Eskom	Standard	Asset Management

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CONTENTS

TABLES

1. INTRODUCTION

Heating Ventilation and Air Conditioning (HVAC) systems in Eskom power plants and buildings services are a combination of different elements. The HVAC different elements generally include chilled and condenser water pumps, chilled water generators, cooling towers, air handling units, ductwork, pipework, condensers, evaporators, electrical and control system which are integrated to work together and produce heating, ventilation and air conditioning that cannot be achieved by independent elements or components.

HVAC systems are generally categorized based on the fluid media used for heat rejection as detailed below:

a) Air to Air HVAC systems which are mainly Direct Expansion (DX) systems.
b) Air to Water HVAC systems which mainly comprise of air cooled and water-cooled chilled water generators with their applicable subsystems.
c) Water to Water HVAC systems which mainly comprise fan-coil systems, radiant panel and silent cooling chilled beams to mention few.

HVAC systems are complex systems and no different to other mechanical systems as they have finite life span which require proper design and maintenance during service period to ensure the delivery of conditioned air at right quantity, with acceptable temperatures and relative humidity into the respective spaces.

HVAC systems in power plants and building services are designed and installed to maintain environment conditions for reliable operation of electrical and process control equipment, and for the comfort and safety of plant workforces.

HVAC systems are generally designed by different entities either internal or external to Eskom. The aim of this document is to aid the design and project engineers when developing a technical specification for Heating Ventilation and Air Conditioning (HVAC) Works.

The HVAC technical specification is written with new installations in mind but can also be applied to modifications on existing installations. When applying the technical specification to existing installations it is important to understand the design approach used for the existing installations and to select equipment similar to the equipment in the existing installation.

The primary functions of the HVAC systems are:

a) To provide and maintain good indoor air quality and dust control.
b) To provide a safe environment for occupants.
c) To maintain internal temperatures to the limits as specified by mechanical ventilation and air-conditioning.
d) To provide adequate cooling, ventilation for the effective operation of power generation equipment.
e) To dissipate heat gains from power generation equipment.
f) To prevent the build-up of fumes, odors and other gases during the operation and maintenance life of the station.
g) To interface closely with the Fire Protection systems to ensure integrity of fire compartments and fire zones.
h) To provide adequate extraction of air for smoke control.
i) To keep escape routes safe; and
j) To integrate with the Building Management System and Consolidated Building Management System (BMS or CBMS)

2. SUPPORTING CLAUSES

2.1 SCOPE

The specification includes systems and equipment most frequently used in Eskom power stations and facilities projects, which mainly covers vapour compression air conditioning systems of both chilled water system and direct expansion system, variable flow refrigerant system, heat pumps, air handling, ventilation, filtration etc.

The specification does not cover hot water or steam heating, thermal storage heating, vapour-absorption system for cooling, and ice storage systems.

2.1.1 Purpose

The specification has been developed to reduce time required for compiling the specification for various projects handled by different engineers. It will assist in a uniformed approach by designers and project engineers when specifying HVAC system and equipment requirements.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] 240-70164623 Eskom Heating Ventilation and Air Conditioning (HVAC) Design Guideline

[2] 32-894: Eskom Server Rooms and Data Centres Standard

[3] 240-56355731 Environmental conditions for process control equipment used at Power Stations

[4] 240-56227516 LV Switchgear and control-gear assembly and associated equipment for up to and including 1000V and 1500V.

[5] SANS 10142-1 The wiring of premises Part 1: Low-voltage installations

[6] 240-54937450 Fire Protection and Life Safety Design standard

[7] 240-54937448 Fire Detection and Life Safety Design Standard

[8] 240-106628253 Welding Requirements on Eskom Plant

[9] 240-101712128 Standard for the Internal Corrosion Protection of Water Systems, Chemical Tanks and Vessels and Associated Piping with Linings

[10] 240-106365693 Standard for External Corrosion Protection of Plant Equipment and Piping

2.2.2 Informative

[11] 240-56177186 Eskom Battery Room Standard

[12] 240-56356396 Earthing and Lightning Protection Standard

[13] 240-56227443 Requirements for Control and Power Cables for Power Stations Standard

[14] 240-56355541 C&I Computer and Equipment Rooms Civil and General Building Requirements Guideline

[15] 240-5636535 Architectural Design and Green Building Compliance Manual

[16] 240-57617975 Procurement of Power Station Low Voltage Electric Motors Specification Standard

[17] 240-56030537 Specification for Centrifugal Pumps

[18] 240-56536505 Hazardous Locations Standard

[19] Act 85 of 1993 Occupational Health and Safety Act (OHSA)

[20] ISO 9001 Quality Management Systems.

[21] SANS 0108-1974 Classification of hazardous locations

[22] SANS 60079 Part 15 Electrical apparatus for explosive gas atmosphere

[23] 240-51544462 Integrated Demand Management Supplier Contract Quality Requirements Specification Informative

2.2.2.1 General

[24] 240-49230148 Maintenance and logistics support design guideline

[25] 240-53114186 Project Plant Specific Technical Document and Records Management Procedure

[26] 240-53113685 Design Review Procedure

[27] 240-53114002 Engineering Change Management Procedure

[28] 240-53665024 Engineering Quality Manual

[29] 240-54179170 Classification and Designation of Technical Documentation Standard

[30] 240-55864764, Chemistry for Potable Water Standard

[31] 240-106192541 Chemistry Standard for Auxiliary Cooling Water

[32] 240-56355466 Alarm Management System Guideline

[33] 240-56355843 Pressure Measurement Systems Installation Standard

[34] 240-56355888 Temperature Measurement Systems Installation Standard

[35] 240-56364535 Architectural Design and Green Building Compliance Manual

[36] 240-56364542 Structural Design and Engineering Standard

[37] 240-60782552 Process Flow Diagram Standard

[38] 240-61227631 Piping and Instrumentation Diagram (P&ID) Standard

[39] 240-71432150 Plant Labelling and Equipment Description Standards

[40] 240-86973501 Engineering Drawing Standard Common Requirements

[41] 250- 53114002 Engineering change management procedure

[42] 240-105020315 Standard for Low Pressure Valves

[43] SANS 10111 Engineering drawings

[44] SANS 10162 The structural use of steel

[45] SANS 10173 The installation, testing and balancing of air-conditioning ductwork

[46] SANS 10400 The Application of National Building Regulations

[47] SANS 1381- Painting

[48] SANS 1391 Approval of welders

[49] SANS 347 Categorization and conformity assessment criteria for all pressure equipment

[50] SANS0140 Codes for identification

[51] 240-53113712-1 Chemistry standard for demineralised water

[52] 240-240-129014618 Cyber Security Standard

2.2.2.2 Forms and Templates

[53] 240-56227927 Electrical Load List Template

[54] 240-61379718 Control & Instrumentation Instrument Schedule Template

[55] 240-61379755 Control & Instrumentation Drive & Actuator Schedule Template

[56] 240-72344339 C&I Virtual Signal List Template

[57] 240-72350241 C&I Panel Interface List Template

[58] 240-55864360 Mechanical Equipment List Template [MELT]

[59] 240-60782527 Control Philosophy Report Template

[60] 552- Application for defect (concession)acceptance

[61] 240-56176097 Electrical Cable Schedule Template

2.2.2.3 Standards specific to HVAC industry

[62] CIBSE Commissioning Code A: Air Distribution Systems

[63] Commissioning Code B: Boilers

[64] CIBSE Commissioning Code C: Automatic Controls

[65] CIBSE Commissioning Code M: Commissioning Management

[66] CIBSE Commissioning Code R: Refrigeration

[67] CIBSE Commissioning Code W: Water Distribution Systems

[68] ASHRAE 15 Safety Code for mechanical refrigeration

[69] ASHRAE62 Ventilation for acceptable indoor air quality

[70] ASHRAE55 Thermal environmental condition for human occupancy

[71] ASHRAE 52.1 and 52.2 Standard test methods for filters

[72] ASHRAE51/ AMCA210-Method of testing fan for certified performance rating

[73] SANS 10400-XA Energy Usage in Buildings

[74] SANS 10400 Part T and W The application of the National Building Regulation in Fire Protection

[75] SANS1424 Filters used in air conditioning and general ventilation

[76] SANS 1238 Air conditioning ductwork

[77] SANS 1400 The application of the National Building Regulations

[78] SANS193 Fire dampers

[79] SANS 10140 Identification Colour markings

[80] SANS10147 Refrigeration systems including plants associated with air-conditioning systems

[81] SANS 10173 Code of practice for installation, testing and balancing of HVAC ducting-

[82] SMACNA Duct construction standard

[83] ASHRAE G1 Guideline for commissioning of air conditioning systems

[84] AHRI- 550/590 Standard for Performance Rating of Water Chilling Packages

[85] EN 779 Standard test method for filters

[86] ASME B31.5 Refrigeration piping and heat transfer components

2.2.2.4 Standards applicable to HVAC water systems

[87] SANS 62 Steel pipes and fittings 150mmm and below

[88] SANS 719 Steel pipes and fittings above 150mm

[89] SANS 936 (BS5155) Float valve

[90] SANS 1123 Flanged fittings

[91] SANS 564 Flanged gaskets of reinforced rubber

[92] SANS 1056-3 Ball valves Part 3: Light duty valves

[93] SANS 1551-1 Check valves (flanged and wafer types) Part 1:

[94] SANS 1849 Butterfly valves for general purposes

[95] SANS 191 Cast steel gate valves

[96] SANS 665-1 Wedge gate and resilient seal valves for general purposes

2.3 DEFINITIONS

Definition	Description
Approved by	The accountability of the Approver of the document is equivalent to the specified role of Functional Responsible/Owner as identified in 240-53114186 and 32-6 for Documents and Records Management.
BACnet	A Data Communication Protocol for Building Automation and Control Networks. A data communication protocol is a set of rules governing the exchange of data over a computer network that covers everything from what kind of cable to use to how to form a particular request or command in a standard way.
Contractor	Refers to the corporation appointed to perform the engineering, procurement, and construction works required for the project.
Employer	Refers to Eskom Holdings State Owned Company, who will be represented by the Project Manager, Supervisors and/or Engineers. Project Managers, Supervisors and/or Engineers may be appointed to manage the contracts of the Employer. The appointment will be in accordance with the applicable conditions of contract. In these cases, the Contractor interact with entity appointed by the Employer
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.
Interface	Interface in these document means either to hard wired or software interaction between the Contractors and/or other Works
LonWorks	LonWorks (local operating network) is a networking platform specifically created to address the needs of control applications.
Master Zone	Area from which the control system is performed.
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

Definition	Description
	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.
Others	Others, as defined in these documents includes the other discipline specific Contractors i.e. Electrical, C&I, Civil etc.
Pipework	The term “pipework” used herein includes pipes both straight and bent, branches, stubs, orifice carriers, flanges, gaskets and bolting, and the pressure-bearing parts of forged or cast construction for valves or fittings, including bodies, covers and bolting.
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
Subcontractor	Party employed by the Contractor for specialised work (i.e. electrical installation)

2.3.1 Disclosure Classification

Controlled Disclosure: Controlled Disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
AHRI	Air Conditioning Heating and Refrigeration Institute (former ARI)
AHU	Air handling unit
AMCA	Air Movement and Control Association (International)
ASHRAE	American Society for Heating Ventilation Refrigeration and Air conditioning
ASME	American Society for Mechanical Engineers
BACnet	Building and Automation Control Network
BMS	Building Management System
C&I	Control and Instrumentation
CIBSE	Chartered Institution of Building Services Engineers
CM	Corrective Maintenance
COP	Coefficient of Performance
DB	Dry bulb temperature
DOL	Direct Online
DP	Due point temperature
DX	Direct Expansion
EA	Extract Air
ESP	External Static Pressure

Abbreviation	Description
FA	Fresh Air
FDS	Fire Detection System
h	Enthalpy (kJ/kg)
HVAC	Heating, Ventilation Air Conditioning
KKS	Krafswerk Keinnzeichen System (identification system)
LDE	Lead Discipline Engineer
LonWorks	Local Operating Network
LPS	Low Pressure Services
LV	Low Voltage
MCB	Miniature Circuit Breaker
MERV	Minimum Efficiency Reporting Value
MSDS	Material Safety Data Sheet
MTTF	Mean Time To Failure
MTTR	Mean Time To Repair
MV	Medium Voltage
O&M	Operation and Maintenance Manuals
PER	Pressure Equipment Regulations
PM	Planned Maintenance
RA	Return Air
RH	Relative Humidity
RPM	Revolutions Per Minute
SA	Supply Air
SANS	South African National Standards
SHE	Safety, Health and Environment
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
TBF	Time between failures
VRF	Variable Refrigerant Flow
VRV	Variable Refrigerant Volume
VSD	Variable Speed Drives
WB	Wet Bulb temperature

2.5 ROLES AND RESPONSIBILITIES

Engineering Managers, or their Authorised Delegates, are to be responsible for ensuring that this General Technical Specification is implemented by a competent person only, as per Eskom Governance and Competency requirements

A competent person is responsible for compiling the project specific scope of work and ensuring that this technical specification forms part of the Works Information; and is adhered to during plant & material selection, manufacturing, supply, delivery, off-loading, hoisting, erection, testing, balancing & commissioning to serve, training, guarantee and maintenance after final completion of the HVAC installation.

2.6 PROCESS FOR MONITORING

The primary process for monitoring will be governed by Design Review Procedure (240-53113685).

The general technical specification for HVAC systems is a live document. This document will be reviewed and updated every three years to reflect changes as required, with detail increasing at each time so that this document is continually updated for relevant use and applicability to plant engineering.

2.7 RELATED/SUPPORTING DOCUMENTS

Refer to Section 2.2.1 and 2.2.2.

3. GENERAL REQUIREMENTS

This section is to be read in conjunction with the Works Information (WI) and is written as a supplementary to these conditions.

3.1 SCOPE OF WORK

The Heating Ventilation and Air Conditioning (HVAC) scope of works, as detailed in these specifications' documents, bill of quantities and accompanying drawings; comprise of the engineering, the provision of all labour 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 air conditioning and ventilation installation.

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

a) Detailed design (where required).
b) Plant and material selection.
c) Installation drawings.
d) Codification and labelling of the plant
e) Testing, balancing and commissioning documentation.
f) Operating Instruction and Maintenance Manuals.
g) Inspection Record Cards/Checklists; and
h) Quality assurance.

3.2 CONTRACTOR'S DESIGN

The Contractor is to design, produce required drawings and select plant and material which satisfies the following:

a) The overall plant performance and efficiency specification.
b) The specified reliability; and keep maintenance costs to a minimum.
c) Local and statutory authorities. Each system and sub-system components are to be evaluated for compliance with PER of OHSACT of 1993 and be categorised (where applicable) according to SANS 347.
d) Space constraints and construction requirements.
e) Local content.
f) The specified and applicable standards confirmed in the specification including all the legal requirements in respect of safety and the prevention of environmental pollution.
g) Facilitation of efficient manufacture, inspection, transportation, installation, maintenance, cleaning and repairs.
h) Safe and satisfactory operation for a life expectancy of the chosen technology under the conditions prevailing at specific sites.
i) Prevention of undue stresses being produced by expansion and contraction due to temperature change and other local natural and manmade conditions.

j) Plant operation of 365 day per annum; and 24 hours a day (where applicable).
k) 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; and
l) All electrical equipment, forming part of the specified equipment shall be sealed against penetration by hose cleaning operations, and be also accessible for repair and maintenance.

The Contractor submit the following as part of his design:
a) Documents including equipment data sheets and specification for selected equipment, electrical cabling and other associated equipment.
   i. Mechanical equipment list
   ii. Electrical load List
   iii. Control philosophy
b) Manufacturer's product data highlighting Minimum Efficiency Reporting Value (MERV) for filtration media.
c) Detailed electrical wiring diagrams including schematic and control circuits.
d) Detailed sequencing manner for installation procedure of Works.
e) Technical literature for all items of equipment that forms part of the complete installation, including, evaporators, condensing units, refrigerant circuits, ventilation fans, electrical and control circuits etc.
f) Proposed corrosion protection systems, including data sheets for coating of proposed equipment.
g) List of recommended spares and technical specifications for the spares, part numbers and the stock levels required.
h) Detail design (when applicable)

The Invitation to Tender will indicate which of the contractor's design documents need to be submitted as part of the tender. It may include some or all the above documents. Design documents submitted as part of the tender are resubmitted as part of the Contractor's design.

3.3 DRAWINGS

The drawings, plant and material selection and sample submissions are to be handled as follows:

3.3.1 Employer's Drawings

The drawings prepared by the Employer show general layout of all equipment and distribution systems, complete with schematic arrangements. These, together with the specification, give sufficient information to enable the Contractor to estimate the cost and to determine how the system must be installed, tested, balanced, inspected, operated, serviced and maintained. These drawings are not dimensioned shop drawings and cannot be used as shop drawings. Location dimensions shown are only indicative of the routes and zones in which the service must be installed.

3.3.2 Contractor's Drawings

Any design drawings provided by the Contractor as part of his design are to be prepared in accordance with SANS 10111 (Engineering drawing practice) and 240-86973501 (Engineering Drawing Standard Common Requirements). General arrangement and detailed drawings be cross referenced using KKS system or other codification system prevailing on Employer site.

3.3.2.1 Shop Drawings

Shop drawings are to indicate all equipment, distribution systems, testing/inspection/instrumentation positions, access requirements and builder's work requirements. Shop drawings are be based on the Employer's requirements for the works or design shown on the drawings, approved equipment selections and samples.

The Contractor is to review, stamp all shop drawings to confirm that co-ordination with building and services drawings have taken place before submitting to the Employer for acceptance or approval.

The contractor's drawings are to be prepared in accordance with SANS 10111 (Engineering drawing practice) and 240-86973501 (Engineering Drawing Standard Common Requirements). General arrangement and detailed drawings be cross referenced using KKS system or other codification system prevailing on Employer site.

3.3.2.2 "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 floor and ceiling layout drawings indicating all terminal and/or fan coil units and/or controller positions. Safety, control and instrumentation, and drawings are also to be included "As Built" drawings indicating the intended functioning, capacity data and control functioning of all systems.

3.4 PLANT AND MATERIAL SELECTION

The Contractor is to select plant & material which complies with the specifications and submits these to the Employer for approval.

3.5 SAMPLES

Samples are any samples required by the Employer which may be over and above those listed in the Samples schedule to be submitted. These are physical examples to illustrate materials, plant or workmanship, and to establish standards by which the Works may be judged.

3.6 OPERATION AND MAINTENANCE

3.6.1 Reliability Cantered Maintenance

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 by John Mowbray 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 HVAC unit's component/item function, function failure, failure cause, failure consequences and proactive tasks. The contractor will provide detail tables of each installed HVAC units 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.

3.6.2 Planned Maintenance

The planned maintenance shall be execution in 3-monthly maintenance service, except if the suppliers recommend a different service interval, the later shall take preference. The contractor will provide a PM schedule that will include the following:

a) Inspections time periods of applicable HVAC equipment/items including manufacturer's inspection requirements.
b) All HVAC 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 shall include the manufacturer's maintenance requirements.

The PM schedule will be associated with Maintenance guides/instruction lists indicating the function to be executed and the material to be used for each piece of HVAC equipment

3.6.3 Operation and Maintenance (O&M) Manuals

The operating manuals are to be available for comments prior to commissioning of the equipment as described in the detailed specification. The operation and maintenance manuals are to include but not be limited to the following:

a) List of Contents (Index)
b) Description of Works. 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
c) Operation
d) Maintenance (Maintenance Guides/Instruction Lists, PM Schedule, etc.). Each Maintenance 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.
e) As Built drawings. Full as-built drawings and detailed drawings, brochures and catalogues for each system and each element of each system
f) The names, addresses and telephone/fax numbers/email addresses of all responsible persons and manufacturers/suppliers. Guarantees and warranty.
g) Plant and material acceptance testing certificates
h) Testing and commissioning procedure
i) Commissioning results
j) Troubleshooting
k) Spare parts including essential and recommended spares list.

3.7 PLANT CODIFICATION AND LABELLING

The plant codification system is to be uniform to entire project. The newer plant utilises KKS system, and this should be applicable to HVAC system both mechanical and electrical equipment shall be coded. The level of codification numbers should be agreed with the Employer. The codification should be reflected on the relevant drawings.

3.8 TESTING AND COMMISSIONING

3.8.1 Pre-commissioning documents

The following documents are supplied to the Employer by the Contractor prior to commissioning:

a) 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 drawing shall have at least a plan and two different elevations or sections giving overall dimensions.
b) Documents including equipment data sheets and specification for selected equipment, electrical cabling and other associated equipment.
c) Manufacturer's product data highlighting Minimum Efficiency Reporting Value (MERV) for filtration media.
d) Detailed electrical wiring diagrams including schematic and control circuits.
e) Details of water treatment requirements.

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 literature for all items of equipment that forms part of the complete installation, including, evaporators, condensing units, refrigerant circuits, ventilation fans, electrical and control circuits etc.
i) Corrosion protection systems, including data sheets for coating 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) Plant codification lists for each section of the Works.
p) Operating and maintenance manual including compliance to safety in handling of electrical and chemical equipment and processes.

3.8.2 Inspection prior to testing and commissioning

Prior to tests taking place on the completed or a section of the installation the Contractor check the following points:

a) That the components comprising the installation or sections of an installation are installed as described in the specification and drawings.
b) That the components have been installed correctly.
c) That the manufacturer‘s test data for plant and components, if necessary for testing and commissioning, has been provided and is available for reference.

3.8.3 Cleaning and flushing of ductwork and pipe work systems

All pipe work and ductwork systems included in this contract are to be thoroughly cleaned internally to remove any foreign matter. The following operations shall be carried out:

a) The cleaning of completed pipe work and ductwork to remove dirt etc. accumulated in pipe work and ductwork during installation by flushing out the installation.
b) The external cleaning of all pipe work and ductwork carried out to remove surplus jointing material, paper labels, dirt and grease.
c) Flushing of pipework
d) Blow through of ductwork.

3.8.4 Testing

The site testing of the various installations take place prior to the application of thermal insulation. High- and low-pressure ductwork is tested for air tightness, using the system fan or fans, by observation and air flow measurement. The sum of measured air quantities at all outlets (supply system) and inlets (extract system) are compared with the air quantity measured in the adjacent main duct. Any discrepancy greater than plus or minus 5% for low velocity and 1% for high velocity indicate that unacceptable leakage exists and should be remedied.

All leakage tests are witnessed by the Employer and are independent of any performance tests on the whole system, which is as detailed elsewhere in this specification.

Installations or sections thereof, which is embedded in the structure or concealed in permanently sealed ducts or voids, etc., is, in addition to the above specified tests, individually tested as they are laid and before being concealed.

On completion of the installation the Contractor carry out sound tests to measure the sound pressure level in each octave band in each space, under the supervision of the Employer and with all plant running. The Contractor uses a sound analyser with one octave band range 63 to 8000 Hz to establish the sound spectrum on each space. In carrying out these analyses the Contractor pays particular regard to the following points:

a) All items of mechanical services plant or equipment must be running normally.
b) Areas adjacent to these areas being tested are unoccupied.
c) There should be no interference from the Contractor's machines or equipment or from any other abnormal noise source.
d) The microphone is between 1 and 2 meters from floor level.
e) Microphone is not to be held in air velocities greater than 1, 2 m/sec and in any case never nearer than 1,2m from a noise source such as grilles, diffusers etc.
f) An average of three readings is to be taken for each area for each octave band.
g) Sample readings of background noise dBA should be taken with equipment not in operation before and after noise reading in any one area.

3.8.5 Commissioning

The Contractor does comprehensive pre-commissioning, commissioning as well as quality monitoring on all the HVAC systems in exact accordance with CIBSE Commissioning Codes C (Automatic Controls), A (Air Distribution), R (Refrigeration Systems), B (Boilers), W (Water Distribution Systems) and or ASHRAE Commissioning Guideline.

The Commissioning Report must:

a) Demonstrate that the services were commissioned in compliance with 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 of the recommendations.
d) Reference appended extracts of commissioning records for major plant and equipment; and
e) Comply to safety requirement as per OHSA when handling mechanical and electrical equipment or chemical substances

The commissioning includes the setting of all controls, dampers etc., and the balancing of the systems to meet the required design air volumes. The Contractor is required to include in the commissioning manuals readings obtained at all grilles, at the air handling units and other fans, at points on the ductwork prior to branch connections and pressure and velocity readings on the supply, return and extract ducts. Ducts are tested and balanced according to SANS 10173 latest revision

The commissioning procedure to be adopted is prepared by the Commissioning Authority. During commissioning the Contractor set the installation to work and competent personnel demonstrate 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.

Items of equipment which are of a specialist nature e.g automatic controls etc. are commissioned by the manufacturer's representative who instruct the Employer on the function and proper operation of the equipment.

3.9 COMPLETION

The contractor completes the following in accordance with the relevant specifications on or before the completion date:

a) The Plant is erected and commissioned.
b) Signed erection and safety clearance certificates.
c) The final 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.
g) Supply of any maintenance materials as listed in the contract and those normally supplied by equipment manufacturer

The complete system is to be subjected to performance tests under full working conditions. This is done in the last month of the defect liability period. The Contractor shall supply the necessary field-testing instruments (thermometers and flow meters) and detailed description of field-testing arrangement to prove a capacity/performance measurement accuracy of ± 5% for performance acceptance testing.

3.10 MAINTENANCE AND SERVICING DURING DEFECTS LIABILITY PERIOD

The Contractor performs all required maintenance until the end of the defect's liability period if so specified in the contract. The contractor is to execute maintenance and maintenance management under the supervision of Employer for a period specified in the contract.

The Contractor must return to site whenever is required or as defined by the detailed maintenance schedule forming part of the Operating and Maintenance manuals. The minimum intervals for the contractor to be onsite for inspection after taking-over of works shall be 3, 6, 9 and 12 months respectively. The plant is to be equipped with new sets of primary, secondary, and tertiary (where applicable) filters at the end of defect liability period.

A report after each visit shall 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 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 shall 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 own expense the whole or such parts thereof as the engineer may deem necessary, with apparatus to be specified by the Employer.

Final acceptance will only 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.

3.10.1 Service Level Agreement

The Employer expects the HVAC maintenance 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 HVAC equipment.
b) Restore any interruption to conditioned air supply within the agreed restoration times.
c) Maintain an accurate database of all assets maintained.

d) Comply with all safety requirements which include but is not limited to OHS Act requirements, handling of electrical and chemicals handling hazards

A maximum response time as detailed by the project specific specification of HVAC works will have to be allowed for all failures from the time the notification had been delivered to the contractor.

3.10.2 Maintenance information requirements

The contractor will provide maintenance information on each part of the plant during the 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 plant maintenance shall be executed by means of Employer request number which shall 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

3.11 TRAINING AND TECHNOLOGY TRANSFER

The Contractor is to provide on-site training and training material to the building owner/manager Engineers, Operators and Maintenance personnel. The contractor will, satisfy the Employer or authorized representative that maintenance 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

Steps for conducting on-site training is to include:

a) Preparation
b) Introduction
c) Explanation
d) Demonstration

e) Practice Under Supervision
f) Conclusion

The operating and maintenance manual must be available during the training of site staff. Site staff must also be made familiar with the contents of that manual.

3.12 EQUIPMENT WARRANTY

The warranty requirements are to be as per general conditions of contract. The Contractor transfers the ownership of all manufacturer equipment warranties to the Employer by the end of the defect's liability period.

4. TECHNICAL REQUIREMNTS

4.1 GENERAL

This section deals with the main items of material and equipment which are the Contractors responsibility to supply, erect and put into operation. The whole installation is carried out with the best quality of materials and highest class of qualified and experienced workmanship and complies with the latest amendments, variations on additions of the standard specifications.

4.2 FUNCTION OF PLANT

The main objective of HVAC in a power plant and building services in general is as follows however not limited to:

a) That all Server Rooms and Data Centres including C&I equipment rooms and other computer rooms are equipped with air-conditioning systems that will be able to control the ambient conditions between 20°C±2°C. The relative humidity is to be controlled between 45% ± 5% without condensation, as per the requirements of Eskom Server Rooms and Data Centres Standard (32-894).
b) That all C&I equipment rooms and other computer rooms are equipped with air-conditioning systems that will be able to control the ambient conditions between 22°C±2°C. The relative humidity is to be controlled between 20% to 75% without condensation, as per the requirements of Environmental conditions for process control equipment used at Power Stations (240-56355731).
c) That all control rooms are equipped with air-conditioning systems that will be able to control the ambient conditions to between 22°C±2°C. The relative humidity is to be controlled between 50% ± 10%.
d) That all offices are equipped with air-conditioning systems that will be able to control the ambient conditions to between 22°C±2°C. The relative humidity is to be controlled in accordance with the requirements of ASHRAE 55: Thermal Environmental Conditions for Human Occupancy (latest edition).
e) All battery rooms, medium and low voltage switch gear rooms, substations be equipped with air-conditioning systems that will be able to control the ambient conditions to 25°C maximum for 99% at all times and the humidity does not necessarily have to be controlled but is to be monitored and recorded.
f) All Variable Speed Drives (VSDs) rooms be equipped with air-conditioning systems that will be able to control the ambient conditions to 30°C maximum for 99% at all times and the humidity does not necessarily have to be controlled but is to be monitored and recorded.
g) All other ventilated areas are to be controlled at maximum temperature of 6°C above ambient conditions; and
h) All rooms are to be maintained under a positive pressure, so as to minimise dust ingress.

The power plants and buildings are to be provided with HVAC system as per the requirements of Eskom Heating Ventilation and Air Conditioning (HVAC) Design Guideline (240-70164623).

4.3 EQUIPMENT AND INSTALLATION REQUIREMENTS

4.3.1 Water Cooled Chillers

Chillers, cooling towers and pumps are to be selected to match one another. The water-cooled chilled water generators are to be standard factory assembled, commissioned and tested, complete with compressor(s) shell and tube condenser(s) and evaporator(s), control panel(s) etc. The unit uses vapour compression cycle as operating fluid. It is pre-wired, and factory charged with refrigerant and oil and refrigerant leak tested.

4.3.1.1 Water Cooled Chiller selection parameters

The chiller to be selected to operate without safety cut-out for the following conditions, which may occur simultaneously:

a) Return chilled water temperature- design plus 10ºC
b) Entering condenser water temperature of 40ºC maximum
c) Power supply at nominal Voltage less 10%

The chiller capacity is to be proportionally controlled from 20% to 100%. Control arrangement to result in leaving temperature not lower than 0.5ºC below the specified.

4.3.1.2 Water Cooled Chiller Control Panel

The chiller units are to be complete with integral motor control centre/control panel including wiring to motors, fans, controls, etc. Motor control centre/control panel ensures fully automated operation with all safety functions as follows:

a) The chiller is to start Direct On Line (DOL) unless otherwise specified in the detailed specification
b) The chiller plant is to be controlled and monitored by a dedicated electronic programmable system (“Chiller Plant Manager) which has the ability to interface and communicate with a BMS (Building Management System) without the use of additional installed hardware or software.
c) Communication to BMS system is to be via BACnet (Standard 135/1995 protocol and RS 485 or higher communication facility) or LonWorks.
d) Each chiller and pump is to be provided with an auto-off on selector switch. In the auto mode the chillers and pumps is to be controlled by the “Chiller Plant Manager”.
e) The “Chiller Plant Manager” is to be capable of the following functions:
    i. Time-of-Day-Scheduling: to provide 24 hours start/stop control for each day of the week.
    ii. Duty Cycle to cycle equipment according to user defined on/off patterns.
    iii. Demand limiting.
    iv. Chiller sequencing.
    v. Monitoring of chiller plant run-time and starts.
    vi. Provide maintenance scheduling facilities.
    vii. Soft loading to start the minimum number of chillers for morning pull-down load.
    viii. Control of auxiliaries e.g. chilled water pumps.

The “Chiller Plant Manager” is to be provided with all the necessary control modules, interfacing modules, interconnecting wiring and sensors to perform its required function. A remote PC and monitor terminal and modem are also to be provided. The terminal and modem are to be located on a floor to be determined. All required software is to be included and the unit is to be pre-programmed.

Flow switches are to be provided in each chiller circuit to confirm water flow before the chiller start is initiated. If chilled water is not established even though the pump contacts are made, then a no-flow signal is to shut the chiller down. This fault is to be indicated on the chiller’s own control panel and be relayed to the “Chiller Plant Manager”.

Supply and return chilled water temperature sensors must be provided in each chiller circuit. These sensors must relay signals via the chiller’s own control panel to the “Chiller Plant Manager”.

Early detection and warning of refrigerant loss is to be available.

Resistance temperature detectors are to be embedded in the starter windings to sense high motor temperatures and provide additional motor protection.

As a minimum, the following is to be displayed on the panel:

a) Motor amperage and voltage.
b) Entering and leaving chilled water temperature.
c) Evaporator and condenser pressure.
d) Power consumed.
e) Percentage cooling capacity.
f) Operating hours.
g) Head tank pressure

The water chiller is to be fully protected and to fail safe. Safety protection is to be provided for the following possible external abnormal and overload conditions and displayed on the chiller control panel:

a) No or reduced condenser water flow.
b) No or reduced chilled water flow.
c) Low chilled water temperature.
d) High condenser refrigerant pressure.
e) Low evaporator temperature and pressure.
f) Low oil flow.
g) Low oil pressure.
h) Voltage drop, phase reversal, phase loss, severe phase imbalance and power loss.
i) Motor current overload and water contacts.
j) High motor temperature.
k) Faulty oil heater or low temperature
l) Low pressure in expansion tank

4.3.1.3 Water Cooled Chiller Installation

Chillers are to be installed in accordance with the manufacturer's instructions. Level adjustable spring isolators are to be used between the chiller and chiller base.

The chiller components, especially the compressors, are to be readily accessible for maintenance without major dismantling of other items or equipment.

The oil separator is to be an integral part of the compressor assembly and ensure exceptionally low oil circulation.

Bearings are to be of the Class 5 design.

Evaporators and condensers are to be of the shell and tube type, with the refrigerant in the shell and the water in the tubes.

Tubes are to be seamless copper, individually replaceable, externally finished and externally enhanced.

Piping connections to evaporator and condenser are to be either via standard removable water boxes with flanged connections or via flanged bends to provide access to the tubes without dismantling the piping system.

The compressors are positive displacement type, preferably screw or helical rotary type, with continuous capacity control from 100-20%. The evaporators and condensers are shell and tube type with seamless copper tubes rolled and expanded into tube sheets. The tubes will be individually replaceable. The

evaporator and condenser shall be supplied with standard removable water boxes with flanged water connections.

The oil separator is an integral part of the compressor assembly to ensure sufficient, not excessive oil circulation.

Air vent and drain cock are to be provided to each chiller.

4.3.1.4 Water Cooled Chiller Testing and Performance

The chillers are tested according to AHRI standard 550/590 or equivalent and approved. Minimum coefficient of performance (COP) for water cooled chiller when tested according to AHRI 550-2003 at standard condition to be as detailed by the table below:

Table 1: Minimum coefficient of performance (COP) for water cooled chiller when tested according to AHRI 550

Chiller Size	Minimum COP
1. Below or equal 350 kW	4
2. 350 to 750 kW	5
3. 700 kW and above	6

4.3.2 Air Cooled Chillers

The air-cooled chilled water generators are standard factory assembled, commissioned and tested, complete with compressor(s) shell and tube condenser(s) and evaporator(s), control panel(s) etc. The unit uses vapour compression cycle as operating fluid. It is pre-wired, and factory charged with refrigerant and oil and refrigerant leak tested.

The chillers are tested according to AHRI standard 550/590 or equivalent and approved. Minimum coefficient of performance (COP) for water cooled chiller when tested according to AHRI 550-2003 at standard condition to be as detailed by the table below:

Table 2: Minimum coefficient of performance (COP) for air cooled chiller when tested according to AHRI 550

Chiller Size	Minimum COP
1. Below or equal 350 kW	2.5
2. 350 and above	2.75

The chiller to be selected to operate without safety cut-out for the following conditions, which may occur simultaneously:
a) Return chilled water temperature- design plus 10ºC
b) Entering condenser air temperature of 50ºC max
c) Power supply at nominal Voltage less 10%

The chillers are to be suitable for operating satisfactorily in ambient temperatures down to -10°C. Low ambient kit is to be provided if necessary. The chiller capacity is to be proportionally controlled from 15% to 100%. Control arrangement to result in leaving temperature not lower than 0.5ºC below the specified values.

4.3.2.1 Air Cooled Chiller Control Centre

Chillers are to be provided with a factory mounted, microprocessor (digital) based control panel that ensures fully automated operation with all safety functions.

The chiller is to be fully protected and to fail safe. Safety protection is to be provided for the following possible external abnormal and overload conditions and displayed on the chiller control panel:

a) No flow or reduced chilled water flow.
b) Low chilled water temperature.
c) High condenser refrigerant pressure.
d) Low evaporator temperature and pressure.
e) Low oil flow.
f) Low oil pressure.
g) Voltage drop, phase reversal, phase loss, severe phase
h) Imbalance and power loss.
i) Motor current overload and water contacts.
j) High motor temperature.
k) Faulty oil heater or low temp.
l) Low pressure in expansion tank

As a minimum, the following is to be displayed on the panel:

a) Motor amperage and voltage.
b) Entering and leaving chilled water temperature.
c) Evaporator and condenser pressure.
d) Power consumed.
e) Percentage cooling capacity.
f) Operating hours.
g) Head tank pressure

Chillers are to be complete with integral motor control centre/control panel including wiring to motors, fans, controls, etc. Motor control centre/control panel are not to be subject to undue vibration. Motor control centre/control panel ensures fully automated operation with all safety functions as follows:

a) The chiller is to start Direct on Line (DOL) unless otherwise specified in the detailed specification.
b) The chiller plant is to be controlled and monitored by a dedicated electronic programmable system (“Chiller Plant Manager) which has the ability to interface and communicate with a BMS (Building Management System) without the use of additional installed hardware or software.
c) Communication to BMS system is to be via BACnet (Standard 135/1995 protocol and RS 485 or higher communication facility) or LonWorks.
d) Each chiller and pump is to be provided with an auto-off on selector switch. In the auto mode the chillers and pumps is to be controlled by the “Chiller Plant Manager”.
e) The “Chiller Plant Manager” is to be capable of the following functions:
    i. Duty Cycle to cycle equipment according to user defined on/off patterns.
    ii. Demand limiting.
    iii. Chiller sequencing.
    iv. Monitoring of chiller plant run-time and starts.
    v. Provide maintenance scheduling facilities.
    vi. Soft loading to start the minimum number of chillers for morning pull-down load.
    vii. Control of auxiliaries e.g. chilled water pumps.

The “Chiller Plant Manager” is to be provided with all the necessary control modules, interfacing modules, inter-connecting wiring and sensors to perform its required function. A remote PC and monitor terminal and modem are also to be provided. The terminal and modem are to be located on a floor to be determined. All required software is to be included and the unit is to be pre-programmed.

Flow switches are to be provided in each chiller circuit to confirm water flow before the chiller start is initiated. If chilled water is not established even though the pump contacts are made, then a no-flow signal is to shut the chiller down. This fault is to be indicated on the chiller's own control panel and be relayed to the "Chiller Plant Manager".

Supply and return chilled water temperature sensors must be provided in each chiller circuit. These sensors must relay signals via the chiller's own control panel to the "Chiller Plant Manager".

Early detection and warning of refrigerant loss is to be available.

Resistance temperature detectors are to be embedded in the starter windings to sense high motor temperatures and provide additional motor protection.

4.3.2.2 Air Cooled Chiller Installation Requirements

Chillers are to be installed in accordance with the manufacturer's instructions. The compressors are positive displacement type, preferably screw or helical rotary type, with continuous capacity control from 100-20%.

The evaporators and condensers are shell and tube type with seamless copper tubes rolled and expanded into tube sheets. The tubes will be individually replaceable. The evaporator and condenser shall be supplied with standard removable water boxes with flanged water connections.

Level adjustable spring isolators are to be used between the chiller and chiller base.

The chiller components, especially the compressors, are to be readily accessible for maintenance without major dismantling of other items or equipment.

Preference is given to hermetic motors to prevent the possibility of oil and refrigerant leaks at the shaft seal between the open motor and the compressor. Should open drive compressors be offered as an alternative, they are to be of the totally enclosed fan cooled type. Standard protected drip proof motors are not acceptable.

Circulation of the oil used for bearing lubrication and compressor oil injection is to be by differential pressure without the use of a mechanical oil pump.

Bearings are to be of the Class 5 design.

Evaporators are to be of the shell and tube type, with the refrigerant in the shell and the water in the tubes. Tubes are to be seamless copper, individually replaceable, externally finished and externally enhanced.

Piping connections to evaporator are to be either via standard removable water boxes with flanged connections or via flanged bends to provide access to the tubes without dismantling the piping system.

The chiller supplier is to check and sign off that the connecting piping system is adequately supported so that no strain is imposed on the chiller.

Air vent and drain cock are to be provided to each chiller.

The evaporator is to be insulated with a minimum of 19mm closed cell insulation. Evaporators for dual compressors are to have two independent refrigeration circuits.

Air cooled condenser coils shall be seamless copper tubes with aluminium fins. Condenser fans are to be propeller fans (or centrifugal for high ESP applications) with fan guards. Condenser fans and coils are to be provided with hail guards.

The oil separator is to be an integral part of the compressor assembly and ensure exceptionally low oil circulation.

An acoustic enclosure is to be provided to obtain specified ambient noise levels. The enclosure is to be fully accessible without special tools.

4.3.3 Chilled and Condenser Water Pumps

The pumps capacity and head are approximate only and shall be selected to match other components of the chilled water plant.

The installation of centrifugal pumps is to be based on Eskom standard specification on centrifugal pump (240-56030558).

The chilled water pumps are to be centrifugal pumps and selected with relatively flat head/quantity characteristics such that change in operation pressure is not causing excessive alteration in the water quantities.

Pumps are to be designed to facilitate replacement of all wearing parts without removing the motor or pipework. The accidental reverse of flow should not damage the pump

Mechanical seals are to be provided with drip trays forming an integral part with the pump casing. A minimum of 25mm drainpipe is to be installed between each drip train and the nearest floor drain channel. Impellers are to be of bronze unless otherwise specified in the detailed specification, fully enclosed and hydraulically balanced.

Shafts are to be stainless steel, metal bearings are the ball or roller types provided with threaded plugs (not grease cups on nipples) and are to be cleaned and packed with new grease before commissioning.

Unless otherwise approved, pumps are to be directly coupled to the drive motor and run at speeds not exceeding 1500 rpm and are complete with flexible drive couplings to allow for angular and axial misalignment.

The pump installation is complete with flanged inlet and outlet connections, matching flanges, removable coupling guard and fabricated steel base for pump and motor, etc.

Pump discharge connections larger than 75 mm diameter and operating at more than 20 m total dynamic head, are provided with casing wearing rings. Rings are to be bronze, chrome iron, nickel iron or other suitable composition. One set of spare wear rings to be supplied with oversized outside diameter to enable them to be machined at site to proper dimensions

Pumps are provided with automatic air release valves with separate isolating and test cocks unless the pump is made as a self –venting by arrangement of nozzles

Bearings shall be designed for a minimum operation of 100 000 hours.

4.3.4 Piping, Fittings and Valves

Chilled water and condenser water piping are medium black steel in accordance with SANS 62.

Detailed shop drawings of physical and schematic layout of pipework are to be submitted for Employer's approval, before any pipework erection starts at site.

Piping in plant rooms is to be arranged that normal inspection and servicing of equipment is not obstructed.

Horizontal water pipes to run with a slope of not less than 2%. Low points are to be provided with valved drains and hose nipples not smaller than 20mm. Each high point is to be provided with an automatic air vent valve, structurally designed for the same pressure as the valves used. Outlets of vent valves are to be piped to floor drains, drip pans, etc. as approved.

Provisions are to be made to close the flanges and openings of all plants and pipes to protect them from damage and entry of dirt during transit and partial erection. Ends of pipes are reamed before being made up into fittings.

Piping is to be supported at suitable intervals with preformed wood blocks replacing insulation at those points. Canvas overlaps the blocks and vapour seal is continuous. Clamps or saddles are to be outside the vapour barrier.

Supports are to be designed to avoid vibration and strain. Where necessary, rigidly supported flexible connectors or loops are to be incorporated.

The maximum horizontal piping support is to be provided as follows:

Table 3: Maximum horizontal support spacing of pipes

Nominal Pipe Size	Span
15mm – 32mm	2,5m
40mm – 65mm	3,0m
80mm – 90mm	3,6m
100mm – 150mm	4,25m
200mm – 300mm	4,75m
350mm and above	6,00m

Piping and fittings of 65mm and larger are flanged or welded. Piping and fittings of 50mm and smaller are to either screwed, flanged or welded.

Branch connections are to be made with tees. Alternatively, factory made welded nipples may be welded directly to mains where the branch size is not less than 50mm and not over 2/3 of the main size, and threaded welded outlets may be welded directly to the mains where the branch size is not over 75mm and not over 2/3 of the main size and the main is not smaller than 50mm.

Matched flanges are to correspond in construction and dimensions to flanges on equipment and are provided with the correct bolts, nuts and gaskets.

Flanged fittings are in accordance with SANS 1123 to suit the class of pipe used.

Flange gaskets are to be of reinforced rubber insertion, in accordance with SANS 564.

Valves are of the same manufacturer and type for the same function.

Where valves are flanged, mating flanges are to match the valve flanges.

Gate, globe, check valves and strainers are to be copper alloy up to and including 50mm and cast iron in larger sizes.

Valves for Chilled Water, Condenser Water and Potable Water are of the following materials and construction:

4.3.4.1 Copper Alloy Gate Valves

Copper alloy gate valves are to be constructed in accordance with Standard for Low Pressure Valves (240-105020315). Copper alloy valve bodies are to be with screwed bonnets and screwed ends, non-rising copper alloy stem and solid tapered wedge type discs of bronze.

4.3.4.2 Cast Iron Gate Valves

Cast iron gate valves are to be constructed according to Standard for Low Pressure Valves (240-105020315). Cast iron valve bodies are to be with flanged ends, bolted bonnets and yokes rising bronze spindle with outside screw and yoke, solid cast iron wedge disc with bronze seat rings on body and disc and bronze trim. Spindle to have back seat to facilitate repacking of valve while under pressure.

Gate valves shall be used as isolating or shut-off valves. Use non-rising stems only where space is limited.

4.3.4.3 Copper Alloy Globe Valves

Copper alloy globe valves are to be constructed according to Standard for Low Pressure Valves (240-105020315). Copper alloy valve bodies are to be with screwed bonnets and screwed ends, rising copper alloy stems with inside screw, bronze trim and bronze seat rings and bronze discs.

4.3.4.4 Cast Iron Globe valves

Cast iron globe valves are to be constructed according to Standard for Low Pressure Valves (240-105020315). Cast iron bodies are to be with flanged ends, bolted bonnets and yokes, rising bronze stems with outside screw and yoke, replaceable bronze seats and replaceable discs and bronze trim.

The type of disc is to be suitable for the application. Globe valves are used for throttling or balancing purposes.

4.3.4.5 Butterfly Valves

Butterfly valves are to be constructed according to SANS 1849. Cast iron bodies are to be with suitable rubber lining inside, flanged ends and rubber insertion between flanges.

Lever operation will have position indication and locking mechanism. Butterfly valves are to be used for throttling or balancing purposes.

4.3.4.6 Diaphragm Valves

Diaphragm valves are to be constructed according to SANS 1808-13. Cast iron bodies are to have screwed ends up to 50mm and flanged ends 65mm and over. Diaphragm valves are to be used for rough control or as shut-off valves.

4.3.4.7 Check Valves

Check valves are to be constructed according to SANS 1551-1. Cast iron or steel bodies are to be screwed ends up to 50mm and flanged ends 65mm and over. Working parts to be spring-loaded, completely guided or swing-flap operation and fabricated or stainless steel or bronze with elastic seats.

Check valves are to be of the `non-slam' type with horizontal or vertical installation. Valves with stainless steel perforated cone and resilient conical diaphragm are also acceptable. If flange mounted, a short straight removable flanged pipe section or bobbin is to be provided for easy removal.

4.3.4.8 Float Valves

Float valves are to be constructed according to SANS 936. Copper alloy valve bodies and working parts are to be with screwed connections, and valves shall be suitable to open against the system pressure.

4.3.4.9 Air Vents

Air vents are to be automatic and to have bodies of cast-iron with screwed ends, floats, float mechanisms and all working parts of stainless steel.

Vent pipes are to be installed at all high points in the system, or as shown on the drawings. Vent pipes are to be provided with globe valves at a position easily accessible. Vent pipes will be taken up to 200mm above the highest point in the system.

4.3.4.10 Strainers

Strainers are to be of angle or Y-type. Strainers up to 50mm are to have copper alloy bodies with screwed ends and bronze screens. Strainers of 65mm and over are to have cast iron or fabricated steel bodies with flanged ends and screens of stainless steel or bronze. Screens are to be perforated as detailed by the table below.

Table 4: Details of strainer screen perforation

Size	Perforation
Up to 50mm included	0,8mm
65-150mm	1,8mm
200mm and over	3,2mm

4.3.4.11 Balancing Valves

Balancing valves are to be bronze or cast-iron valve bodies, bronze fixed orifice discs, and internal seals, screwed ends up to 80mm, flanged ends 100mm and over.

Balancing valves are to be provided with screwed take-off connections to which a pressure differential gauge can be coupled and provided with check valves in the take-offs.

4.3.5 Feed and Expansion Tanks

The feed and expansion tanks are to be of welded construction, constructed from 304L stainless steel. The tanks are to be completed with outlet, overflow, drain, inlet ball valve, fixed vented cover.

The tanks are mounted on a stand constructed from heavy gauge angle iron. A platform is to be provided around the tank, complete with handrails, ladder, etc.

The tanks are to be isolated from dissimilar materials at both support and piping connections with an approved corrosion preventive method. The tanks must have a facility for mounting of high- and low-level controllers.

4.3.6 Cooling Towers

The cooling tower are to be installed as described in the detailed project specifications with associated pipework, valves, pumps and controls.

The heat rejection plenums are to be extended over the roof level, if the plant is located inside the building. The heat rejection plenums are to be supported from the roof trusses with the purpose made supporting structures. The installation is to be co-ordinated with the building contractor to prevent rain penetration. The plenums are to be constructed from the same material as the cooling tower.

The cooling towers condenser water system is to be of closed circuit, forced or induced draught type.

The cooling towers to be corrosion protected under all conditions of normal usage, bearing in mind their exposure to weather, polluted air and various water treatment system.

The cooling tower casing of fiberglass is preferred. Any equivalent alternative is subject to Employer approval. Air intake screens and removable water strainers are to be provided.

Sumps and all parts requiring maintenance are to easily accessible. Replaceable spray eliminators are to be provided at discharge to minimise water wastage.

All electrical devices are to be waterproof but mounted out of the spray.

Spray nozzles are cleanable, replaceable type.

Means are to be provided for continuous bleed off to waste to prevent a build-up of salt concentration in the water.

The sump thermostats and latching relays are to be provided to cycle the fans and modulating bypass valves, to maintain a constant leaving water temperature under varying refrigeration load condition.

The blow down from cooling towers shall be piped to the disposal point provided by employer.

The blow down water is going to dirty water system or to sewer but not to the storm water system.

Water treatment on any closed loop or open loop to be via permanently installed dosing pods.

4.3.7 Chilled Water Air Handling Units

The air handling units are to be located as described in the detailed project specifications. The field assembled air handling units are to be plenum type, sized to allow a service man to work comfortably inside.

Where equipment such as coils or filters is to be smaller than the cross-sectional area of the plenum, the spaces around the equipment are sealed off by means of sturdy blank-off plates. Unit casings, for installations consisting of more than one unit, are of a standard size as far as possible.

The casings are to be of double wall, factory made panels with internal insulation and a thickness of 50 mm. Panels are to be fastened to each other in an airtight and watertight manner by means of an efficient and suitable locking arrangement and the use of a suitable sealing compound.

Construction of panels and the locking method are to be designed so that flexure of the composite side panels of the casing are not more than 1/200 of the span under a stress equivalent to static air pressure of 2500 Pa. Structural reinforcement is to be provided if necessary to ensure the rigidity of the panels. Junctions between the floor and side panels and the roof and side panels are to be rigid, strong, watertight and airtight. Casing panels and access doors are fabricated of approved sandwich panels. Sizes of closing panels on the sides and roof are measured on site before manufacture.

The insulation is to have a minimum density of 48 kg/m³ and a conductivity of 0,033 W/m°C at 24 °C average temperature. The insulation does not settle, tear loose produce dust or be environmentally unacceptable.

The air handling units are complete with filters, cooling coils, electric heaters, drip trays, fans, etc. as required. Light fittings are fitted in each individual plenum with switches mounted on the air handling unit panels.

The units are complete, and quality and performance tests are carried out and accepted by Employer.

Access doors are provided to each of the two fan compartments, filter/coil compartment and to the return air/fresh air mixing plenum. Doors are of the perforated sheet double wall construction, with insulation. Doors are factory installed in panels provided with door openings and are hinge on sturdy hinges. Doors are provided with two door handles which can be operated from inside and from outside the plenum. Doors open against the system air pressure and shall be airtight. The doors are 600 mm wide x 1500 mm high (minimum).

4.3.8 Cooling Coils

The cooling coils and chilled water plant capacities are to match. Any discrepancies have to be clarified in tender stage. The cooling coils are to be of copper tube with aluminium fins and the fin spacing and number of rows are to be such that the air leaving the coils will have wet and dry bulb temperatures as specified.

The velocity across the cooling coils is not to exceed 2.5 m/s.

4.3.9 Heater Banks

Electric heaters are to be always easily accessible for inspection and element replacement and have a permanent warning notice on the inspection cover.

Every precaution is taken to minimise fire risk. Therefore, elements are of the prime surface, stainless steel sheathed, mineral insulated type designed to operate at black heat in still air.

Heater elements are supported so that they do not vibrate in operation.

Terminal boxes are positioned and ventilated, if necessary, to remain cool and all electric wiring in the terminal box are of a heat resistant type which will not fail in the event of failure of air flow and the safety thermostat. This safety thermostat provides back-up protection and is of the automatic resetting type. It is so located that it will operate to disconnect power before permanent damage occurs but at the same time it must not operate spuriously when the fan is tripped for any reason. Main protection is by sail or pressure switch sensing air flow in the duct.

All electric duct heaters are of standard design, manufactured, wired and tested at works prior to delivery too site.

Type tests include checking under normal and failed airflow that elements and castings, terminals and wiring operate within acceptable temperature limits and that safety's function.

Wiring which is liable to exceed temperature limits for PVC is in silicone insulated or similar high temperature wire, not asbestos insulated.

The heater bank casing is to have flanges for connecting into duct systems.

In addition to a well-ventilated terminal compartment for elements and overheat stat (lock out type) a small totally enclosed electrical junction box is provided below each terminal compartment. This includes gland plate with knockouts for four conduits:

Fuse or MCB protection is provided for each heater bank in the main air-conditioning switchboard.

Internal linings are of a non-combustible material (asbestos cement is not acceptable) and are such that the surface temperature on the outside of the ducting does not exceed 40ºC at these areas.

4.3.10 Humidifiers

Steam humidifiers are to be of the fully automatic cabinet type suitable for connecting to potable water supply.

The humidifiers are to be supplied as fully automatic packaged units complete with chromium nickel steel steam cylinder, corrosion resistant heating element, replaceable collector bag, steam distribution header, regulators spray nozzles, steam and condensate lines, prewired electrical and control circuits etc.

The humidifiers are to be suitable for connection to standard 3 phase supply or single phase. The humidifiers are to be provided with necessary step or proportional control to achieve required humidity control range.

4.3.11 Reverse Pulse Filters

The filter unit is to be of a package unit type design complete with backward curve centrifugal, dust collector, sound attenuator/silencer, damper, controls, etc., housing and high efficiency filters.

The cabinet is to be designed to accommodate an up flow or a down flow air pattern. The objective of the cabinet design is to optimize the cabinet dimensions and the separation of the dust from the air stream.

The position and arrangement of the filters is to ensure that the velocity of the air stream/airspeed is not increased. The filters are to be easily accessible and be able to be removed safely without spillage.

The fan and fan motor are to be positioned on the clean air side of the filters. The fan is to be easily accessible and maintenance friendly.

The cleaning nozzles and internal piping are to be positioned on the clean air side of the filters.

Ducting is to be able to connect at the inlet side of the unit by means of proper flanges as to ensure no leakage is permitted to contaminate the air.

Control and electrical equipment are to be placed in a separate compartment. Care is to be taken not to place electrical equipment in contact of the dust.

Collection of dust is to be at the lowest point of the unit in removable containers or collector.

Filters are to be of the cartridge type. The filter contraction is to be self-supported suitable for pulse jet cleaning applications. The filters are to be provided with a dial type manometer with pressure scale. The operating range is to be clearly marked on the pressure scale. Filter holding frames are to be capable of accepting equivalent filters of recognized makes.

Frames must be rigid to withstand at least twice the total pressure drop across dirty filters.

The pulse jet system is to be designed to make use of dry air at a pressure of 550 – 700 kPA. Care is to be taken not to exceed 700 kPa

The complete system is to be equipped with an automatic control system measuring the differential pressure in the clean air plenum and dirty air plenum. This is to be combined with a pulse timer to control the cleaning mechanism.

The fans are to be selected to operate more on the flat side of the operating curve. Fans are to have the capacities as required in the schedule and be selected at a filter static pressure loss of 75% of the maximum as recommended by the filter manufacturer. The variation in fan capacities is not to exceed + 30 % of the value specified with clean filter to – 10 % of the required quantity with dirty filters. Fan motors are to be drip-proof motors to IP 44 or better.

Air inlets and outlets not connected to ducting or equipment are to be provided with easily removable.

Equipment is be provided with sound attenuators, enclosures, or sound attenuating cowls in order to meet the minimum sound levels specified above or to comply with the Occupational Health and Safety Act.

The contractor is to supply the necessary field-testing instruments (thermometers and flow meters) and detailed description of field testing arrangement to prove a capacity/performance measurement accuracy of + 5% for Reverse Pulse Filter Unit performance acceptance testing.

4.3.12 Air Filters for Air Handling Units

4.3.12.1 General

All air-conditioning air-handling units are to be provided with the primary washable and secondary disposable filters to both fresh and return air.

The cable tunnel supply air fan rooms are provided with the washable primary filters.

All filters are to have a nominal overall face dimension of 600 mm x 600mm. Acceptable tolerance is to be provided as per SANS 1424

The filter efficiencies are be based on the face velocity of 2.5m/s.

All filter banks are provided with the pressure differential manometers and the pressure differential switches calibrated in SI units, connected with the control system for indication.

A complete set of spare filters both primary and secondary are to be supplied for all projects.

4.3.12.2 Compliance to Standard

The filters are to comply with the following standards:

a) The filters to comply with SANS 1424 and/or ASHRAE 52-76 standard.
b) The other acceptable filtration standards which efficiencies are similar to specified above ASHRAE and SANS standards but testing method of filters with efficiencies for control and electrical rooms are as follows:
    i. ASHRAE 52.1 – 85% dust spot efficiency
    ii. ASHRAE 52.2- MERV 13
    iii. EN 779-2011- class F7

4.3.12.3 Primary Cleanable Filters

The filter media is to be of a random laid non-woven, synthetic polyester fibre which is saturation bonded. The media is to be pleated, self-supporting on polypropylene. All pleats are to be evenly spaced not touch each other. The effective filter media is not less than 4.5 times the actual face area of the filter element.

The filter frame is to be galvanized steel or aluminium and the media is to be settled into the frame by means of the bonded sealant.

The frame is to be not thinner than 0.5 mm of “U” channel formation. Edges must be smooth to prevent injury of the personnel handling the frame and be corrosion protected.

The sealant is to be CFC free type. The sealant is to be firmly bonded and sealed into the frame by means of a polyurethane adhesive sufficiently thickened to prevent any air leakages in final differential pressure or during cleaning process

Average arrestance is to be at 2.5 m/s face velocity >93%.

4.3.12.4 Secondary Disposable Filters

The filter media are to be of high-performance synthetic material either deep pleated or bag type. The sealant is to be CFC free type. The sealant is to be firmly bonded and sealed into the frame by means of foam gasket tightly fitted to the frame to prevent any air leakages even in final differential pressure. The filters are to be weather resistant

4.3.13 Fans

Fans shall be of reputable manufacturer. The manufacturer shall be in possession of certified performance rating of fans. The test method and results must agree 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 always demonstrated and accessible to the Employer for monitoring.

4.3.13.1 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

4.3.13.2 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.

4.3.13.3 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.

4.3.14 Direct Expansion Systems

The direct expansion systems are systems using the refrigerant as a driving force and in this category the following systems are included:

a) Variable Refrigerant Flow (VRF)/Variable Refrigerant Volume (VRV) System
b) Split systems
c) Heat pumps
d) Self-contained air conditioning units

4.3.14.1 Variable Refrigerant Flow (VRF)/Variable Refrigerant Volume (VRV) System

The VRV/VRF 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 VRF/VRV 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 VRF/VRV 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 VRF/VRV 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 VRV/VRF system is to be through independent wired remote controllers and through HVAC BMS as specified. The complete VRV/VRF system units are to be capable of interfacing with motion sensors (motion detector) that are provided by others.

The contractor is to be 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 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^{0}C.

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.
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.

4.3.14.1.1 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 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 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 VRF/VRV 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 be installed between the condensing unit frames and the supporting brackets.

4.3.14.1.2 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.

4.3.14.1.3 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.

4.3.14.1.4 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.

4.3.14.1.5 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 bypass 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.

4.3.14.1.6 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 at 06h00 and switch off at 18h00. 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.

4.3.14.1.7 Central Remote Controller

The complete VRV/VRF system is to be provided with controls which area capable of interfacing with a HVAC BMS 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 BMS. The interfacing with a HVAC BMS 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.

4.3.14.2 Custom Built Air Handling Units (AHU) with Remote Condensing Units

The complete system is to be factory assembled, factory charged, factory run tested of mentioned capacities, air-cooled, direct expansion type air conditioning system consisting of one or more condensing units (outdoor). 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 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 50% 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 or 230V±10%, 50Hz, single phase supply. 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 system is to be of the inverter two (2)-pipe cooling only 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 indoor units.

The operation of the system is to be through local common controller to fully control the units and it must be able to accommodate alarm signals. The controller of the units is to be set up to control on the return air temperature and programmed such that should the temperatures within the respective rooms rise above 26°C or should a fault occur on the running unit, the controller will automatically start the standby unit.

The controller is to be able to switch over operation of the units at specified intervals, for instance once every week, to ensure equal operating time of both units. Manual override switch is to be installed to have any HVAC equipment switched on by maintenance when required.

The controller must accommodate fault signals with date and time, which will send a signal to the DCS in case of any failure or other parameter faults on the unit. The common controller is to indicate the operating status of the unit and malfunction by means of readout displays and audible alarm of the following malfunctions:

a) System fault
b) Loss of Air Flow
c) Clogged or Dirty Filters
d) High Room Temperature
e) Low Room Temperature
f) High Room Humidity
g) AC failure to be connected at the incoming power point of the air conditioning units or isolators on load side of isolator.

The common controller is to be compactable to connect with Fire Detection System and Building Management System (BMS) of standard makes.

4.3.14.2.1 Custom Built Air Handling Unit

Fan delivery is not to decrease more than 10% when filters are dirty or increase more than 10% when operating under maximum return air conditions. The operation point is to be in stable part of curve.

Fan motor is to be non-overloading at any operating point between zero external pressures and break off point impeller.

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.

All necessary instrumentation, including bulkhead plenum lights, inspection and testing provisions (including location) to enable the Operator to log performance and identify malfunctioning of equipment, in accordance with trouble shooting instructions, is to be installed and grouped together in such a way as to facilitate logging with maximum accuracy and reduce Operator's time to a minimum.

Unit casing shall have the following minimum requirements:
a) All air handling units to be at least 2.1 m high and 1.3m wide to allow sufficient maintenance access.
b) The factory assembled, sectionalised double wall insulated casing is to provide repair and/or removal access through easily removable panels to the various unit parts like fan and coils.
c) Sealed type bulkhead plenum lights with compact fluorescents are to be provided in each separate compartment.
d) A light switch with pilot light is to be provided next to the access door leading into the compartment.
e) The light fittings and wiring are to be suitably moisture proofed.
f) Insulation is to be in accordance with general insulation requirements.
g) Casing construction is to be in accordance with SMACNA Standards or approved equal.
h) Access doors are to be installed in the casing where shown, and where required for inspection, maintenance and replacement of equipment, instruments and controls.
i) Access doors are to be of the walk-in type, minimum 600 mm wide and 1700 mm high, consisting of a double skin insulated door, panel and frame. The frame is to be provided with a profiled rubber seal.
j) Access doors are to be of the hinged type and open against the air pressure. The two (minimum) door handles are to be of robust construction. An external lock is to be provided. The doors are to be openable from inside and outside.
k) Access doors to the spray plenum are to incorporate a double-glazed view window.
l) The roof and sides are to be suitably reinforced to carry the panel's own weight, people traffic and the air pressure differential.
m) Unit is to be airtight and weatherproof, suitable for mounting in exposed locations subject to wind, rain and hail.

Unit pre-filter and main filter banks are to have the following minimum requirements:

a) Filter frame to be suitable for standard commercial range of filter elements and filter media available.
b) Provide air filter gauge for each filter bank.
c) Provide adequate personnel access space for filter removal and replacement.
d) The filter elements and filter frame are to be corrosion protected. Ensure construction of filter frame and method of holding down filter elements allows no passage of unfiltered air through filter bank.
e) Each unit must have primary and secondary filters.
f) Primary filters on all the units must all be of the same type and size namely “duplex panel filters” with size 600 mm x 600m x 50 mm deep. These filters are to have a high dust holding capacity as specified in the equipment schedules. The primary filters must all be washable.
g) Secondary filters on all the units must all be of the same type and size namely “glass fibre pocket filters” 600 mm x 600 mm x 600 mm deep. The secondary filters are to be disposable.

Unit cooling coil section is to have the following minimum requirements:
a) Coil sections are to have heavy duty coil tracks extending the full width of the unit to provide easy slip in, slip out coils for ease of service and maintenance.
b) Piping connections to coils are to be flanged and so arranged that independent coil replacement is possible.
c) Each coil is to be provided with its own Type 316 stainless steel drip tray to prevent flooding of lower coils by condensate.
d) Cooling coil, connections and return bends shall be tested to 2000 kPa and rated for operation at 1700 kPa.
e) The coil section is to have a marine grade (Type 316) stainless steel frame.

Supply fan section is to have the following minimum requirements:
a) The supply fan is to be of the centrifugal type with backward curved impeller or vane axial type as listed in the schedule.
b) The fan motor is to be suitable for speed control.
c) Fan and motor assembly is to be installed on a steel channel base and isolated from the supporting structure by spring vibration isolators and neoprene pads.
d) Bearings are to be self-aligning, pillow block re-greaseable, selected for an average life of 200 000 hours at design operating conditions.
e) Fan wheels are to be keyed to the shaft and designed for continuous operation at the maximum rated fan speed and motor load. Select fans and shafts to operate at least 25% below the first critical speed. Fan wheels and shafts are to be statically and dynamically balanced as an assembly. After final assembly, test the entire unit for vibration.
f) Fans are to be belt driven with adjustable sheave and have readily adjustable provision to provide variation in centre distance.
g) Belts to be of the oil resistant type and selected for 10 000 operating hours at a minimum of 1.2 times the motor rating and one slip free start per day.
h) The motor to be of the totally enclosed fan cooled type. The motor starter, motor and drive to be selected to ensure slip free starting without unacceptable voltage drop.
i) The fan to be selected assuming a pressure drop across the filter equal to the average pressure drop caused by the filter in its clean and dirty states and operating at maximum supply air volume.

Automatic dampers are to have the following minimum requirements:
a) The dampers to be of the opposed blade type and interlinked with a robust geared mechanism.
b) The blades to be of aerofoil section with neoprene blade seal at one edge; not wider than 165 mm; and supported at intervals of not more than 800 mm by maintenance free non lubrication type bearings.
c) The operating mechanism to be within the overall size of the damper frame, except for the drive arm and the motor platform.
d) The arm is to be clearly visible and marked “open closed”.
e) The leakage rate, with the damper in a fully closed position is not to be more than 0.150 $m^3/s/m^2$ at a pressure differential of 100 Pa.

4.3.14.2.2 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.

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

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 ARI standard 575 or 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 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 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 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 be installed between the condensing unit frames and the supporting brackets.

4.3.15 Close Control Units

4.3.15.1 Under-ceiling Close Control Split Units

The unit cabinets are to be constructed from fully galvanised sheet metal powder coated to an approved colour. Each unit is to be provided complete with fans, fan motors and drives, direct expansion cooling coil, hot gas reheating (or electric heaters), air filters, control system with alarms and switchboard.

The contractor is to supply and install custom build drain pans underneath the indoor units. The custom drain pans are to be manufactured from 1,2mm 316-stainless steel and must accommodate a 25mm drain connection. The sides of the drain pan are to be 50mm high and must extend 50mm larger than the footprint of the entire size of the indoor units. The indoor units are to be installed inside the drain pans. The contractor is to allow for adequate PVC drain piping for this purpose. The drainpipe is to be routed to the nearest drain point located on the outside of the building.

Fan motors are to be non-overloading at any operating point of their performance curves. Fan delivery must not 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

The units must be fully protected and shall fail safe. Minimum safety protection, caused by possible external abnormal conditions, shall be provided for the following:
a) High discharge pressure. (Manual reset)
b) Low Suction pressure. (Auto reset)
c) Thermal overload for single phase motors.
d) Combined thermal overload and phase-failure for three phase motors.
e) Low oil pressure differential.
f) An excessive drop of voltage or power interruption shall disconnect the system with automatic re-start and normal operation and control when fault condition is rectified.

4.3.15.1.1 Indoor Units

The indoor units are to have a rigid steel frame with cover plates which will accommodate supply fan, evaporator coil, air filters, drip tray inside unit with suitable condensate drain point.

The indoor fan is to be selected assuming a pressure drop across the filter equal to the average pressure drop caused by the filter in its clean and dirty states.

The cooling coil must consist out of aluminium fins mechanical bonded to copper tubes. The unit is to be fitted with an anti-freeze stat.

The unit is to be equipped with a drip tray manufactured from galvanized steel. The condensate is to be drained to the nearest drain point (See drawing for possible drain point). The condensate lines are to be equipped with a water trap and the lines are to be made of I.D Ø25mm x O.D Ø26mm PVC tubing which must be properly secured to the building structure.

4.3.15.1.2 Outdoor Units

The condensing units are to be factory fabricated and be suitable for outdoor installation. The casing and structure for the condensing units are to be of robust construction and must be machine pressed and folded. The panels are to be of galvanized sheet metal steel duly powder coated. The casing is to have removable panels to allow access to the condenser coil, the compressor and fan.

The condensing unit is to consist of a compressor, condenser coil, fan, refrigerant accessories and the necessary controls. 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 be installed between the condensing unit frames and the supporting brackets.

Condenser coils are to have copper tubes, mechanically expended into aluminium fins. The coil in the outdoor unit is to be “hail”-proof. Compressors may be either semi-hermetic, suitable for field servicing or hermetically sealed.

Condenser coils offered are to provide special protection against harsh and salty environmental conditions, coils shell either be copper / copper, epoxy coated / or any other coil fin protection process. Coil protection offered is to be a standard application applied and approved by the manufacturer.

4.3.15.1.3 Management Controllers

The closed control split units are to be fitted with a controller to fully control the operation of the units and it must be able to accommodate alarm signals. The controller of the units is to be set up to control on the return air temperature and programmed such that should the temperatures within the respective rooms rise above 26°C or should a fault occur on the running unit, the controller will automatically start the standby unit.

The controller is to be able to switch over operation of the units at specified intervals, for instance once every week, to ensure equal operating time of both units. Manual override switch is to be installed to have any HVAC equipment switched on by maintenance when required.

The controller must accommodate fault signals with date and time, which will send a signal to the HVAC BMS in case of any failure or other parameter faults on the unit. The common controller is to indicate the operating status of the unit and malfunction by means of readout displays and audible alarm of the following malfunctions:

a) System fault
b) Loss of Air Flow
c) Clogged or Dirty Filters
d) High Room Temperature
e) Low Room Temperature
f) High Room Humidity
g) AC failure to be connected at the incoming power point of the air conditioning units or isolators on load side of isolator.

The common controller is to be compactable to connect with Fire Detection System and Building Management System (BMS) of standard makes. One signal per zone from the FDS to the HVAC System, indicating a fire instance, is accommodated for as a hard-wired fail-safe (normally energised) connection from the FDS to the HVAC System. The intelligence to open/close fire dampers or stop/start fans lies within the HVAC controller and is based on the fire and smoke extraction philosophy.

4.3.15.2 Down/Over Blow Equipment Cooling Units

Each unit is to be provided complete with fans, fan motors and drives, direct expansion cooling coil, hot gas reheating (or electric heaters), air filters, control system with alarms and switchboard.

The cabinets are to be designed to supply air from the bottom and return air to the filters in the top portion of the unit. The cabinet frames are to be constructed of welded tubular steel. All interior sheet metal is to be welded to the frame assembly. Exterior panels are to have concealed fasteners and must be quickly removable for easy access to the components. The panels are to be arranged to provide access to the electrical control panel and compressor section without interrupting the air flow. All exterior panels are be insulated with a minimum of 25 mm thick closed cell foam Insulation.

The cabinet are to have the same colour and finish as the computer equipment. The air-conditioning contractor is to determine the exact finish on the computer equipment before an order is placed for the units. Tube, cable and pipe connections are to be through the open base of the units.

The unit is to be provided with hot gas reheating of sufficient capacity to maintain the relative humidity in the room at 50 % minimum. Alternative types of heating will also be considered.

The filter section is to form an integral part of the unit within the frame and cabinet. The filters are to have an efficiency of not less than 65 % by the ASHRAE 52/76 Atmospheric Dust Spot Test. The filters are to be serviceable from either side of the unit without the use of ladders.

Units are to be equipped with both temperature and humidity control of the solid-state electronic type.

The contractor is to supply and install a control system in the form of a Management Controller that will be connected to two indoor units. The controller will fully control the new air conditioning system in terms of duty and standby operation as well as automatic changeover in case of failure of any unit. Once a fault occurs of the duty unit, and the temperature inside the equipment room rises to 26°C, a thermostat will energize the standby unit, and the exchange will be controlled on 26°C. The control system will accommodate a fault signal which will send a signal to the control room

Operating controls are to include on/off switch and delay timers to prevent hunting, push to test for warning lights, manual reset button, loss of power or low voltage indication and red visual displays of the following warning signals:

a) System fault
b) Change filters
c) Under floor water alarm
d) High temperature
e) Low temperature
f) High humidity
g) Low humidity
h) High-head pressure
i) Loss of air flow

The contractor is to supply and install custom build drain pans underneath the Air Handling Units. The custom drain pans are to be manufactured from 1,2mm 316-stainless steel and shall accommodate a 25mm drain connection. The sides of the drain pan shall be 50mm high and shall extend 50mm larger than the footprint of the entire size of the Air Handling Units. The contractor is to further supply and install 100mm x 100mm x 2mm galvanized square tubing underneath each drain pan to allow adequate fall for drain piping. The Air Handling Units are to be installed inside the drain pans.

The contractor is to supply & install a 25 mm drainpipe into the stainless-steel drip pan below the coil and humidifier to the nearest drain or gully. A properly designed “U”-type water trap is to be installed at each drain pan. The drainpipe is to be chased into the slab. If this is not possible the drainpipe is to be covered by a stainless-steel V plate.

The contractor is to supply and install galvanized frames that must be able to support the AHU’s. The frames are to be manufactured from 50 x 50 x 5 angle iron and all four legs will be adjustable for height and feet will have 100 x 100 x 5 galvanized plate so as to prevent damaged to the custom drain pan specified above. The frames will be positioned inside the drain pans with vibration eliminator rubbers and are to be manufactured to fit the exact dimensional footprint of the AHU’s and be at least 200mm high. The legs of the frame are to have lock nuts to secure its position. Vibration eliminator rubbers are to be installed between the frames and the floor.

The contractor is to supply and install a water detector into the drain pan of each of Air Handling Unit (AHU). The water detector must detect water leaks and route the alarm to the internal controller of the air handling units. The alarms are to be linked to the general alarm of the Management Controller.

The indoor and condenser units are to be both from the same manufacturer. Condenser coils offered are to provide special protection against harsh and salty environmental conditions, coils shell either be copper/copper, epoxy coated / or any other coil fin protection process. Coil protections offered are to be of standard application applied and approved by the manufacturer.

The condenser units are be equipped with variable fan speed. The power source required is 230 V and must be supplied by the contractor from the indoor unit. The condenser 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 be installed between the condensing unit frames and the supporting brackets.

Although drawings are attached to the specification the positions of all equipment mentioned above are to be confirmed with the Employer's representative and all other involved disciplines before installation commences. The signing of the contractor's shop drawings is to be suitable confirmation. In the event that the contractor proceeds without signed working drawings he does so at his own risk.

4.3.15.3 Heat Pumps (Air Cooled)

Heat pumps are to be completely self-contained with stainless steel or epoxy coated casing suitable for outdoor use.

Each refrigeration circuit is to be fitted with a sight glass, replaceable filter dryer, manual liquid shut off valve, low pressure switches and suction and discharge pressure gauges.

Reverse cycle is to be thermostatically controlled and defrost is to be demand controlled and not timer controlled.

A condensate drip pan of stainless steel is to be fitted and piped to the nearest drain point.

A heat pump is to be selected for maximum compressor running 24hr/day. Heat pump is to be selected to run at Wet bulb temperature as low as -10ºC and as high as 25ºC. Minimum COP is to be at least 3 for both cooling and heating operations.

Each heat pump is to be fitted with a control panel which contain fault indications. Controls are to be able prevent compressor short cycling on low demand.

The compressor is to be interlocked with evaporator fans and the flow switch to prevent operation unless those are functional.

Access to all working parts of the heat pump unit is to be provided with openable panel.

4.3.15.4 Self-contained Air Conditioning Units

Self-contained air conditioning units are to be supplied completed with fans, direct expansion cooling coil, compressor unit, condenser, expansion valve, refrigerant tubing and accessories, air filters, return air grille and mixing plenum, control panel and control thermostat. Units are either total indoor type (i.e. window room air conditioners) or total outdoor unit (i.e. single package cooling unit or heat pump). Condensers are air or water cooled.

Air cooled condenser can be remote, connected with refrigerant piping or built into unit (i.e. single package cooling unit or heat pump) with ducted air in and out. Water cooled condenser can be evaporative cooling type of or built into unit with water connections.

Indoor units are suitable either to connect to ductwork or with air plenum fitted with adjustable air louvers to direct air. Varies configurations are available to supply air into the floor plenum, ceiling plenum or directly to the room. Return air is similarly handled.

Outdoor units are suitable for ducted supply and return with purposely design air mixing plenum to accommodate required fresh air intake air filters. The units installed outdoor are to be weather resistant through usage of material or epoxy coating to all expose surfaces.

Easily detachable access to all components which require maintenance is to be provided. The interior of the cabinet is to be insulated with neoprene or 25 mm thick sonic liner or other approved insulation methods.

Compressors are to be sealed or semi sealed reciprocating or rotary type

Indoor air supply is to be centrifugal type.

Outdoor fans (condenser fans) are to be centrifugal or axial fans for ducted installation or propeller type for free air flow. Axial air flow fan is preferred for dusty environment.

Controls are to be incorporated with the unit (weatherproof for external units) for on/off condition and thermostatic capacity control.

4.3.16 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. 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 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 5: Thickness of refrigerant copper piping

Pipe Size (OD) in mm	Wall thickness in mm
54.10	1.5
41.28	1.3

Pipe Size (OD) in mm	Wall thickness in mm
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 6: Maximum Support Spacing for refrigerant piping

Pipe Size (OD) in mm	Maximum Support Spacing (mm)
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 subcomponent 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 by-passes 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 shut-off 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 shut-off 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 sweat-ends, 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.

4.3.17 Drain Piping

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 drainpipes on the inside of the building. The drain piping is to be supported every two meters by mean of brackets.

4.3.18 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.

4.3.19 Air Terminals

4.3.19.1 Grilles and Diffusers

Grilles and diffusers are to be selected for correct sizing and positioning to obtain the most efficient air distribution in the space served.

Grilles and diffusers are to be made of aluminium and be complete with a sponge rubber sealing gasket around the fixing flange to prevent leakage and help eliminate dust streaking.

Each outlet is to be capable of passing the air quantity specified without creating undue resistance, noise and local draughts.

Side wall supply registers are to be of the double-deflection type and each to be complete with adjustable horizontal face bars, adjustable rear bars and opposed blade damper. The damper shall be adjustable from the face of the register by means of a key or like means. The adjustable blades are be secured in set positions with nylon grommets.

Ceiling diffusers are to be round, square or rectangular type and be constructed to provide single-, two-, three- or four-way blow, with each side delivering a quantity of air proportional to the area served. Ceiling diffusers are to have removable cores.

Supply air registers and diffusers must not be mounted flush with the base or side of the supply duct but have to be interposed to a short length of branch ducting to ensure even distribution from the outlet and to decrease the noise level generated.

Extract/Return air grilles are to be of the single deflection fixed vane type fitted with opposed blade damper.

Transfer and door grilles are to be fixed blade inverted vee type with companion flanges where appropriate.

The supply air diffusers required for the equipment rooms are to be of the industrial type variable twist outlet. The variable twist outlets must provide adjustable air diffusion and be positioned as shown on detailed project drawings.

4.3.19.2 Weather Louvers

Weather louvers installed in the cladding and other structures are installed by builder to HVAC contractor design. The coordination with the steel or building contractor’s will be required.

Where it is specified on project drawings or in detailed specification that louvers are supplied by air conditioning contractor, the coordination with builder is required. The scaffolding required to install those louvres to be supplied by air conditioning Contractor.

The louvers to be manufactured from galvanised steel, corrosion protected with powder coating and galvanised vermin screen.

4.3.19.3 Variable Volume (VV) Diffusers

The Variable Volume (VV) diffusers are to be a product of reputable suppliers who has a track record of reliability and local service.

The variable volume is to be achieved with low voltage (24V) electrical drives to promote safety of the installation in accessible ceiling spaces.

Wiring is to be silicone or similar high temperature resistant; fire rated, and not be asbestos insulated.

Minimum air volume is to be factory pre-set and is not to be lower than 50% of the design flow.

Easy access to all parts needing pre-setting or maintenance is to be provided.

The air terminal is to be suitable for attaching on a standard flexible connection.

The air terminal is to be complete with factory calibrated balancing device to adjust the specified air volumes under “full-open” conditions.

The discharge pattern is to be constant under all flow conditions, i.e. no dumping under minimum flow to occur.

The diffuser and mounting plate to be powder coated to an approved colour.

The diffusers with drives and re-heaters are to be positioned as indicated on the project drawings. The re-heaters are to be protected against overheat with adequately rated switch. The electric heater to be provided with:

a) Auto reset thermal cut-out device set at 65^{o}C.
b) Manual reset thermal cut-out device set between 80 – 100^{o}C with reset button, labelled and operable without removing any terminal box cover.
c) Elements are to have an adequate resistance to earth, with due regard to the possible condensation of moisture during the cooling cycle.

The Contractor ensures that the ceiling construction is sufficiently strengthened to take the operating weight of the terminal.

Noise level in the conditioned space through the operation of the unit at any operation point not to not exceed NC 40 measured 1.5m from terminal, assuming an 8dB attenuation in each octave band

The throw (min. to max.) is based on an end of throw velocity of 0.50 – 0.25 m/s respectively under maximum flow conditions.

4.3.20 Dampers

All dampers necessary for the correct adjustment and control of the various air distribution systems are to be provided, arranged and adjusted to suit the circumstances relating to each particular instance. Such devices are in all cases being of a design and pattern which will not permit more than 5% leakage when in the closed position. The 5% leakage value should be tested and proven.

All dampers are to be products of specialist manufacturers and are to be of rigid construction. Dampers wider than 1200mm are to have a divider plate in the middle.

Blades are to have steel turning unions in bronze steel bearing or ball bearings, properly aligned to ensure smooth operation from fully open to fully closed. Operating links are to be steel or brass rods adjustable in length and of such proportions that they will withstand without appreciable deflection, a load equal to not less than twice the maximum operating force of the damper motor. Couplings in linkages are to be made with steel or brass pins or with amply sized ball and socket joints. Steel parts are to be finished in enamel paint or other approved protective finish.

Control air dampers are to have extruded aluminium blades and be externally gear driven. Control air dampers are to be opposed blade construction details, and each hand set damper fitted with a locking device, capable of being fixed after adjustment and giving a visual indication of the damper position.

Maintenance access is to be provided through ceiling panels, where applicable and an access door be provided i.e. the ductwork at each damper.

The motorised dampers shall be provided with a mounting plate for the actuating motor and the ball bearings, unless otherwise stated.

Each main branch duct is to be provided with a control air damper of approved design.

The operating mechanism of all dampers is to be easily accessible for adjustment.

The contractor is to submit the flow resistance of the dampers in the full open position.

Fire dampers are be provided where indicated on the project drawings and be in accordance with SANS 193 or BS 476 Part 8. Fire dampers are to provide the same fire resistance as the structural elements whose integrity they protect. Each fire damper is to have a fire rating of at least two hours and be provided with a re-fusible fire link to be activated when excessive duct temperatures are encountered.

Electrically operated dampers are to be provided with a motor actuator which is to activate from the smoke detector system. Resetting and testing of the electrically operated smoke/fire dampers are to be controlled remotely. Wiring to be silicone or similar high temperature resistant, fire rated, and shall not be asbestos insulated.

Fire/smoke dampers are to be of the multi-blade type construction with metal-to-metal seals. The fire dampers are to be adjustable for air volume control.

Fire resistant sealing of the openings around the fire dampers located in the concrete floor slabs of the riser shafts and all walls is to be carried out by the Contractor.

The installation and setting of the dampers is to be in accordance with the manufacturer's instructions. Sleeves are to be fitted to all dampers to suit the wall or floor slab thickness.

4.3.21 Welding

Welding is to be carried out in accordance with Standard for Welding Requirements on Eskom Plant (240-106628253).

4.3.22 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.

4.3.23 Painting and Corrosion Protection

Welding is to be carried out in accordance with Standard for the External Corrosion Protection of Plant, Equipment and Associated Piping with Coatings (240-106365693) and Standard for the Internal Corrosion Protection of Water Systems, Chemical Tanks and Vessels and Associated Piping with Linings (240-101712128).

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 7: 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

Equipment or Plant	Colour Code
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

4.3.24 Noise Levels

Noise levels in the air-conditioned areas are to be as specified in detailed specification (see HVAC design guideline 240-716 4623 to be included by the Designer) when measured at a point 1,5 m above floor level and at a distance of 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.

4.3.25 Water Treatment Requirements

The potable water (drinking water) will be used in the chilled water and condenser water systems both in commercial and power station environment. When the condenser water system is connected to the station auxiliary cooling system the water quality of this system is to be used (i.e. demineralized water).

The Contractor is to provide chemical dosing connection points with valves in each system. The Contractor is to be responsible for checking the quality of the water before commissioning of the systems, and again before the end of the defects period, and provide any chemical dosing that would be required.

Dosing pods should be installed permanently at both open and closed loop systems.

The safety in handling of the dosing chemicals needs to be described in the operating manuals.

The water quality is described in Eskom document 240-55864833 Chemistry Standard for Auxiliary Cooling Water, 240-55864764 Chemistry standard for potable water and 240-53113712 Demineralised water production using Iron exchange resin (chemistry standard).

4.4 CONTROL AND INSTRUMENTATION

4.4.1 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.

4.4.2 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.

4.4.3 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

4.4.4 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.

4.4.4.1 Temperature Indication

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

4.4.4.2 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 is 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.

4.4.4.3 Relative Humidity Indication (hygrometers)

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

4.4.4.4 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.

4.4.4.5 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.

4.4.5 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.

4.5 ELECTRICAL INSTALLATION

4.5.1 Minimum Requirements

The electrical part of HVAC works is to fully comply to Eskom standard specification 240-56227516 (LV Switchgear and Control Gear Assemblies and Associated Equipment for Voltage up to and Including 1000V AC and 1500V) and SANS 10142-1 (The wiring of premises Part 1: Low-voltage installations).

4.5.2 Contractors Responsibilities

All electrical equipment necessary for the safe and efficient working of the HVAC plant is to be provided by the Contractor in terms of this Specification. This includes local control panels, switchgear, and instrumentation, interface cabling amongst the Contractors' plant, motors, actuators, heaters and any other electrical auxiliary equipment as is necessary for the proper operation of the plant. The contractor is to interface with other Contractors and the Employer to ensure that equipment supplied by the Contractor interface correctly with other equipment from other Contractors.

The Contractor is to submit the electrical plant operating philosophy to enable integration of the plant forming part of the works into the overall plant operating system.

The Contractor is to provide the racking and cabling between field equipment and switchgear and any junction boxes (provided by the Contractor). All cable racks provided by the Contractor are to include safe, accessible servitudes (designed by the Contractor) for cable racks. The cable servitude and cable racks design are to be subject to approval by the Employer.

All cables including power cables, control cables and any special cables e.g. fibre optic, co-axial, compensation etc. are to be provided by the Contractor between the switch board and field devices. The Contractor is to provide cable schedules and termination schedules. The Contractor is to supply, install, terminate and test all cables between the switchgear, junction boxes and field devices.

The earthing of mechanical plant for example vessels, support structures, and ducts are to be performed by the Contractor in accordance with the earthing and lightning protection standard.

4.6 FIRE SYSTEM INTERFACE

Fire interface is described in the document 240-54937450 Fire Protection and Life Safety Design Standard.

5. AUTHORISATION

This document has been seen and accepted by:

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Mfundo Verby	Middle Manager – Auxiliary Study Committee Chair
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6. REVISIONS

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February 2022	1.3	N Ndika	Draft Document updated to incorporate comments and inputs from Auxiliary SC. Draft Document issued to Power Plant and Auxiliary Technical Committee Members for Comments Review
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7. DEVELOPMENT TEAM

The following people were involved in the development of this document:

- Dithole Kubyane
- Prenolan Gangan

8. ACKNOWLEDGEMENTS

- All team members to as listed under section 5 above.