Any uncertainty regarding this procedure is to be clarified with the Employer and clarification updates should be reflected in updated versions of this procedure.

7.5.3.Design Review Documentation

The Contractor conducts design reviews as per the Contractors official design review procedure. Contractor further takes note of the Employers Design Review Procedure and participates in all design reviews as specified by the Employer. The Employer may “Accept”; “Accept with Comments” or “Reject”. If required, the Contractor makes the necessary revisions on the documentation and ensures acceptance is obtained from Employer. The Contractor includes these design reviews as part of the schedule and suggests appropriate timing for such reviews.

7.5.4.Procedure for Submission and Acceptance of Contractor’s Design

The Contractor ensures the following:

a) The design is prepared, supervised and managed in accordance with the Employer's principles and quality procedures.
b) The design is prepared, reviewed and verified by individuals who are competent and are registered with ECSA or other international recognised bodies.
c) The design of the Works complies with the Contract Specification, generic specifications, standards, drawings, the Project Manager's instructions and other documents.
d) The design is accurately recorded in the design submissions including calculations, verifications, detailed construction drawings, specifications, test and commissioning plans and operation and maintenance manuals.
e) The design is reviewed and endorsed as compliant by an internal Reviewer prior to sending it for verification by the Employer.
f) The design is developed and submitted for review in accordance with the Contract Specification and agreed schedule.
g) All design information, data, drawings and other documentation is produced for the Works in accordance with the Contract.
h) The Detail design report is to be according to the Employer's Detail Design Report Template, 240-49910707.

7.5.5.Design Review Procedure

The Contractor is the Design Authority for Medical Gas and Services System, Controls, Electrical, Civil, Structural and Building related Works of the contract as defined in the Employer's Design Review Procedure. The Contractor is responsible for following this design procedure and conducts all the design reviews as specified in this procedure. The Contractor is responsible for conducting the following reviews:

a) Design Freeze Review (Detail Design)
b) Pre-Commissioning Review
c) Acceptance Testing Review
d) Handover Review

For design review purposes the designs will be reviewed per part of the Works as well as an integrated design where all interface issues between the various parts are addressed as follows:

a) The interim design stage will be an iterative process between the Employer and the designer with regular progress meetings.
b) The interim design stage will culminate with the submission of a report.
c) After receipt of the design report, the Employer will have ten (10) working days to review and submit comments to the designer.
d) The designer will then have five (5) working days to submit the updated final design report.
e) The submission will then constitute the End of Phase review and the Employer will accept the final design report with comments by the Employer and updates by the designer within five (5) working days.

7.5.6.Process for Submission of Documents

The Contractor submits all documents according to the templates that are referenced on the list of Standards. The process for the submission of documents is described below:

a) The Contractor submits the documents/drawings to the Employer.
b) The Employer's Document Controller registers the documents.
c) The Employer's Document Controller will supply the documents/drawings to all relevant parties within the Employer's project team.
d) The Employer's project team reviews the documents/drawings and will submit all comments or inputs to the Employer and the Employer submits to the Contractor for consideration.
e) If the Employer finds major deficiencies in the submitted documents/drawings, the Contractor revises the documents/drawings and resubmits to the Employer.
f) The Employer reviews the documents/drawings and if no major deficiencies are found, the Contractor organises a Design Review session.
g) The Employer and the Contractor conduct a Design Review.
h) If any fundamental errors were found in the designs or further actions are required, the Contractor record all concerns raised and revises the designs.
i) The Contractor organises a Design Review session once all designs were revised according to the concerns raised by the Employer.
j) If no fundamental errors were found in the designs during the Design Review session, the Contractor compiles the Design Review minutes or report and submits it to the Employer.
k) The Employer's Document Controller registers the report.

l) The Employer's project team reviews the Contractor's report/minutes. If the report/minutes are not acceptable, the Contractor revises the report/minutes and resubmits to the Project Manager.
m) The Project Manager accepts the Contractor's design once the report/minutes are accepted by the Employer's project team.

The Contractor is to implement the following activities for approval:

a) The Contractor reviews, stamps, dates and signs to signify his/her approval and submit in the manner required by the Employer in orderly sequence so as to cause no delay in the work, all Contractor's drawings, equipment selections and/or samples required by the Works or subsequently by the Employer. Contractor's drawings, equipment selections and samples are to be properly identified as specified or as the Employer may require.
b) At the time of submission, the Contractor informs the Employer in writing of any deviation in the Contractor's drawings, equipment selection or samples from the requirements of the Works.
c) Each individual plant & material selection submission is to be accompanied by a copy of the applicable detailed technical specification. Each clause of this specification to be marked "Complies" or "Does not comply", complete with reason stated, alternative offered and countersigned by the Contractor.
d) Plant & material selection submissions are to be indexed similar to the index for plant & material part of the "Operating Instructions and Maintenance Manual".
e) The Contractor is to submit two copies of drawings and plant & material selections along the channels agreed.
f) By submitting drawings, plant & material selections and/or samples, the Contractor represents that he/she has determined and verified all site measurements, site instruction criteria, materials, catalogue numbers and similar data, and that he/she has checked and co-ordinated each services drawing and sample with the requirements of the Works.
g) The Employer shall review the Contractor's drawings, plant & material selections and samples so as to cause no delay, but only for conformance with the design of the Works. The Employer's approval of a separate item does not indicate approval of an assembly in which the item functions.
h) The Contractor makes any corrections required by the Employer and re-submits the required number of corrected copies of the Contractor's drawings, plant & material selections or new samples until approved. The Contractor directs specific attention in writing on resubmitted drawings to revisions other than the corrections required by the Employer on previous submissions.

The following documents are supplied to the Employer by the Contractor as a minimum:

a) Documents, including detailed calculations such as hydraulic and pipe stress analysis (where required), pipe supports, handers and racks,
b) Documents including equipment data sheets and specification for selected equipment, electrical cabling and other associated equipment.
c) Dimensioned shop drawings showing the general arrangement of all plant and equipment including isometrics and P&ID's or PFD's where required. Sufficient views must be given to ensure clarity and the drawings are to have at least a plan and two different elevations or sections giving overall dimensions.
d) Dimensioned shop drawings showing proposed method of fixing of all the plant and equipment
e) Detailed electrical wiring diagrams including schematic and control circuits.
f) Detailed sequencing manner for installation procedure of Works
g) Detailed programme for the Works in sufficient detail as to represent the units of work to enable the representative to assess the progress of the Works
h) Technical specification and literature for all items of equipment that forms part of the complete installation
i) Proposed corrosion protection systems, including data sheets for coating proposed of equipment
j) List of recommended spares and technical specifications for the spares, part numbers and the stock levels required
k) Detailed building Works for complete Works
l) Detailed maintenance, reliability, control and operating philosophies
m) Testing, balancing and commissioning procedures
n) Plant and material acceptance testing
o) Detailed operation & maintenance manuals with As-Built drawings & Commissioning Results
p) Plant codification lists for each section of the Works
q) Construction competition reviews

r) Acceptance testing reviews
s) Quality assurance reports
t) Close out reports

7.6.TIME REQUIRED FOR ACCEPTANCE OF DESIGNS

The Project Manager will return one copy of the drawing marked “Accepted”; “Accepted with Comments” or “Rejected”. as may be appropriate.

The notations “Accepted” and “Accepted with Comments” authorize the Contractor to proceed with the manufacture of the Plant covered by such drawings subject to the corrections, if any, indicated thereon.

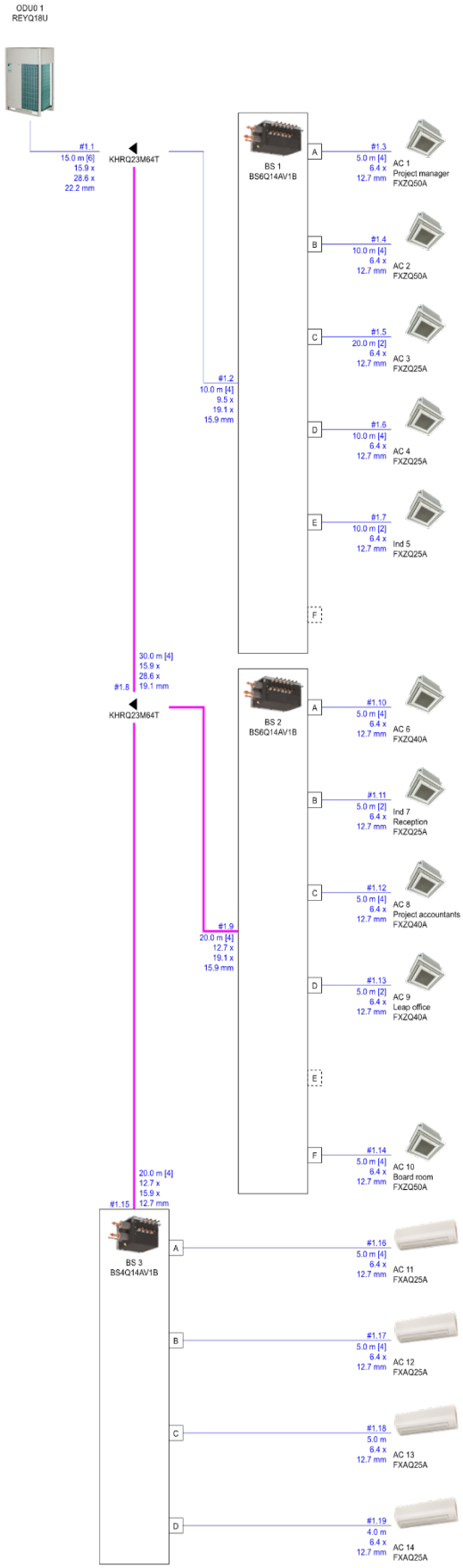
Where prints or drawings have been “Rejected” or “Accepted with Comments” the Contractor makes the necessary revisions on the drawings and submit further copies for acceptance in the same procedure as for the original submission of drawings.

Every revision shows by number, date and subject in the revision block on the drawing.

The Contractor is to allow for 10 calendar days for review of documentation by the Project Manager.

8.DRAWINGS ISSUED BY EMPLOYER

The schematics (piping and electrical) are shown below.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28.6 x
22.2 mm
KHRQ23M64T
#1.2
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9.5 x
19.1 x
15.9 mm
BS 1
BS6Q14AV1B
A
#1.3
5.0 m [4]
6.4 x
12.7 mm
AC 1
Project manager
FXZQ50A
B
#1.4
10.0 m [4]
6.4 x
12.7 mm
AC 2
FXZQ50A
C
#1.5
20.0 m [2]
6.4 x
12.7 mm
AC 3
FXZQ25A
D
#1.6
10.0 m [4]
6.4 x
12.7 mm
AC 4
FXZQ25A
E
#1.7
10.0 m [2]
6.4 x
12.7 mm
Ind 5
FXZQ25A
F
30.0 m [4]
15.9 x
28.6 x
19.1 mm
#1.8
KHRQ23M64T
#1.9
20.0 m [4]
12.7 x
19.1 x
15.9 mm
BS 2
BS6Q14AV1B
A
#1.10
5.0 m [4]
6.4 x
12.7 mm
AC 6
FXZQ40A
B
#1.11
5.0 m [2]
6.4 x
12.7 mm
Ind 7
Reception
FXZQ25A
C
#1.12
5.0 m [4]
6.4 x
12.7 mm
AC 8
Project accountants
FXZQ40A
D
#1.13
5.0 m [2]
6.4 x
12.7 mm
AC 9
Leap office
FXZQ40A
E
F
#1.14
5.0 m [4]
6.4 x
12.7 mm
AC 10
Board room
FXZQ50A
20.0 m [4]
12.7 x
15.9 x
12.7 mm
#1.15
BS 3
BS4Q14AV1B
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#1.16
5.0 m [4]
6.4 x
12.7 mm
AC 11
FXAQ25A
B
#1.17
5.0 m [4]
6.4 x
12.7 mm
AC 12
FXAQ25A
C
#1.18
5.0 m
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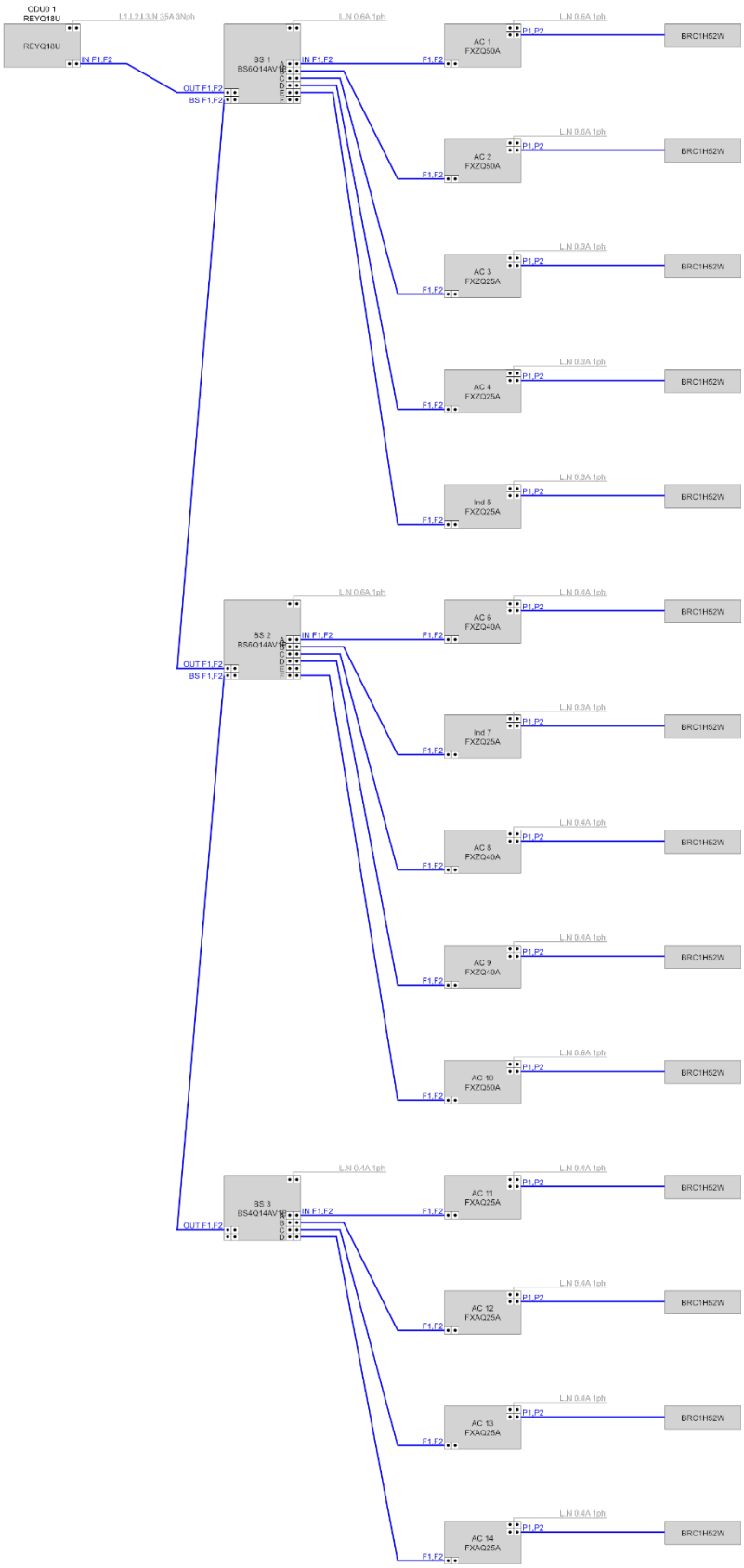
AC 13
FXAQ25A
D
#1.19
4.0 m
6.4 x
12.7 mm
AC 14
FXAQ25A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REYQ18U
L1,L2,L3,N 35A 3Nph
REYQ18U
IN F1,F2
BS 1
BS6Q14AV1B
OUT F1,F2
BS F1,F2
L,N 0.6A 1ph
IN F1,F2
AC 1
FXZQ50A
F1,F2
L,N 0.6A 1ph
P1,P2
BRC1H52W
AC 2
FXZQ50A
F1,F2
L,N 0.6A 1ph
P1,P2
BRC1H52W
AC 3
FXZQ25A
F1,F2
L,N 0.3A 1ph
P1,P2
BRC1H52W
AC 4
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P1,P2
BRC1H52W
Ind 5
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P1,P2
BRC1H52W
BS 2
BS6Q14AV1B
OUT F1,F2
BS F1,F2
L,N 0.6A 1ph
IN F1,F2
AC 6
FXZQ40A
F1,F2
L,N 0.4A 1ph
P1,P2
BRC1H52W
Ind 7
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P1,P2
BRC1H52W
AC 8
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F1,F2
L,N 0.4A 1ph
P1,P2
BRC1H52W
AC 9
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F1,F2
L,N 0.4A 1ph
P1,P2
BRC1H52W
AC 10
FXZQ50A
F1,F2
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P1,P2
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BS 3
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OUT F1,F2
L,N 0.4A 1ph
IN F1,F2
AC 11
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F1,F2
L,N 0.4A 1ph
P1,P2
BRC1H52W
AC 12
FXAQ25A
F1,F2
L,N 0.4A 1ph
P1,P2
BRC1H52W
AC 13
FXAQ25A
F1,F2
L,N 0.4A 1ph
P1,P2
BRC1H52W
AC 14
FXAQ25A
F1,F2
L,N 0.4A 1ph
P1,P2
BRC1H52W