



HVAC Equipment Specification

Version: 01

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A. Drawing register

SECTION 1: DETAILED SPECIFICATION

1 Introduction

This specification is to be read in conjunction with the General specification documents included in this data pack

This document provides the proposed scope, brief, project principal design, supply, installation, testing, commissioning and documentation for supply of the HVAC plant installation for SITA's Buro Beta data centre.

1.1 Objectives

1. The intent of this specification is to:
 - a) Define the priorities and objectives that shall guide the design & documentation decisions
 - b) Define the technical requirements for the equipment, installation, testing, commissioning & documentation
 - c) Equipment requirements
 - d) Preparation of documentation
 - e) Factory Acceptance Testing
 - f) Delivery of equipment
 - g) Commissioning of equipment

1.2 Scope delineation

The following table confirms the scope of the HVAC contractor's supply:

Table 1-1 Scope delineation

		Delineation of scope			
Item	Description	Responsible Contractor			
		BMS (Future)	Electrical	HVAC	HVAC Supplier
1	Manufacture, supply, deliver to site, rig into final position, install commission all HVAC equipment	-	-	X	X
2	Supply and rig into final position of chillers	-	-	X	X
3	Install into final position CRAC, UPS units, primary and secondary pumps, tanks	-	-	X	-
4	Connection to (both electrical and mechanical), final installation and commissioning (all)	-	-	X	Assist
5	Install condensate drain piping, bunds and piping to suite	-	-	X	-
6	Supply, deliver, install, connect and test all electrical connection to all HVAC related equipment including all cables and DB's as specified.	-	-	X	Assist
7	Electrical supply point with isolator to within 1.5m of equipment including CRAC's, UPS units, Fresh air units (FAU), ancillary equipment including COC	-	-	X	-
8	Final piping connection to chilled water plant including CRAC, FAU, UPS unit's chillers and pumps	-	-	X	-
9	Final ducting connection to fresh air unit	-	-	X	-
10	Connection between chiller MCC and secondary pumps	-	-	X	-
11	Installation of field sensors and equipment to ducting and piping		-	X	-
12	BMS communication connections to plant and field equipment	Future	-		-
13	Communication connections between plant & field sensors to CPC	-	-	X	-

14	Supply, manufacture, install support structures approved by structural engineer for piping, and ducting	-	-	X	-
15	Provision of concrete plinths for pumps, bases, platform/base for chillers and tanks	-	-	X	-
16	Labelling of equipment	-	-	X	-
17	Commissioning all HVAC systems		-	X	Assist
18	Decommission & removal of existing cooling towers, condensate pumps, and all existing condenser water piping throughout site	-	-	X	-
19	Decommission & removal of existing DX type CRAC units on data floors throughout.			X	X
20	Decommission & removal of existing redundant CO2 storage vessel on site complete with associated piping systems	-	-	X	-
21	All builders works, partition walling, Partition wall removal, coring through external walling,			X	X

2 Design Requirements

2.1 Industry Standards & Guidelines

All work shall meet all the requirements of national and local Statutory Authorities and shall be in accordance with the following:

Table 2-1 Industry standards

Standard Number	Description
ASHRAE 90.4	Thermal energy standard for data centres
ASHRAE TC9.9	Data centre powered equipment thermal guidelines best practices
SANS 10400	South African national standards
OSH Act 1993	The occupational health and safety act of 1993, as amended
SANS 10142	Wiring of premises
	Government, Provincial and Local authorities' ordinances, regulations, by-laws, rules and other statutory requirements
SANS	Specifications and codes of practice issued by the South African Bureau of Standards and British Standards Institute. The former shall have precedence over the latter where both bodies have issued conflicting

specifications or codes of practise.

- 1) The Contractor shall obtain and complete all notices required by the above authorities as necessary and shall obtain all consents necessary for the various works to be executed and shall pay all fees in connection therewith.
- 2) The work shall also be carried out strictly in accordance with the current editions of all applicable British Standards or other National Standard acceptable to the Architect/Engineer. All electrical installations and materials supplied shall comply with the corresponding local authority code of practice for electrical works and installations.
- 3) All Codes, Acts, Standards and regulations shall be the latest published edition.
- 4) Where discrepancy arises, the provisions in the standards and requirements of the local Authority Having Jurisdiction (AHJ) shall take precedence on all matters relating to the works.
- 5) The equipment that offered and selected shall comply with local authority equipment efficiency standards. The Architect/Engineer shall have the final approval on the equipment that offer for base on the energy consumption and efficient.

3 Detailed specifications

- 1) This document serves to highlight requirements specific to the HVAC in the following areas:
 - a) Data halls as shown on the drawings
 - b) UPS room as shown on drawings
 - c) External chilled water plantroom area as shown on drawings
- 2) Important to note:
 - a) The data hall's cooling is currently served by an existing installation consisting of 3 x closed circuit evaporative type cooling towers with associated pumps. These towers currently provide condenser water to numerous existing water-cooled DX CRAC units located throughout the data halls and switching centre. Due to the continuing operations of the building, the design and installation intent is to prevent any disruption to the existing HVAC cooling systems. Should a disruption be noted or work that could lead to a disruption, this should, in a timeous manner, be brought to the engineer's attention.

- b) Roof penetrations or any penetrations through waterproofing is restricted, should a penetration be required through the roof or any waterproofing, this should, in a timeous manner, be brought to the engineer's attention.

3.1 Brief Description of Works

3.1.1 Air Conditioning and Mechanical Ventilation System

1) The works forming part of this contract are defined in this Detailed Specification, General Specification, the Appendices and indicated on the accompanying tender drawings.

2) The scope shall include, but is not limited to the following:

a) Air Conditioning System

i) External Works (chiller plant): Supply, install, testing and commissioning one lot of insulated and Sheetmetal clad black steel chilled water pipe work complete with valves, strainers, fitting, gauges, sensors, insulation, supports, painting and all other accessories to form a complete and functional system. GI seamless pre-insulated pipe work shall be used for closed loop piping.

ii) Internal works: Supply, install, testing and commissioning one lot of insulated black steel chilled water pipe work complete with valves, strainers, fitting, gauges, sensors, insulation, supports, painting and all other accessories to form a complete and functional system. GI seamless pre-insulated pipe work shall be used for closed loop piping.

iii) Supply, install, testing and commissioning one lot of condensates drainpipe systems complete with valves, fitting, supports, and all other accessories to form a complete system.

iv) Supply, install, testing and commissioning of secondary pumps, maintenance sets electrical boards as specified complete with all components, switchgear, bus bars, wiring, VSD's, controls and all other accessories for the following systems:

- Secondary chilled water pumps x 4 pump systems.
- Primary chilled water pumps x 3 pump systems
- Water treatment systems combined with pressure maintenance sets

- v) Single line diagrams shall be submitted to comply with the technical specifications but not limited to protection relays, phase indicating lights, appropriately sized busbars, spares, surge protective devices, appropriately sized breakers and discrimination types. The contractor shall make the necessary reference to the relevant sections and subject to review for approval by the Engineer or Client Representatives.
- vi) Supply, install, testing and commissioning of 3 x air-cooled chillers (2 x duty and 1 x standby) complete with Variable Speed Drive (VSD), free cooling systems, the pre-insulated chilled water pipe works, gauges, sensors, insulations, valves, fittings, cables, wiring, supports, plinths, painting and other accessories.
- vii) The chiller controllers shall also have their own battery supply to ensure 5.0 mins of operation of uninterruptible power supply in the event of power failure to prevent the shutdown of chiller controllers.
- viii) Supply, install, testing and commissioning of pressure maintenance system, chemical treatment system, side stream filtration and the makeup water and de-gassing system.
- ix) Supply, install, testing and commissioning of Chilled Water Thermal Energy Storage tanks complete with sensors, insulation, cladding, valves, fittings, cables, wiring, supports, plinths, painting and other accessories to form a complete system.
- x) Supply, install, testing and commissioning of new chilled water CRAC type units to the Hall A & B area as shown, complete with fittings, valving, electrics to form a complete system. **Units to accommodate a dual power supply to units with auto switchover.**
- xi) Supply install, testing, and commissioning of new chilled water CRAC units serving the UPS rooms complete with piping, condenser units, fittings, and other accessories to form a complete system. Incoming power supply dual power supply Units to accommodate a dual power supply to units with auto switchover.

b) Mechanical DX Fresh Air package unit

- i) Removal of the existing fan filter unit on the rooftop as shown on the drawings inclusive of the removal and replacement of the expanded metal roof cover as shown on the drawings.

- ii) Supply & hoist onto the rooftop a new air-cooled full fresh air package unit as specified.
- iii) Supply and install new internal fresh air ducting into the passageway as indicated with outlets into the ceiling void of the area at high level.
- iv) Supply, install, testing and commissioning of control system and electrics to form a complete system.

c) Existing Installation

- i) The decommissioning and removal of the existing external Evapco fluid coolers x 3 in a phased manner with associated external condenser water piping systems. Two cooling towers are Model LSWA878 (serial Nr 15-7894/5) and the remaining cooling tower is Model LSWA 58B, Serial Nr 15-789/6, make Evapco. . The transport and off-loading of the 3 x cooling towers to the Centurion SITA site at 459 John Vorster Drive, Centurion, Pretoria, Gauteng.
- ii) The decommissioning and removal of all existing **internal** condenser water piping systems located under the raised false floor as indicated on the drawings together with all other systems pertaining to the existing installation once the chilled water system is fully operational and commissioned.
- iii) The decommissioning and removal of the existing CRAC units served by the cooling towers in the data halls, UPS rooms as indicated on the drawings once the chilled water system is fully operational and commissioned.
- iv) Removal of the fresh air ducting in the passageways as indicated on the drawings.
- v) Removal of the Fan filter unit located on the roof as indicated on the drawings.
- vi) The demolishing of the perimeter walling adjacent to the Southern parking area to make way for the new chiller installation.
- vii)The removal and refitting of the expanded metal protection grid on the rooftop once the fan filter unit has been removed and new package unit installed.

d) Builders Works

There is no building contractor appointed. The HVAC contractor is to include all builders works under their appointed scope. The following forms part of the builder's work falling under this contract:

- i) The appointing of a professionally ECSA registered civil/structural engineer to design and monitor the building construction works for all builder works as billed.
- ii) The demolition of the existing plinths and the design and construction of the bases and plinths for the chiller systems, pump systems and tank systems.
- iii) The construction of new external perimeter walling enclosing the chiller system at the Southern parking area.
- iv) The closing of all openings along the perimeter walls at both high level and within the floor voids of the data halls so as to maintain suitable pressurisation of the floor voids and data halls as specified. This includes the sealing of all around piping, data and electrical cabling and other as specified.
- v) The construction of the floor void bunding system along the pipe routing as specified.
- vi) The coring of openings externally and internally to accommodate the new chilled water piping and the sealing thereof.
- vii) The making good of any external piping penetrations where condenser water piping was removed.

e) Electrical Works

There is no electrical contractor appointed. The HVAC contractor is to include all electrical works under their appointed scope. The following forms part of the electrical work falling under this contract:

- i) Supply, delivery, installation testing (including CoC's) and commissioning of the complete electrical installation to support the full scope as required for this HVAC installation.
- ii) The electrical installation shall start from main DB's already provided and shall include, but not be limited to, cabling to sub boards, the sub boards themselves, cabling and connection to equipment from the sub boards and everything

related to the provision of a fully functional installation according to best of industry standards.

- iii) The electrical drawings as well as the bills of quantities should be read together to get a complete picture of the full extent of the electrical installation.
- iv) The new HVAC electrical installation shall form part of and be an extension of the new main electrical installation (recently completed). As such, it shall conform to the existing installation in terms of equipment used and standard of the installation.
- v) Distribution boards shall comply to the attached specification and shall be Schneider PrismaSet or equally approved but shall not be of a different manufacturer as the new boards installed on site.
- vi) All HVAC related boards such as pump control panels, chiller MCC's etc. shall comply to the same specification as the rest of the distribution boards supplied under this contract unless there is a compelling reason to deviate from the specification. Such reason should be clearly highlighted during the tender briefing stage and brought to the engineer and client's attention as no cost implications shall be entertained on this once the contract is awarded.
- vii) Distribution boards shall be manufactured/assembled by a Schneider accredited Prisma partner and each board shall receive a certificate from the OEM stating that the board is compliant and carries their equipment guaranties and warranties before the boards shall be delivered to site.

3.1.2 Specialist Works

- 1) The Contractor shall submit in his tender a list of specialist contractors, and engineers (for builders work structural designs) he intends to engage for each of the above items of work, as part of tender evaluation.
 - (a)
 - 2) The proposed specialist contractors shall have successfully completed projects of similar size and complexity to the works within the last five years.
 - (b)
 - 3) The Contractor shall not be allowed to change the proposed specialist contractors without the written approval of the Client and engineer.

3.2 Water makeup and treatment

Supply the following in a skid mounted format for ease of installation:

- 1) Pressure maintenance set
- 2) Closed loop expansion tank with pressurization pumps
- 3) Degassing and make up water tank
- 4) Manual chemical dosing and water treatment

	Information		Required
1.	Identification	-	
2.	Service	-	Chilled water system
3.	Location NOTE: EXTERNAL installation thus exposure to the elements	-	As indicated on drawings
4.	Chilled water system volume	M3	71
5.	Equipment IP rating		IP65
6.	Number of sets including all of the below per set/skid	No	2
	Fully automatic vacuum degassing set		
1.	System pressure	Bar	1-4
2.	Processing capacity	l/hr	500
3.	Electrical	W	500
4.	Fluid connections (inlet / outlet)	mm	20
	Closed loop expansion tank complete with pressurization pumps		
1.	Number of pumps	No	1
2.	Flow rate	l/s	3
3.	Working pressure	Bar	3
4.	Pressurized expansion tank (hydrosphere type)	No	1
5.	Volume	L	250 (to be confirmed by supplier based on system)

			volume)
	Make up water tank		
1.	Volume	L	1000
2.	Tank material of construction		Stainless steel
3.	Float switch with dry run alarm		Yes
4.	Quick fill valve		Yes
	Manual chemical dosing water treatment		
1.	To be included in skid as per V.D7.03		
	Alarms		
1.	Pump continuous run alarm		
2.	Dry run alarm		
3.	Make up tank low low-level alarm		

3.3 Primary and Secondary Pump Sets

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

- 1) Pumps shall be current catalogued products and documentation shall include performance curves or selection table for the expected range of operational conditions.
- 2) Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.
- 3) The flow rate at break-off point of the curve for the impeller selected shall be at least 1,5 times the specified flow rate.
- 4) The head at zero delivery of the curve for the impeller selected shall be at least 1,2 times the operating head.
- 5) The efficiency of the pump shall not be less than 70% but not more than 3% below the peak of the efficiency curve for the impeller furnished.
- 6) At the time of equipment submission, submit the following:
 - a) Certified details selection shown on performance curves or tables.
 - b) Operating, testing, balancing and commissioning instructions.
 - c) Trouble analysis guide.
 - d) Detailed pressure drops and net positive suction head calculations for the system

by one or more circulating pumps.

- e) Full details of periodic and annual maintenance and service to be undertaken by the building maintenance staff in accordance with a preventive maintenance programme.
 - f) The service and maintenance instruction.
 - g) The estimated total expenditure on replacement of parts during the service life.
- 7) The pump set shall be engineered, and components selected when operated under normal building conditions with optimum servicing and maintenance, for a minimum service life for 15 years with 3000 operating hours per annum.
- 8) The Engineer reserves the right to call for:
- a) Test certificates and reports from the manufacturer's quality control laboratory or independent test laboratory such as SANS, and/or
 - b) Site inspections, customer reports/references and user's interviews, and/or
 - c) Full engineering, design and component selection details to check correctness of the claimed service life.
- 9) Pump installation shall comply with local authority by-laws and with the Occupational Health and Safety Act of 1993, as amended.
- 10) Pump set shall be installed in accordance with manufacturer's instructions and maintained in "as new" condition at start-up.
- 11) Pump set shall be installed on a common vibration isolated steel and concrete base and levelled.
- 12) Pump and electric motor shall be aligned to within 0,05mm, both radially and directionally to avoid vibration and pumps shall be statically, dynamically and hydraulically balanced within the design operating range.
- 13) The required unobstructed space shall be left around the installation for maintenance and service of the equipment in accordance with the manufacturer's instructions.
- 14) Pump set shall be designed and selected for quiet operation with a maximum permissible pump/motor speed of 1440 rpm.
- 15) Water shall not be spilt over the plantroom floor; condensate and gland leakage shall be piped to nearest drain or gulley and/or a galvanised drip tray shall be provided to each chilled water pump, outlet pipe to drain with galvanised piping.
- 16) Motor shall be of the totally enclosed fan cooled type.
- 17) Pump shall be protected by strainer from all damaging and flow restricting debris.
- 18) A single pressure gauge, snubbed or glycerine filled to prevent pointer vibration, shall, be connected through a three-way valve to read both suction and discharge pressure at each pump. Tappings shall be either in casing or immediately before suction flange and

after delivery flange.

- 19) Lifting eyes or lugs shall be provided for parts weighing over 25 kg.
 - 20) Complete overhauling of the pump shall be possible without breaking piping or motor connections.
 - 21) A metal lubrication instruction plate shall be attached to each pump in a location where it is clearly visible. The plate shall indicate the recommended lubricant, points of lubrication and the recommended frequency of lubrication.
 - 22) Pump shall be equipped with an air vent cock and a valved drain at lowest point of casing.
 - 23) Motor to pump coupling shall be of an approved flexible type. Coupling shall be rated at not less than 125% of motor rating.
 - 24) The rating of the motor shall not be less than the maximum power required by the pump at any operating point between zero and break-off capacity with maximum size impeller for available casing.
 - 25) Pump casing shall be selected for a minimum of 1 000 kPa or 1,5 times the actual discharge pressure, whichever is greater.
 - 26) The pump shall be complete with bronze impeller.
 - 27) The pump shall be complete with mechanical seals.
 - 28) Distribution boards and switchgear shall be Schneider, or equal and approved. The distribution boards shall be assembled by an OEM certified panel builder. The boards shall be IEC 61439 compliant (as tested by an independent testing facility) and the OEM shall issue a certificate for each board stating that it is compliant before the board is delivered to site.
- (c)
- 29) Boards shall be offered in the OEM's standard colours. The distribution boards shall be IP55 rated and shall be installed in such a way that they are not exposed to direct sunlight or rain.
- (d)
- 30) Distribution boards shall be capable of delivering the full busbar rated current after all derating factors have been applied as per the OEM's design criteria. This includes all breaker current capacity ratings (i.e. the main breaker / isolator shall be able to supply the full busbar rated current at the ambient conditions as specified. All other circuit breakers shall be able to supply their design loads after derating).
- (e)
- 31) All breakers above 250A shall be equipped with electronic trip units. All electronic trip units and all meters shall be BACnet IP or Modbus IP enabled.
 - 32) The control philosophy to be incorporated into the pump control panels are described in the "Sequence of Controls" description forming part of this document.

SECONDARY CHILLED WATER PUMPS (LARGE)		Specified
	Unit Type	Centrifugal

General	Gen	Service	Secondary CHW Pump (Large)
		Supplier	-
		Model	-
		Identification	-
		Number off	2
	Entering water condition	° C	16
Capacities	Water flow rate	ℓ/s	29,9
	Design Head	m	25
	Total Efficiency (similar or greater)		70%
	Power @ operating point	kWe	12.6
	Motor Size (suggested)	kWe	15
	Voltage/Frequency/Phase		400/50/3
	Speed	rpm	VSD
	Weight	kg	TBC
SECONDARY CHILLED WATER PUMPS (SMALL)			Specified
	Unit Type		Centrifugal
General	Gen	Service	Secondary CHW Pump (Small)
		Supplier	-
		Model	-
		Identification	-
		Number off	2
	Entering water condition	° C	16
Capacities	Water flow rate	ℓ/s	15
	Design Head	m	25
	Total Efficiency (similar or greater)		70%
	Power @ operating point	kWe	4
	Motor Size (suggested)	kWe	5,5
	Voltage/Frequency/Phase		400/50/3
	Speed	rpm	VSD

	Weight	kg	TBC
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PRIMARY CHILLED WATER PUMPS			Specified
	Unit Type		Centrifugal
General	Service		Primary CHW Pump
	Supplier		-
	Model		-
	Identification		-
	Number off		3
	Entering water condition	° C	24
Capacities	Water flow rate	ℓ/s	30
	Design Head	m	15
	Total Efficiency (similar or greater)		70%
	Power @ operating point	kWe	4
	Motor Size (suggested)	kWe	5,5
	Voltage/Frequency/Phase		400/50/3
	Speed	rpm	1440
	Weight	kg	TBC

3.4 Thermal Energy Storage Tanks

- 1) **General:** Furnish and install as shown on the plans thermal storage tanks having the capacity and features detailed herein and scheduled on plans. Thermal Storage Tank selection shall allow a 5-minute storage capacity where N redundancy is employed, unless otherwise indicated on drawings or schedule. Thermal Storage Tank selection shall be based on capacity, and dimensions as demarcated in the technical drawings.
- 2) **Description:** Thermal Storage Tank shall be a dished end pressure vessel.
- 3) **Pressure:** Thermal Storage Tank selection shall be rated for 1.5 times operating pressure but not less than 690kPa.
- 4) **Support:** Thermal storage tank shall be supported by a load spreading base ring.
- 5) **Connections:**

a) Thermal storage tank selection shall have the following connections to peripheral systems, and general openings:

i. Low level tangential chilled water **inlet and outlet**

ii. Top central outlet

iii. Bottom drain outlet

iv. Side inspection opening

b) Selection shall account for connection placement and allow adequate access for installation, connection, and maintenance.

6) **Gauges:** Thermal storage tank selection shall have 3 x thermal wells as shown on the drawings and schematics allowing for installation (by others) of temperature sensors. The thermal wells will be 250mm above the bottom inlet to the tank, halfway up the tank and 250mm below the top inlet to the tank.

7) **Baffle:** Thermal storage tank selection shall contain a baffle between bottom inlet and outlet (or similar) to create serpentine flow within the vessel.

8) **Corrosion Protection:** Thermal storage tank selection shall have a cathodic protection system to prevent internal corrosion.

9) **Insulation:** Thermal storage tank insulation shall conform to EN 13501 – Fire Classification of construction products and building elements, or as prescribed otherwise within Division 23, whichever is more stringent. Insulation shall be as per standard specification piping diameter >300mm

10) **Lifting Lugs:** As per manufacturer specification, if the thermal storage tank is to be prefabricated and moved to install, selection shall allow for transport and have lifting lugs capable of supporting total weight of the selection.

11) **SCHEDULE**

	Information		Required
1.	Identification	-	
2.	Service	-	SITA Buro beta site

3.	Location	-	Ground floor near secondary pumps
4.	Number of	No	2
5.	Capacity / Volume	M3	18kL
6.	Minimum operating pressure	kPa	690
7.	Thermal Tank selection	-	1.5 times the operating pressure
8.	Supplier		-

SECTION 2: GENERAL SPECIFICATION

1 Introduction

1.1 General

This general specification shall be read in conjunction with all drawings, schedules, detail specifications and documents listed in the tender transmittal. If there are discrepancies in specifications between documents, then the more onerous specification shall always be used.

1.2 Project introduction

- 1) The State Information Technology Agency (SITA) has engaged Zutari to provide the HVAC design and engineering for the upgrade and fitout of the HVAC systems serving the data halls to its SITA Buro Beta facility in Pretoria. The installation is to accommodate a Tier III level configuration in all respects. The scope covers the HVAC upgrade to the existing data halls as well as the UPS room.
- 2) The total nominal total cooling allowed for in the design by the chillers at completion is 2000kW cooling with and additional 1000kW cooling as standby, using 3 equally sized air-cooled chillers.
- 3) The chilled water piping systems are to be designed to cater for the full future cooling requirements served by both duty chillers, however limited new chilled water downblow CRAC units will be supplied and installed Hall A and Hall B as indicated.
- 4) In addition to the 9 X off chilled water CRAC units serving the halls, 2 x off separate chilled water top entry, side blow CRAC units will be installed under this contract in the UPS room as indicated.
- 5) There is no appointed main contractor, and the HVAC contractor will be expected to address the following services as part of their scope of works:
 - a) All civil/structural and general building services: This includes but is not limited to Chiller pump and tank bases and plinths, coring through walls, construction of perimeter brick walling, removal and reinstatement of rooftop tiles for piping installation and removal, ceiling and floor repairs, closing of passageway openings at high and low level and making good of the works.
(f)
- 6) Electrical Services: An electrical contractor will be appointed to upgrade the electrical systems. However, the HVAC contractor will be required to provide the electrical/control

panels serving the secondary pump systems, primary pump systems, pressure maintenance sets, water treatment systems and control systems.

1.3 Site conditions and location

The contractor shall familiarise themselves with the site conditions prior to undertaking or providing cost estimates for any work. Specific conditions to be observed include, but are not limited to, site access and entry requirements, OHS requirements (including client specific requirements), qualification and identification of personnel.

The following outlines the ambient design temperatures and humidity parameters for equipment:

Environmental inputs	
Project location:	222 Johannes Ramokhoase St, Pretoria Central, Pretoria, 0001
Ashrae N=20yr temps:	Pretoria, Gauteng (WMO 682620)
Summer DB/WB	37.6/23.8 °C (DB/WB)
Winter DB/WB	-1.7/-4.3°C (DB/WB)
Extreme (N=50 year):	38.7°C (Summer DB), -2.6°C (Winter DB)
Deviation:	1.6°C
Elevation:	1326m ASL
Air pressure at elevation:	86.4kPa

Table 1-1 Site design ambient conditions

- 1) These apply to all equipment exposed to ambient outdoor conditions serving the facility. The Uptime Institute requires that the design temperature used be based on the ASHRAE "n=20 years" value. The "n=20" year summer dry bulb temperature is to be used to size the equipment exposed to these ambient temperatures to be able to operate at 100% capacity.
- 2) As the extreme winter temperatures drop below freezing point winterization will also be taken into consideration for equipment and system design.

2 Interpretation

2.1 Definitions

The following definitions and abbreviations apply unless the context requires otherwise:

Table 2-1 Definitions – General

Definitions

General

Approval:	Only "Approved" notation indicates approval to proceed., "Approved with Comments" notation provides provisional approval and does not constitute approval to proceed. "Rejected" notation requires substitution of proposal with
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	an alternative for approval, does not provide approval to proceed
Client:	SITA (Buro Beta)
Contract:	The agreement between the Client and the Contractor
Contract documents:	Shall mean all “Drawings”, “Specifications”, “Schedules” and other documents referenced in the Contract and provided to the Contractor to describe the works
Contractor:	Shall refer to MEP or other subcontractor
Give notice:	Give notice", "submit", "advise", "inform" and similar expressions mean "give notice (submit, advise, inform) in writing to the Client
LLE Contractor / Supplier:	Shall mean Suppliers who are engaged directly to the client to procure and install long-lead equipment
Obtain:	Obtain", "seek" and similar expressions mean "obtain (seek) in writing from the Client
Proprietary:	Proprietary" means identifiable by naming manufacturer, supplier, installer, trade name, brand name, and catalogue or reference number
Prototypes:	Systems and components not previously installed in similar conditions/applications and/or not having at least one year monitored in-service operation.
Provide:	Provide" and similar expressions mean "design, if not detailed in Contract Documents, supply, install and set to work
Samples:	Includes samples and prototypes
Supply:	Supply", "furnish" and similar expressions mean "supply only
Supplier:	Shall refer to supplier of equipment as per the scope matrix
Works:	The work to be executed in accordance with the Contract and includes “systems”, “equipment” and “installation

2.2 Testing and commissioning

Except where otherwise defined in referenced documents, the following definitions apply:

Table 2-2 Definitions – Testing and commissioning

Definitions	Testing and commissioning
Completion Tests (SAT):	Tests carried out before the date for practical completion on installations or systems which have been completed and commissioned, to demonstrate that the installations or systems, including components, controls and equipment, operate correctly, safely and efficiently, and meet performance and other requirements and are integrated with connecting systems. Also referred to as <i>Site Acceptance Testing (SAT)</i> .

Factory Acceptance Tests (FAT):	Tests carried out on manufactured equipment, before delivery to the site. This forms part of the Supplier's internal QA/QC process
Factory Witness Testing (FWT):	This is the process that the manufacturer goes through during FAT but is attended by the CxA, EOR or client.
First of kind / Prototype testing (FKT):	Testing to prove the first of its kind specific equipment for a specific project. Can take place during PCT or FWT. FKT testing needs to be identified by the CxA in its FPT scripts to ensure that if any changes need to be made to the operation of the equipment it can be updated before testing takes place. EoR usually sets up a checklist or approves a Supplier checklist and witnesses factory testing.
Functional Performance Tests:	Demonstration that related components, equipment and ancillaries of a defined system operate and function to acceptance criteria. This will include normal, maintenance and emergency modes of operation, verifying settings, safeties and capacities, and performance of associated monitoring and control functions.
Installation QA/QC	Tests carried out on site on static plant and systems before commissioning (e.g. inspection and testing of welding, electrical insulation resistance testing, and pressure testing of pipework). Also forms part of the contractor QA/QC process
Integrated Systems Tests:	Tests carried out to demonstrate that inter-related systems operate as specified.
Proof of concept testing (PCT):	Very detailed FWT performed to confirm that the first unit complies with the design intent. Remaining equipment will then only be put through a FWT. EoR usually sets up a checklist and witnesses factory testing.
Type Tests:	Tests carried out on an identical item, before delivery to the site and witnessed by an approved independent testing authority.

3 Design / Detailing / Co-ordination by Contractor

3.1 General

The contractor shall carry out / develop the following which includes, but may not be limited to:

- 1) Coordination

- 2) Fixings, supports, plinths, and brackets
- 3) Seismic design of equipment components and restraints
- 4) Design and working drawings of non-proprietary performance specified equipment
- 5) Temporary works not forming part of the completed installation. These include temporary support/access structures
- 6) Detailed lifting plants and method statements (RAMS) for installation, testing, commissioning and setting to work
- 7) Calculation of fan and pump operating pressures based on final equipment selection and system piping arrangement.
- 8) Other elements as noted on drawings and in relevant discipline specifications.

3.2 Performance requirements

Table 3-1 Performance requirements

General:	Provide efficient and effective facilities in line with good commercial practice for delivering and controlling the building services. Any deviations from the specified design shall be referred to the EoR for review prior to proceeding.
Reliability:	Provide reliable plant with multiple units and standby or redundant to maintain availability in accordance with good commercial practice.
Energy Usage and Running Costs:	Always give due regard to equipment selections and system design to minimise energy usage and operating and maintenance costs.
Flexibility:	Provide building services which are sufficiently flexible to enable a reasonable change of use in all areas without extensive modifications.
Sensitivity to Aesthetic Features and Adjacent Uses:	Accommodate building services in an unobtrusive manner that does not detract from the aesthetic appearance nor reduce the amenity of the facilities or adjacent areas. These requirements extend to all aspects of the installation including location, route, fixing, spacing, noise, vibration, colour, shape and finish.
Isolation Facilities:	Provide suitable isolation facilities for operation and maintenance, i.e. all take-offs from piping or cable risers, long horizontal runs and the like.
Accessibility:	Equipment for emergency operation or requiring regular access for maintenance and inspection shall be extended to low level such that special access tools and equipment are not required. Equipment requiring intermittent

access shall be positioned to provide vertical unimpeded access with nominated access equipment.

Commonality: Use common components throughout for systems performing the same function. Do not mix manufacturers or methods of installation.

3.3 General coordination requirements

- 1) Check space requirements of equipment and services which are indicated diagrammatically in the Contract Documents. Select equipment with dimensions and handing to suit the available space.
- 2) Lay-out equipment and services to be accessible for operation, maintenance and replacement and so as not to interfere with access to other installations. Make offsets as necessary.
- 3) Neatly group services, with separate layers for crossing services.
- 4) Setting out personnel access ways 2.1m high and 1.2m wide to all major plant clear of all obstructions, unless otherwise approved.
- 5) Provide adequate space for the removal and/or installation of plant and equipment. Obtain approval if the break-down or demolition of the plant and equipment or any building structure is required.

3.4 Co-ordination

Coordination Drawings: Provide coordinated drawings that demonstrate spatial coordination of the proposed final installation that recognises equipment provided by others, the building form and construction materials. The installation shall comply with the intent of the Contract Documents and be safe to install, maintain, operate and dismantle for removal. Submit the coordination drawings for review or alternatively demonstrate that the intended fit within the building is not possible and propose alternative solutions for consideration.

3.5 Mechanical System Resistances

- 1) Calculate system resistances to fluid and air flows based upon the actual plant layout and selected equipment. Allow for dirty filters and diversified flows. Allow for standby plant and future demand as shown.
- 2) Amend piping, fans, pumps, motors and electrical power supplies to suit the requirements of the actual installation. Submit amended selections for review.

3.6 Electrical Loads and Cable Sizing

- 1) The Contract Documents are based on industry standards or generic equipment. Obtain all selected electrical load information and submit for approval. Include kW, kVA, power factor, motor starter, duty, standby, fire mode, essential or non-essential.
- 2) Provide site measured cable lengths and methods of installation prior to final ordering of equipment.
- 3) The Contract Documents may be amended subject to review of the selected equipment and installation method. The selection may however not deviate from the specification.

3.7 Electrical Protection and Grading

- 1) The Contract Documents may include preliminary electrical protection and grading information based on industry standards or generic equipment.
- 2) Demonstrate that all equipment connected is protected against over current and short current circuit current.
- 3) Schedule of all protective devices and proposed settings
- 4) Overlaid grading curves demonstrating discrimination.

3.8 Balance of Electrical Loads

Balance electrical loads evenly over all phases.

3.9 Structural Interface

- 1) Provide weights, dimensions and methods of connection to the structure for approval. Include temporary works for off-loading and installation.
- 2) Provide dimensioned drawings for all services penetrations through the structure. Obtain approval prior to the forming of penetrations.

3.10 Structural/Civil Elements

- 1) Unless specifically excluded from the Contract Documents the following is to be provided under the HVAC contractor's scope of works:

- a) Design and construction of chiller platforms, tank platforms, pump bases, trenching etc
- b) Coring of new chilled water piping penetrations
- c) Making good of existing removed condenser water piping penetrations
- d) Floor void condensate water bund construction
- e) Demolition of existing, design and construction of new external brick wall to accommodate chiller placement.
- f) Secondary steelwork for piping and cable support and fixing of the systems

2) Provide certification of the structural/civil design.

3) Provide details of forces and methods of connection to the building structure where applicable.

4 Contractor's submission and design responsibilities

1) The contractor's submission shall be completed in SI Units, and the contractor shall perform all conversions from Standard Units where they appear in the equipment specifications.

2) The Contractor shall coordinate to ensure that all elements penetrating the building envelope (walls/slabs/floors/roofing) shall not compromise the air/water/heat/light/noise transfer insulating integrity of said building envelope elements and shall, as necessary, introduce additional builder elements to make good the building envelope integrity element that is otherwise compromised -- this would include, but is not limited to: chemical/mechanical seals, gaskets, waterproofing coating/grout, self-sealing/expanding foam (or alternate solution), sleeves, doghouses, upstand curbs, weatherproof shelters.

3) The Contractor shall coordinate to ensure that all equipment / capacity components or elements that are installed external to the building envelope (and which are not explicitly already provided with weatherproofing enclosures or are intrinsically weatherproof by design) are to be made weatherproof by the introduction of additional builder elements such as additional enclosures which are weatherproof (to the appropriate IP rating), shelters or doghouses as needed.

4.1 Time elapsed

Due to the time elapsing between the release of this specification and the installation and construction works, it is anticipated that some of the equipment proposed will be superseded by later models by construction time. The contractor is to review products and confirm the models of all equipment and products proposed with the engineer one month prior to the procurement and installation of the equipment, interfaces to the other equipment and systems.

4.2 Components and equipment

In addition to section specific requirements the following general component and equipment requirements shall be adhered to:

All materials, equipment and components shall be new, of good quality and fit for purpose. The contractor shall not provide without written approval products that are obsolete, discontinued or about to be discontinued.

- 1) The contractor shall provide equipment and associated accessories which are the products of established manufacturers regularly engaged in the manufacture of such equipment applicable to the system.
- 2) All equipment and materials used in these works shall be standard components that are regularly manufactured and utilised in the manufacturers' system.
- 3) All system components shall operate reliably within the range of -10 degrees to +55 degrees and 98% non-condensing humidity.
- 4) To ensure the long-term dependability of the system, the contractor shall provide all system components with appropriate environmental protections including (as appropriate):
 - a) Protective enclosures
 - b) Seals
 - c) Insulation
 - d) Water proofing
 - e) UV protection
- 5) Any modifications to equipment to meet the intent of this specification shall be performed in a way that does not alter the manufacturers' warranty.

- 6) Contractor must allow for touch up work and safety of equipment.

5 Interfacing with other equipment

- 1) System interfacing requirements shall be as detailed for each service required.
- 2) The contractor shall liaise with all other equipment suppliers and contractors regarding final equipment selection for final electrical loads, location thereof as well as reticulation requirements.

5.1 Installation of components and equipment

- 1) No manufacturing is allowed to take place on site.
- 2) In addition to section specific requirements the following general installation of components and equipment requirements shall be adhered to:
- 3) The contractor shall be responsible for coordination with other works and trades including, electrical and security where work is dependent upon or carried out in conjunction with these works. This includes but is not restricted to:
 - i. Use of site and facilities
 - ii. Closure of restriction of access to site and facilities
 - iii. Scheduling of works and resources
 - iv. Segregation of services
 - v. Site reinstatement
- 4) Major items requiring coordination are listed as follows:
 - a) Coordinate with other trades to ensure that no conflict occurs between proposed cable, cable tray, busbar and ducting routes, pipe runs, air conditioning ductwork, hydraulics pipework and the like.
 - b) Ensure staging of the works is to the requirements of the Construction Program
- 5) The location of all outlets, switches and equipment indicated in the drawings is indicative only and may be relocated within a radius approved by the Engineer to suit coordination with other services, finishes, architectural preference and to meet code requirements. The exact locations are to be determined by reference to architectural plans, sections and details and are to be confirmed with the engineer prior to installation. Architectural room data sheets and room layouts sheets shall also be adhered to.

- 6) The installation and mounting of all equipment shall ensure that the components remain operational and connected to the structure and to their foundations (if applicable) throughout a seismic event by means of proper installation of all anchors and mounting hardware. The contractor shall issue a seismic compliance certificate at completion.
- 7) All equipment shall be securely mounted using proprietary fixtures and fittings as approved by the Engineer.
- 8) The method of equipment installation shall not adversely affect the function or structural integrity of the structure to which the equipment is attached.
- 9) The method of equipment installation shall not compromise the IP rating of the equipment.
- 10) Framework and brackets:
 - a) Site-fabricated framework and brackets shall not be used. All fabrication is to take place off site. Framework and brackets shall be positioned so as not compromise the removal and replacement of equipment.
 - b) Where it is necessary to modify on site any prefabricated galvanised mild steel framework, the cut edges shall be dressed and treated immediately with an approved cold galvanising paint to prevent corrosion.
 - c) Fasteners securing equipment to framework and brackets shall be independent of those securing framework and brackets to walls and floors.
- 11) Positioning of Equipment:
 - a) Final positions of equipment shall be agreed on site, prior to installation.
 - b) Equipment shall be positioned with due regard to the aesthetics of the installation as well as conforming as closely as possible to approved shop drawings.
- 12) Identification:
 - (a) All system components shall be suitably identified with labels. Labels shall be located so that they are easily seen from normal access adjacent to the item being marked.
 - (b) Labels shall not be installed on components normally removed or replaced.
 - (c)
- 13) Warning labels and markings:
 - a) Danger and warning labels, fire and safety equipment labels: White lettering on red background.
- 14) Pipes, conduits and ducts

- a) Identification of the contents of pipes, conduits and ducts.

15) Wiring and terminal strips

- a) Identify wiring with numbered ferrules at both ends.
- b) Number each terminal of terminal strips.
- c) Numbering system: To match electrical and control shop drawings.

16) Equipment identification

- a) Identify each item by name and identification number.
- b) Contents: Match terminology and numbering system of the contract documents. Number multiple items individually.

17) Minimum lettering heights:

- a) Equipment nameplates: 40mm
- b) Danger, warning and caution notices: 10mm for heading 5mm for text.
- c) Warning notices: 7mm.
- d) Minor lettering: 3mm

18) Lettering style:

- a) Helvetica medium.

6 Rigging and hoisting

The Contractor will make provision for rigging and hoisting of its own equipment into position and include for all safety and lifting plans as necessary.

7 Organization and staff of subcontractor

The party responsible for installing and commissioning the equipment and installation must provide sufficient persons of the required competency to ensure the installation is completed and commissioned as per the agreed project timeline. Should additional resourcing be required it will be the responsible of the installing and commissioning party to provide this at no additional cost.

8 SOP, EOP and RAMS

- 1) The Supplier / Contractor is to provide a set of standard operating procedures (SOP) and emergency operating procedures for equipment that has been installed. This is to be compiled in the standard format provided by the Client.

- 2) The Supplier / Contractor will be responsible for compiling all relevant RAMS (risk assessment and method statement) documents required for installation. This also be as per the standard Client format.

9 Training

- 1) The contractor / supplier shall include for and provide training to two separate groups of users, namely System Administrators and System Operators. In general, the training shall include presentations, informal discussions, demonstrations and hand-on activities on the actual system.
- 2) Training for System Operators shall cover all the functions and activities that the operators need to carry out on a daily basis.
- 3) The training for the System Administrations shall include that provided for the System Operators and additional training specific to system administration. Further, the System Administrators training shall also include training on how to teach other staff members by way of a 'train the trainers' approach.
- 4) The System Administrators' training shall be provided for up to 10 personnel. The training shall be carried out up to 2 sessions with 1 or more personnel per session.
- 5) The System Operators training shall be provided for up to 10 personnel. The training shall be carried out up to 2 sessions with 2 or more personnel per session.
- 6) Refresher training shall be provided after client occupation – typically 3 to 6 months following completion.
- 7) The timing of the training shall be agreed between the contractor and the users, but must be completed prior to the completion of level 3 commissioning, handing over of the live system to the user. The contractor shall make provision for training of users on multiple work shifts.
- 8) Training Plan and Course Materials:
 - a) Training plan and course materials shall be submitted to the engineer at least two weeks prior to the commencement of the training for approval. The contractor shall provide all course materials, all support equipment (e.g., computer, projector, whiteboard, flipchart, etc.). The venue for the training shall be on the project site.
 - b) A training feedback form shall also be provided for all trainees to fill out at the conclusion of every training session to evaluate the effectiveness of the training and for future improvement.

9) Training Records and Certificates:

The contractor shall maintain a complete record of the training. The record shall include:

- a) Date and time of training session.
 - b) Name of trainer.
 - c) Name of all trainees.
 - d) Names of trainees issued with a completion certificate.
 - e) Training feedback forms.
- 10) All trainees who have successfully completed the training shall be issued with a certificate signed by the trainer.
- 11) The contractor / supplier shall provide a full set of O&M manuals in both hard copy and soft copy. This manual is to be approved by the Engineer.

10 Documentation Requirements

10.1 General

- 1) Provide in good time to allow review without impediment to the program:
- (d) Copies of correspondence with Authorities.
 - (e) Certified schedule of compliance for all plant and equipment, prior to placing orders.
 - (f) Certified schedule of competency for all tradesmen intended to work on the project.
 - (g) Factory test results where applicable
 - (h) All product data, performance test and commissioning results required by this specification.
 - (i) Shop drawings for fabrication and installation of all equipment and items supplied.

- (j) Inspection, test and commissioning plan for every section of the work as per Main Contractor requirements and Commissioning Agent and Commissioning Manager.
- (k) The procedure to be used to complete the task.
- (l) The skill or competency of the person undertaking the work.
- (m) The review or testing procedure to assure satisfactory completion of the task.
- (n) The person within the Contractor's organization authorized to sign off the task as accepted.
- (o) Client handover and training proposals.
- (p) Record and installation drawings which show all changes to equipment and services layouts, wiring and any other items during the construction period incorporated into the works.
- (q) Operating and Maintenance manuals.
- (r) Maintenance and service records during the defect's liability period.
- (s) Submissions required for the occupation certification as may be required.

10.2 Technical Data

The supplier is to submit, prior to ordering, a full schedule of equipment proposed for the project, including all technical aspects of the piece of equipment including noise and vibration details. The equipment must be in accordance with the specification. The supplier shall draw attention to any changes to the specification that the supplier might wish to propose. Depending on the merits of the proposal, they may or may not be accepted.

10.3 Certification

Submit certification that the plant and equipment submitted meets all requirements and capacities of the contract documents except for departures that are identified in the submission.

10.4 Selections

Before ordering equipment, calculate the respective system capacity requirements based on the equipment offered and layouts shown on the shop drawings and submit the proposed selections.

Contractor is to provide valid instrumentation certification for equipment to prove correct authority and performance prior to ordering.

10.5 Submissions

Submit technical data for all items of plant and equipment.

10.5.1 Data to be Submitted

- 1) Include manufacturers' technical literature and the following information:
 - (t) Model name, designation and number.
 - (u) Capacity of all system elements.
 - (v) Country of origin and manufacture.
 - (w) Materials used in the construction.
 - (x) Size, including required clearances for installation and maintenance.
 - (y) Technical data schedules corresponding to the equipment schedules in the contract documents. If there is a discrepancy between the two, substantiate the change.
 - (z) Type-test reports.

10.6 Control Systems

A full technical description must be submitted as an interpretation of the performance requirements for control systems as detailed in the Contract.

10.7 Shop Drawings

10.7.1 Service Coordination

Ensure coordination with other building and service elements. Show adjusted positions on the shop and record drawings.

10.7.2 Space Requirements

Check space requirements of equipment and services indicated diagrammatically in the contract documents as well as on site and submit a report on consequent variations to the design.

10.7.3 Access and Maintenance Requirements

- 1) The supplier shall identify on a separate set of shop drawings the proposed maintenance strategy for all plant and equipment. This shall include but not limited to the following:
 - a) Air filter access and replacement
 - b) Control panels
 - c) Chilled water pump systems
 - d) Buffer chilled water tanks
 - e) Chiller systems
- 2) In-situ maintenance of major equipment per the manufacturer's recommended maintenance procedures

10.8 Manufacturer's Technical Literature

Manufacturers' technical literature submitted for examination or for inclusion in the Operation and Maintenance Manual shall be prepared and assembled specifically for the project and shall exclude any irrelevant information. Each item shall be clearly identified on the As-Built Drawings and cross-referenced to the Operation and Maintenance Manual.

10.9 Operation and Maintenance Manual

Submit an Operation and Maintenance Manual in accordance with the program; in accordance with the specific requirements outlined for the relevant discipline; and in sufficient time for checking, commenting and returning.

10.9.1 General

The O&M manual shall:

- 1) Provide sufficient information to allow the correct and safe operation and maintenance of all of the equipment and systems installed.
- 2) Be prepared by personnel experienced in the operation and maintenance of the equipment and systems installed.
- 3) Be prepared with sufficient clarity of style and content to simplify the use of the manuals.
- 4) Include relevant material where any referenced document in this specification requires provision of manuals.

- 5) The sub-contractor shall supply four (4) comprehensively indexed Operating and Maintenance Manuals, bound in loose leaf plastic covers, including as built drawings. In addition, all information required for the maintenance of any and all equipment must be included in electronic format saved onto a locked USB device.
- 6) The Operations and Maintenance Manual must describe how the facility will be operated and by whom, as well as the desired level of training and orientation required for the building occupants to understand and use the building systems.
- 7) The manuals shall be submitted to the Engineer for approval 1 week prior to the programmed date for the practical completion inspection.
- 8) Tenderers are to note that the said practical completion inspection shall not be carried out prior to the approval of these operating and maintenance manuals.

10.9.2 Format

- 1) A4 size, loose leaf, in commercial quality 4-'D' ring binder with hard vinyl cover, indexed, divided with plastic tabs and titled and on CD/USB Key in read only format including all manufacturers data, inserted in acrobat *PDF format. Include the following features:
 - (a) Number all pages consecutively
 - (b) Identify the binder with printed title to spine and front cover and identifying the title of the project, the subject matter and the date of issue.
 - (c) Provide 50mm rings with compressor bars.
 - (d) Provide manufacturer's printed data as is specifically appropriate to the project. Where more than one possibility is covered in the data, indicate clearly the appropriate equipment or model.
 - (e) Compile all text using a word processor and provide text laser-printed on bond quality paper.
 - (f) Provide durable plastic dividers for each separate element. Label dividers using laminated tabs.
 - (g) Provide A3 copies of all drawings folded to A4 size and bound to enable unfolding without detachment from the binder. Reinforce punching.

10.9.3 Contents

- 1) Include the following:
 - (a) The front page of the manual to include all emergency contact details for electricity, gas, fire, general emergency etc. to comply with OH&S requirements.
 - (b) Table of contents.
 - (c) Drawings and technical data as required for the efficient operation and maintenance of the installation.
 - (d) Directory of names and contact details of consultants, Contractor, sub-Contractors, and other responsible parties.
 - (e) A general description of the equipment installation.
 - (f) A technical description of each system installed to ensure that the reader can fully understand the scope and facilities provided and performance required. Identify function, normal operating characteristics and limiting conditions.
 - (g) Equipment Descriptions
 - (h) Name, address and telephone and facsimile numbers and email address of the manufacturer and supplier of items of equipment installed together with all identifying markings and numbers including catalogue and serial numbers.
 - (i) Schedules of equipment stating locations, duties, performance figures and dates of manufacture. Cross reference equipment to the record and diagrammatic drawings and schedules.
 - (j) Manufacturer's technical literature for equipment installed. Exclude irrelevant material. Clearly identify specific products and component parts used in the installation.
 - (k) Supplements to the product data to illustrate relations of component parts.
 - (l) Operation Procedures
 - (m) Manufacturer's technical literature as appropriate

- (n) Safe starting, running-in, operating and shutting down procedures. Include logical systematic sequence of instructions for each procedure.
- (o) Control sequences and flow diagrams for each system
- (p) Schedules of fixed and variable equipment settings established during commissioning and maintenance.
- (q) Maintenance procedures
- (r) Manufacturer's technical literature as appropriate. Register with manufacturer as necessary. Retain copies delivered with equipment.
- (s) Recommendations for preventative maintenance frequency and procedures to ensure the most efficient operation of the systems installed.
- (t) Safe trouble-shooting, disassembly, repair and assembly, cleaning, alignment and adjustment, balancing and checking procedures. Include logical systematic sequence of instructions for each procedure.
- (u) Schedule of spares recommended to be held on site. Such spares shall be those items subject to wear or deterioration, and which may involve extended delivery times when replacements are required. Include complete identification details and sources of supply.
- (v) Schedule of normal consumable items, local sources of supply, and expected replacement intervals up to a running time of 10,000 hours. Include lubricant and lubrication schedules for equipment.
- (w) Instructions for use of tools and testing equipment
- (x) Emergency procedures, including telephone numbers for emergency services and procedures for fault-finding.
- (y) Certificates of compliance.
- (z) Copies of manufacturer's warranties.
- (aa) Certificates from authorities.

- (bb) Product certification.
- (cc) Copies of test certificates for the installation and installed equipment.
- (dd) Test reports.
- (ee) Drawings.
- (ff) As-built drawings.
- (gg) Commissioning Data.
- (hh) Full set of authorized commissioning data for all systems.
- (ii) The manuals shall be properly bound and titled. Each set shall consist of 4 sections. Each section shall have the following sub-sections:

Table 10-1 O&M manual contents

<u>Section 0 – Table of Contents</u>		
0.1	Front Page	Provide a front page, identifying the project, the client, the subcontractor, emergency contact numbers and normal contact numbers
0.2	Table of Contents	Provide a Table of Contents for the document
<u>Section 1 – Operation</u>		
1.1	Introduction	Short description of the complete system to familiarize laymen with the system lay- out and operation.
1.2	Detailed description	A detailed description of each system and its equipment, complete with schematic drawings. The purpose of this system is to explain the intended operation of each system and item of equipment to technical personnel. Detailed descriptions of the operation, set-points, adjustments, etc., are thus to be included.
<u>Section 2 - Commissioning data</u>		
2.1	Schedules of data	Detailed commissioning documentation of all the systems shall be included in this section for future reference. These schedules shall include, amongst others, air flows at terminals, major equipment power draws, etc.
2.2	Commissioning data	All commissioning checklists, as signed off by all parties concerned. The original copies of all checklists need to be provided.

2.3	Equipment certifications	All applicable equipment certifications, as applicable.
<u>Section 3 – Maintenance</u>		
3.1	Schedules:	This section shall contain detailed maintenance and service schedules for the complete installation. A maintenance schedule containing three years (following the programmed practical completion) of all the installed equipment requirements shall be completed to ensure the equipment is well maintained. Equipment requiring inspection or replacement with a longer than 3-year maintenance period will be listed separately, and the maintenance period and requirements detailed.
3.2	Troubleshooting	This section shall contain all warning signs, lights or alarms that the equipment may emit. The troubleshooting should also list in short, the procedure to be followed once the described alarm or warning has been activated. This section should also include basic errors which would lead to the malfunction of the equipment.
3.3	Equipment details	This section shall contain manufacturers' brochures, spare parts lists, terms of equipment. Equipment installed is to be highlighted in the manufacturer's brochures.
3.4	List of suppliers	The list of suppliers (complete with addresses and telephone numbers) for each item of equipment shall be included in this section.
3.5	Operation Manuals	All product or equipment specific operational manuals, if applicable, as provided by the suppliers for the equipment installed.
3.6	Warranties and guarantees	All warranty and guarantee information for all equipment, systems, piping, etc. for any and all installations and works completed.
<u>Section 4 – Drawings</u>		
4.1	As-built drawings	A complete set of as-built drawings shall be enclosed in this section.

10.10 Timing and Quality

- 1) Submit one copy of the draft manual 4 weeks before date for practical completion. Include provisional record drawings, preliminary performance data and temporary insertions for items that are not yet finalized.
- 2) Submit three sets of final volumes 2 weeks prior to practical completion. Incorporate all feedback, corrections and notes as applicable.

- 3) Provide softcopy of all models, drawings, calculation files, records, manuals and other information required within the As-Built and O&M documents. Provide soft copies on USB Thumb drives or portable hard drives. Provide three sets.

11 Testing and commissioning

11.1 General requirements

- 1) The contractor must allow for progress meetings, testing, commissioning and participation as required to verify correct operation of the total integrated system.
- 2) Provide sufficient notice so that inspection may be made by the Engineer or Engineer's representative at the following stages:
 - a) Factory testing (witnessing as indicated in detailed specification)
 - b) Delivery to site
 - c) Installation prior to commissioning
 - d) Site testing
 - e) Final inspection ready for acceptance
- 3) The supplier shall provide all site staff necessary to carry out testing and commissioning, and associated procedures. The supplier, Electrical/Mechanical Contractor and Main Contractor shall be involved with the testing and commissioning.
- 4) The supplier shall provide support for Integrated Systems testing.
- 5) Test Procedures and Schedules shall be provided for review as per the requirements of the Commissioning Agent and Commissioning Manager and at the following milestones:
 - i. Factory Acceptance Testing
 - ii. On Site Testing
 - iii. Integration System Testing
- 6) The supplier shall provide:
 - i. Load banks for all equipment load tests
 - ii. Calibrated instrumentation to verify equipment performance.
- 7) The engineer will be appointing by the client to act on their behalf during all testing and commissioning activities.

- 8) Provide details of the proposed testing procedures as part of the tender. Include both factory and site testing.
- 9) Provide all site staff necessary to carry out on site testing, commissioning and associated procedures in conjunction with the Engineer.
- 10) Certified evidence of type tests previously carried out on equipment, which in essential detail is representative of that required under this specification, may be accepted as applicable by the Engineer. The Tenderer shall state in his tender whether such type tests are available, however, he shall still state in his tender the cost of carrying out the type tests listed.
- 11) It is preferred that if type tests are available that these be enclosed with the tender.
- 12) All equipment and materials and personnel shall be provided by the Supplier.
- 13) Three certified copies of all test results shall be supplied to the Engineer and his approval of them shall be obtained in writing by the Supplier before the equipment is despatched from the Supplier's works.
- 14) The Supplier shall include for all required test equipment, personnel and materials required to perform the testing. If additional assistance is required from other trades, the Supplier shall nominate this requirement within their return response.

11.2 Testing requirements

- 1) Provide details of the proposed testing procedures as part of the tender. Include both factory and site testing.
- 2) Provide all site staff necessary to carry out on site testing and commissioning, and associated procedures in conjunction with the Engineer.
- 3) Certified evidence of type tests previously carried out on equipment, which in essential detail is representative of that required under this specification, may be accepted as applicable by the Engineer. The Tenderer shall state in his tender whether such type tests are available, however, he shall still state in his tender the cost of carrying out the type tests listed.
- 4) It is preferred that if these type tests are available that they be enclosed with the tender.

- 5) The Supplier shall include for all required test equipment, personnel and materials required to perform the testing. If additional assistance is required from other trades, the Supplier shall nominate this requirement within their return response.

11.3 Commissioning process

- 1) All parties are to refer to the RACI matrix for testing and commissioning roles and responsibilities.
- 2) The Contract sum shall be deemed to include all cost including labour and materials/equipment required for all testing requirements up to Level 5 (integrated systems testing).
- 3) In addition to section specific requirements by the client the following general testing and commissioning requirements shall be adhered to.
 - a) Comprehensive testing and commissioning of the system shall be required. The contractor shall provide qualified personnel for the supervision of all inspection and testing activities.
 - b) A test plan and programme shall be submitted for approval by the engineer before any tests are conducted.
 - c) The test plans shall be developed to unambiguously demonstrate the correct operation of the installed equipment. The contractor shall identify any testing that may impact on critical operations and seek direction from the engineer.
- 4) At minimum, the test plan shall include the following:
 - a) Details of the equipment to be tested.
 - b) Configuration (e.g. memory, I/O cards, power supplies) of equipment to be tested.
 - c) Software and/or firmware versions of equipment to be tested.
 - d) Major software configuration parameters.
 - e) System diagram showing how equipment is logically arranged.
 - f) Details of any interfaces to third party equipment, both high level and low level.
 - g) Cause and effect matrix detailing all input/output relationships/results.
 - h) Pass or fail criteria to be specified within test documentation.
- 5) The test programme shall be developed providing the sequence of testing to be conducted. As a minimum, the test programme shall indicate the relative start and finish dates for the following:
 - a) System Commissioning Tests
 - b) System Acceptance Tests
- 6) QA/QC tests (L2)

- a) Upon receiving the equipment on site the contractor / supplier shall confirm that the equipment received is as per what was required and that the equipment is in “as new” condition.
 - b) Any defects shall be rectified immediately by the supplier at the cost of the supplier.
 - c) The engineer is required to witness this test and to sign off on the supplier documentation.
- 7) System Commissioning Tests:
- a) Upon receiving approval for the test plan and programme from the engineer, the contractor shall conduct unsupervised System Commissioning Tests in accordance with the test plan and within the dates defined in the programme.
 - b) Any defects shall be rectified immediately by the contractor and the system re-tested. Tests shall be repeated until the contractor is able to complete all approved tests successfully without any defects. Upon successful completion, the contractor shall formally advise the engineer in writing of such, and that they are ready for the System Acceptance Tests.
 - c) The engineer is not required to witness the system commissioning tests but may choose to do so.
- 8) System Acceptance Tests:
- a) The contractor shall demonstrate the functionality of the system using the approved test plan. System Acceptance Tests shall be witnessed and signed off by the engineer or his representatives. The contractor shall provide two-way radio communications and all equipment required for the testing.
 - b) If the System Commissioning Tests have been properly carried out, the systems acceptance tests should be straight forward, and no defects should arise. In any case, should there still be defects; the systems acceptance tests shall be repeated. The contractor shall bear all costs incurred by the engineer or his/her representatives in attending system acceptance re-testing.
 - c) Report of all the test event transactions shall be provided in both soft and hardcopy. Softcopy shall be in the Microsoft Office Excel format for easy analysis.
- 9) The Contractor shall provide all necessary safety equipment and test instruments. All test instruments shall be covered by a current test and calibration certificate.
- 10) All test results shall be included in the handover documentation.
- 11) All certificates to be issued once final commissioning has been completed shall be submitted to the engineer for approval before being issued.

- 12) The Contractor shall make provision for all inspection and testing activities to be witnessed by the engineer. Unless otherwise specified, the period of notice for witness testing shall be 10 working days.
- 13) Unless otherwise agreed by the engineer, no part of the installation shall be commissioned until all defects or omissions revealed by inspection and testing have been rectified. Where a defect or omission renders all or part of the installation unsafe for use, the contractor shall take approved precautions to ensure that no part of the installation can be commissioned.
- 14) Before testing and commissioning, inspections shall be performed to verify:
 - a) All equipment and material is of the correct type and complies with Specifications
 - b) All parts of the installation are correctly installed
 - c) No part of the installation is visibly damaged or otherwise defective
 - d) The installation is suitable for the environmental conditions
 - e) The installation complies with this Specification
- 15) On satisfactory completion of the inspections the following tests shall be performed as a minimum in the sequence listed:
 - a) A power failure shall be simulated to test the standby power supply.
 - b) If required by the applicable standard, or requested by the engineer, cables and wiring shall be insulation tested at 500V after they are installed. The insulation resistance to earth and between conductors shall comply with the requirements of SANS 10142-1. Because 500V can damage electrical and electronic equipment, the insulation test shall be carried out before equipment is connected to the cables or wire. The completed installation shall be tested at a lower voltage, as recommended by the manufacturer.
 - c) Earth continuity should be tested in accordance to SANS10142 - 1.
 - d) Each system component dynamically tested to ensure that they work satisfactorily, and that the correct indications and responses are given by the fire control panel.
 - e) All signals from the system to ancillary systems shall be checked to ensure that the correct actions or responses are achieved.
 - f) After individually testing the components and equipment, system simulation tests shall be done to commission the system and to indicate that the system is working.

12 Guarantee & maintenance during defects liability period

- 1) In addition to section specific requirements the following general maintenance requirements shall be adhered to.

- 2) Comprehensive maintenance shall be provided during the **twelve months** Defects Liability Period. The defect period shall commence upon successful completion of system acceptance testing and the issue of the certificate of completion. This period may be extended as per the detailed specifications and BOQ.
- 3) Comprehensive maintenance shall comprise of:
 - a) Maintenance as per supplier recommendations for all installed items.
 - b) Ad-hoc corrective maintenance for reported faults.
 - c) Keeping a maintenance register.
- 4) Half-yearly preventative maintenance

The maintenance to be carried shall include but not be limited to the following activities:

- a) Consultation with user on any problems encountered and adjustment required (e.g., adjustment of programming of system behaviour, etc.).
- b) Check the operation of all system components for correct operation
- c) Check for correct system reporting of faults, alarms and errors.
- d) Check and confirm interfacing with other connected systems
- e) Check the physical conditions of the installation including mechanical fixing, evidence of corrosion to any part, signs of overheating, abrasion or physical damage.
- f) Check all data, control signal and power connections and terminations.
- g) Check the conditions of all batteries connected to the system. Clean batteries; recoat terminal posts with an approved coating.
- h) Check all labels and signage.
- i) Install software updates and upgrades including patches, firmware, updates and upgrades.
- j) Check time and date on system clock.

- 5) Ad-hoc Corrective Maintenance:

Ad-hoc maintenance shall be carried upon the user reporting a fault.

- 6) Maintenance Register:

- a) A comprehensive maintenance register shall be kept by the maintenance service provider.

The maintenance register shall include the following minimum information:

- i. Name of person reporting or discovering fault.
- ii. Date and time of fault reported or discovered.
- iii. Nature of fault.
- iv. Date and time technician arrived on site.
- v. Name of technician attended to fault.

vi.Date and time fault is resolved.

vii.Details of the action taken to resolve the issue including any parts being replaced.

b) The maintenance register shall be an electronic register such a Microsoft Office Excel or Access database file. The electronic maintenance register shall be the property of the user and shall be handed over to the user at the end of the maintenance contract. Hard copy reports shall be updated and submitted to the user following any changes to the register.

7) Quality of service:

Quality of service shall be based on the key performance indicators below.

Service/Fault Description	Minimum Standard
Fault Reporting Help desk	Calls answered within 30 seconds during business hours. Return calls within 8 hours during weekends, public holidays and non-business hours.
Critical fault that impact on safe operation.	Technician on site within 24 hours of fault being lodged and fault resolved within 48 hours.
Urgent fault that impact on efficient operation.	Technician on site the next business day of the fault being lodged and fault resolved within 3 business days.
Minor fault that inconveniences the operation.	Technician on site within 2 business day of the fault being lodged and fault resolved within 5 business days.
Maintenance register	Every maintenance activity is accurately recorded in the register at the conclusion of the service activity. The maintenance register must be made available for inspection by the user following a 24 hours' notice.

SECTION 3: STANDARD SPECIFICATION

Definitions and abbreviations

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

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

'ASHRAE'	American Society of Heating, Refrigeration and Air Conditioning Engineers
'ARI'	Air Conditioning and Refrigeration Institute (USA)
'ASME'	American Society of Mechanical Engineers
'ASTM'	American Society of Testing Materials
'AWWA'	American Water Works Association
'BSS'	British Standard Specification
'BSI'	British Standard Institute
'BS CP'	British Standard Code of Practice
'CIBS'	Chartered Institution of Building Services
'DIN'	German Standards Institute
'HVCA'	Heating and Ventilating Contractor's Association (UK)
'NBFU'	National Board of Fire Underwriters (USA)
'NBS'	National Bureau of Standards (USA)
'NEMA'	National Electrical Manufacturers Association (USA)
'NFPA'	National Fire Protection Association (USA)
'SABS'	South African Bureau of Standards
'SMACNA'	Sheet Metal and Air Conditioning Contractors National Association, Inc (USA)
'UL'	Underwriters Laboratories

1 Compliance with regulations and standards

This specification is to be read in conjunction with the Detailed and General specification forming part of this data pack.

- 1) It shall be the responsibility of the HVAC Contractor to ensure that all equipment and methods used in the installation, comply with all relevant statutory regulations, and amendments thereto in particular the following:
 - a) S.A.N.S. Code of Practice 10142, as amended, for the Wiring of Premises.
 - b) The Occupational Health & Safety Act of 1993, as amended.
 - c) Government, Provincial and Local Authorities Ordinances, Regulations, By-laws, Rules and other Statutory requirements.
 - d) Specifications and Codes of Practice issued by the South African Bureau of Standards and British Standards Institute. The former shall have precedence over the latter where both bodies have issued conflicting specifications or codes of practice.

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

2 Identification

All identification shall be as set out in the General specification and as per specific requirements of the client. Should the below be in conflict with the General specification the former takes precedence.

2.1 Labels

- 1) A label shall be provided under each gauge, meter, instrument, pilot lamp, remote control switch, motor controller and panel mounted item and equipment identifying the equipment controlled by such items.
- 2) The labels shall consist of non-corroding material TRAFFOLITE with non-glossy appearance, engraved, block on a white background. All labels shall be of the screwed-on type unless otherwise approved.

2.2 Valve Tags and Charts

- 1) Aluminium numbered tags including letters to identify the system, shall be fastened by heavy brass chain to all valves indicated on the drawings.
- 2) The metal tags shall be 50 mm in diameter, 1 mm thick, and shall have stamped-in numbers and letters.
- 3) The HVAC Contractor shall be responsible for submitting a list of all valves and controls, giving location and function, together with diagrammatic charts featuring each piping system with valves and controls, identified by numbers and letters shown on the corresponding tags.

2.3 Piping

- 1) In addition to painting of external surfaces (including insulation), colour coded polyvinyl chloride bands shall be applied to pipes identifying their content and direction of flow.
- 2) Bands shall be provided to piping at valve locations, at points where piping enters or leaves a partition, wall, floor or ceiling and at least at every 10 m centres of straight runs. Where piping is concealed, bands shall be applied to valves or other devices whenever access is

provided by doors or panels. Exit and entrance points to each vessel, tank or place of equipment shall be identified by bands. Insulated pipes shall be banded after insulation and painting work has been completed.

- 3) The band's width shall be minimum 200 mm wide for pipes up to 250 mm diameter and 400 mm wide for larger diameter piping. The pre-printed letters on band, identifying the services shall be of at least 20 mm high.
- 4) Piping of less than 25 mm nominal bore need not be colour banded but shall be painted all over with the identifying colour of its content.

2.4 Ductwork

- 1) All ductwork shall be identified by writing in words the service of the duct and by pointer showing the direction of flow. Markings shall appear at least at the point of origin and whenever ducting enters or leaves walls, floors or ceilings and for every 20 m centres of straight lines.
- 2) The identification letters shall be at least 50 mm high and the flow arrow 150 mm long.

2.5 Access Panels

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

2.6 Colour Schedules

- 1) Unless otherwise indicated, the following colour schedules shall apply.
 - a) All equipment, ducts, pipework, metal parts and insulated and plastered surfaces shall be thoroughly descaled, cleaned and painted with a priming coat and two coats of oil paint.
 - b) Paint shall be of the highest quality super enamel as manufactured by Plascon or equal, and shall be applied strictly in accordance with the manufacturer's recommendations and directions Colour derived from PLASCON COMPUTACOLOUR are denoted (c.c.)
 - c) All colour bands shall be 250mm long. In cases where banks of parallel pipes runs occur, the colour bands shall be of a uniform length and grouped together wherever possible.

- d) Colour bands, where specified or exposed services shall be applied at all entries to junctions, connections to appliances, bulkhead and wall penetrations and both sides of valves.
- e) Bands shall be at 3 000mm centres on straight sections.
- f) Colour bands, where specified or concealed services shall be applied to all access points to ducts, shafts, ceilings, etc.
- g) In concealed accessible areas, the banding shall be applied to pipework or trunking at 2000mm centres.
- h) Where chilled water piping is clad with sheet metal, it is to be painted continuously. Where unclad, it is to be banded.

Table 2-1 Piping and air conditioning colour schemes

Chilled Water flow and return	Midnight Blue G.116	Continuously	Continuously	-
Chilled water F & E	Midnight Blue G.116	Continuously	Continuously	-
Condenser water flow & return	Magic Green G.408	Continuously	Continuously	-
Condenser water F & E	Magic Green G.408	Continuously	Continuously	-
Computer boosted water supply	Sunlight yellow G.12	Continuously	Continuously	-
Treated water	Verda 9 (c.c.) M-37-4	Continuously	Continuously	-
Drains	Black G.2	Continuously	Continuously	-
Refrigerant (hot gas)	Copper Polish and Varnish	Continuously	Continuously	-

		s	s	
Refrigerant (liquid)	Copper Polish and Varnish	Continuou s	Continuou s	-
Refrigerant (suction)	Everest Grey G.71	Continuou s	Continuou s	-
Bleed water	P.W.D. Brown G.18	Continuou s	Continuou s	-

3 Sound and vibration control

- 1) The HVAC Contractor shall be responsible for the rectification of any excessive noise and/or vibration caused by the operation of the air conditioning and ventilation system installed under this sub-contract.
- 2) The HVAC Contractor shall be responsible for the detail design of concrete inertia blocks, if required or specified, but such blocks will be provided by others.
- 3) Each vibration isolation system shall be designed for a static deflection factor necessary to give maximum transmissibility as scheduled below:

3.1 Maximum Permissible Transmissibility

Table 3-1 Maximum permissible transmissibility

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

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

- 1) The sound control system shall provide for noise levels specified under the relevant clauses in the detailed specifications.

3.2 Isolation of Mechanical Equipment

- 1) All equipment shall, wherever possible, be orientated in such a way that maximum sound radiation patterns are directed so as to cause least disturbance. (Maximum sound radiation occurs in the direction in which fluid enters and leaves the equipment)
- 2) All rotating machinery shall be balanced. The critical speed shall be at least 20% above the operating speed.
- 3) Vibration isolation mountings shall be provided for all equipment. Mountings shall be installed in accordance with the manufacturer's instructions. However, the HVAC Contractor shall be responsible to ensure that amplitude of motion and vibration transmission will not exceed the specified limits.
- 4) Floor mounted equipment shall be erected on a concrete plinth, which shall protrude at least 25 mm above finished screeded floor level.
- 5) Isolators shall be selected to give both horizontal and vertical flexibility (compression and shear). The amplitude of motion due to operation of the supported equipment shall not exceed 3 mm.

- 6) Spring isolators shall be designed and installed in such a way that the ends of the springs are constricted to remain parallel during deflection. For stability, the outside diameter of springs shall be at least equal to their compressed height at rated load. Springs shall have a minimum additional travel to solid, equal to 20% of the rated deflection. Each spring mounting shall be set on 7 mm thick neoprene acoustical pads.
- 7) Suspension type supports, i.e. springs combined with suspension rods, shall be rendered dynamically damped where necessary, by the provision of suitable dynamic dampers (dashpots) arranged diagonally or onto vertical building faces.

3.3 Isolation of Piping and Ducts

- 1) All connections to equipment shall be sufficiently flexible to prevent excessive strain to allow the equipment freedom to move and to prevent plant vibration being conducted. Initially, special flexible connections may be omitted in a piping system and use shall be made of natural flexibility of resilient hangers or mountings for vibration isolation. However, flexible connections shall be inserted, and other necessary adjustments shall be made, at the HVAC Contractor's expense, should the need arise.
- 2) All ductwork and piping within 15 m from connected vibration-inducing equipment shall be hung on resilient hangers. The first four hanger supports shall be capable of supporting piping at a fixed elevation during installation and, in addition, shall have a secondary adjustment to transfer the load to the spring element within the mounting, after the system has been filled with water.
- 3) The HVAC Contractor may be required to disconnect the piping after the installation is completed to demonstrate that no strain is exerted at the connections to the equipment.
- 4) Where piping and ductwork passes through walls, floors or ceilings or plantrooms, acoustical seals shall be employed to confine airborne noises to the inside of such rooms.

3.4 Sound Attenuation

- 1) Sound attenuating units or treatment shall be provided as indicated and/or required to control the noise from air conditioning and ventilation systems to within the limits specified. Noise levels caused by the equipment shall not exceed the ambient noise levels by more than 7dB in each frequency on the site boundary.
- 2) It should be noted that the provisions for sound attenuation shown the Engineer's drawings (or the absence of same) are based on average published data for equipment noise and inherent attenuation. The HVAC Contractor shall, nevertheless, produce his own calculations

for noise levels in the areas specified, and provide additional silencing equipment and/or treatment if necessary.

- 3) To minimize the need for sound attenuation, fans shall be selected to operate near their maximum efficiency point when producing the required air quantity and static pressure.
- 4) Sound attenuators and acoustic treatment in ducts shall be proof against fire, fungus and erosion and not produce dust or come loose.
- 5) "Packaged" attenuators shall normally be flanged for bolted connections, and flexible duct connectors shall be used as shown or required.
- 6) Attenuators shall have an air resistance not exceeding 75 Pa measured at sea level at maximum air quantity.

3.5 Noise Measurement

- 1) The HVAC Contractor shall submit sound pressure levels measured on the completion of the installation, detailing the sound pressure levels in dB (re: 2×10^{-5} Pa), for the seven International Standard Octave Bands measured by means of a sound meter in at least six (6) areas within the building, as selected by the Architect.
- 2) Measurements for sound pressure level data shall be taken by the HVAC Contractor, or at his expense by an approved organization, under full or nearly full cooling and air flow conditions.
- 3) Noise level in the conditioned space through the operation of the unit at any operation point shall not exceed the specified internal, NC level with an 8 db room attenuation factor in each octave band. Due allowance shall be made for all attenuators required to meet the specified noise levels whether shown on the drawings or not. Operating of the unit shall not cause noise levels in the surrounding areas to be more than 7 db, in each frequency, above ambient noise levels at any boundary of the site.

4 Insulation

- 1) All piping and ducting shall be insulated as specified below.
- 2) All insulation of piping, ductwork and equipment shall comply with BS 5970, provisions of BS 5422. Test reports may be requested from an approved testing laboratory, at the HVAC Contractor's expense, to certify the declared thermal conductivity under operating temperature of the chosen insulating materials.

- 3) Insulation shall be applied in accordance with manufacturer's general instructions in a neat and workmanlike manner so as to present a smooth and even surface. The insulation shall be compatible with the surface to be insulated and shall not demonstrate or cause any corrosion or stress corrosion under operating conditions. Vapour proofing and adhesives shall be compatible with the insulation; under no circumstances shall an adhesive or solvent be used which could attack or dissolve the surface or material of the insulation.
- 4) Covering which is subject to abrasion during normal maintenance shall be protected by perforated sheet metal with corners and edges of insulation being returned by formed angles fixed to panel edges inside the casing. Covering which may be splashed with water under operating conditions shall be suitably protected and drained to waste.
- 5) Piping, ductwork or equipment shall be clean, dry, free from grease, rust and scale and shall be tested and approved for tightness and workmanship prior to application of insulation. Insulation shall be continuous through sleeves, wall and ceiling openings.

4.1 Materials and Finishes

- 1) Any insulation material and their finishes used shall resist rotting, fire, decay, fungus growth, attack by vermin or erosion, thermal or acoustic, whichever may occur under operating conditions.
- 2) The thickness of insulation, unless otherwise specified, shall conform with the following dimensions for the various normal application:

Table 4-1 Insulation thickness

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

4.2 Piping Insulation Material

- 1) Piping insulation material shall be as follows:

- a) Piping > than 100mm (Outside Building): Mylar foil covered polystyrene – Bends insulated with fiberglass rope and wool materials, super coated with a 12mm thick layer of insulpro hardsetting insulation plaster and finished with a gauze reinforced vapour barrier.
- b) Piping > than 100mm (Inside Building): Mylar foil covered fibreglass – Bends insulated with fiberglass rope and wool materials, supercoated with a 12mm thick layer of insulpro hardsetting insulation plaster and finished with a gauze reinforced vapour barrier.
- c) Piping < than 100mm: Elastometric Armaflex.
- d) All external (exposed to rain and sunlight) piping and all piping up to 3m high or shall be clad in with a stainless-steel cladding.

4.3 Ducting Insulation Material

- 1) Ducting insulation material shall be as follows:

Table 4-2 Ducting insulation material:

External insulation	25mm fibreglass
Density	16kg/m
Conductivity	0.045 W/mK
Vapour barrier	Foil reinforced Kraft
Fixing	Pinned and strapped
Internal insulation	Armaflex
Inside building	25mm
Outside building	50mm
Density	16kg/m
Fixing	As per supplier requirement

- 2) Where specified thickness of insulation exceeds commercially available sizes, insulation in two or more layers, with all joints staggered, shall be applied. Overlaps shall be at least 50 mm.
- 3) To ensure that the correct thickness of insulation and covering has been applied, the HVAC Contractor shall, if required to do so, cut one or more section from the finished insulation. If deficiencies are revealed, the HVAC Contractor shall, at his own expense, remove the whole and provide and fix the correct insulation.

4.4 Fire Hazard Ratings

- 1) Satisfactory test results from the National Building Research Institute or test reports from an approved testing laboratory may be required, at the HVAC Contractor's expense, to certify the fire hazard ratings for proposed materials for insulation, covering and vapour sealing do not exceed those specified.
- 2) Such Building Research Institute of the South African Council for Scientific and Industrial Research, and in accordance with test procedures BS 476.
- 3) Insulating materials, finishes, vapour barriers and adhesives shall conform to the fire hazard ratings specified as follows:
 - a) The fuel contribution index shall not exceed 0 when compared with asbestos taken as 0.
 - b) The smoke contribution index shall not exceed 10 when compared with hardboard taken as 100.
 - c) The spread of flame index shall not exceed 0 when compared with asbestos taken as 0.
- 4) Any productions of combustion of said materials shall be completely non-toxic and non-corrosive.

4.5 Piping and Fittings

- 1) Unless otherwise specified or noted, the following piping need not be insulated:
 - a) Vent, overflow, drain and relief piping, cold water make-up piping; water treatment piping, condensate water piping.
- 2) The insulation shall be externally covered. The covering to insulation on cold piping shall form a complete vapour barrier as specified below.
- 3) Covering of insulation which is visible but not readily accessible shall be finished neatly, and painted. Where the covering used, as specified above, is not suitable for the purposes, hard setting compound shall be applied, trowelled true and smooth, and painted.
- 4) Insulation in plantrooms and enclosures and insulation which is visible and accessible, i.e. up to 2,5 m above floor level shall, in addition to the covering specified above, be neatly

enclosed in metal casings made out of aluminium or galvanised steel of at least 0,8 mm thickness or covered with 12 mm thick minimum hard setting compound, reinforced by galvanised mesh.

- 5) Insulation of piping exposed to the weather shall be metal cased as specified above, and this casing shall be lapped so as to be rainproof. Casing shall be painted.
- 6) Self-tapping screws, or blind rivets, the application of which could damage the vapour sealing, shall NOT be used for fixing metal casings to vapour sealing.
- 7) Rigid preformed piping insulation shall be applied, wherever possible, for the insulation of bends, tees, elbows, flanges and valves. Where pre-formed pipe insulation is not possible to use, blocks or batts shall be securely wired or banded in position and all joints and voids shall be filled with mineral wool.
- 8) Alternatively, the Engineer may permit the use of foamed-in-situ insulation inside metal casings applied to such special positions.
- 9) Where practically possible, piping shall be supported OUTSIDE the insulation or cradles as specified below. Where the load on the insulation exceeds the strength thereof, a suitable part of the insulation shall be replaced by material having higher crushing strength. Normally, dry hardwood will be acceptable for this purpose.
- 10) Where insulation is specified for piping, the same shall apply to all fittings and pipe connections within the system.

4.6 Ductwork

- 1) Unless otherwise specified or noted, the following ductwork need not be insulated:
 - a) Return air ductwork; exhaust air ductwork; supply ventilating systems except when incorporating heating.
- 2) Unless otherwise specified or noted, insulation shall be applied to the outside of the duct.
- 3) Concealed ductwork shall be insulated with rigid or flexible materials. Flexible materials shall have a density of at least 16kg/m³.

- 4) Ductwork which is exposed and visible but not readily accessible shall be insulated with rigid material having a facing of aluminium foil or hard setting cement finished smooth and true, and painted.
- 5) Ductwork in plantrooms and ductwork which is exposed, visible and readily accessible, i.e., up to 2,5 m above floor level, shall be insulated with rigid material and protected against mechanical damage either by aluminium sheet of at least 0,8 mm thickness or be reinforced hard setting compound of minimum 12 mm thickness, and painted.
- 6) Ductwork insulation exposed to atmospheric conditions shall be covered by galvanized steel sheet metal panels lapped so as to be weatherproof and painted.
- 7) Self-tapping screws, or blind rivets, the application of which could damage vapour sealing, shall NOT be used for fixing metal casings.
- 8) Where insulation is fixed to the inside of the ductwork, the surface treatment of such insulation exposed to the air flow shall resist shredding and erosion, and where such insulation is adjacent to humidifiers, air washers or cooling coils; the surface shall have water protection.
- 9) The insulation shall cover flanges by means of boxes or by increasing the thickness of insulation to give at least a 6 mm cover at these points.

4.7 Fans

- 1) Fans handling cooled or heated air, and externally subject to ambient temperatures, shall be insulated on all exposed surfaces with a semi-rigid material cut to shape, covered with galvanised bird-wire held with welded pins at 300 mm centres each way and hard setting cement of at least 20 mm thickness.
- 2) The minimum insulation thickness shall be the same as specified for ducting.

4.8 Air Handling Units and Enclosure

- 1) Air handling units shall be insulated with rigid material on all exposed areas, held in place by pins and washers at 450 mm centres each way, and covered with sheetmetal panels.
- 2) Air handling unit enclosures, either being in metal, concrete or brick and containing cooled or heated air, shall be insulated.

- 3) Where possible, such insulation shall be on the inside of the enclosure, suitably retained and protected.
- 4) The minimum thickness of insulation shall be as specified above, for ducts.
- 5) For such internal insulation the enclosure will act as vapour seal for cooling plant, and the fabric of said enclosure shall therefore be treated as follows:
 - a) Metal enclosures: all seams, rivet holes etc. sealed.
 - b) Masonry enclosures: internally coated with suitable bitumen emulsion.

4.9 Cooling Coil Sumps

- 1) Sumps shall be mounted on 25 mm thick insulation having a thermal conductivity of not more than 0,04 W/m NC.
- 2) Alternatively, they may be internally lined with an equivalent thickness of foamed-in-situ plastic, internally moisture proofed.

4.10 Vapour Barriers

- 1) Insulation used on piping, ducting and plant, operating below ambient temperatures, shall be coated with a vapour barrier to be applied immediately after dry insulation has been fitted.
- 2) No chilled water, refrigerant, suction gas or cold air shall pass through insulated piping, ducting or equipment before vapour proofing has been applied.
- 3) Where insulation shall be removable, eg. at flanged joints, etc. the main insulation shall be stopped short of the fitting with the vapour barrier sealed to the shell. The removable portion of the insulation shall then be fitted as a separate item with its vapour barrier overlapping and sealed to the main vapour barrier. Attention shall be given that the vapour barrier and the insulation are not pierced or damaged by supports.
- 4) At discontinuities and at section ends, the vapour barrier shall be returned to the surface to prevent moisture from entering the insulation at the edges.
- 5) Where it is unavoidable to connect hangers, supports or anchors solidly to cold services, such hangers etc. shall be "feathered" with insulation, and vapour sealed, after the main insulation

and vapour sealing has been applied, which later shall be carefully sealed onto the metal of the support.

- 6) At the point where the support is attached to the building fabric, insulation such as rubber or neoprene pads or bushes shall be provided to prevent invisible condensation and corrosion.
- 7) Piping vapour barrier shall be Mylar foil laminate.

5 Air Distribution System

5.1 General

- 1) The Sub Contractor shall supply and install the outdoor air distribution system as shown on the drawings.
- 2) The entire ducting system, shall not leak more than 4% of the maximum design air flow at design duct static pressures, as determined in the manner specified.
- 3) Ducts shall be even, and internally smooth with neatly finished joints, shall be free from vibration and drumming under all operating conditions and shall ensure an even flow of air without undue pressure loss.
- 4) The entire ducting system, including flexible ducts, finishes, hangers and supports, dampers and valves, connections, access doors, acoustical treatment and thermal insulation, sealants and sealing gaskets, shall be selected, constructed and installed to give a minimum working life of 20 years under expected building service conditions.
- 5) Unless otherwise indicated, all ductwork sizes shown on the drawings are clear internal air passage sizes.
- 6) Ductwork in plantrooms and ductwork which is exposed and visible shall be painted in accordance with "Painting and Protection Against Corrosion" Part B.
- 7) Ducting shall be identified for services and direction of flow in accordance with "Identification" Part B.
- 8) The Sub Contractor shall select, construct and install the ducting and other sheetmetal work in accordance with the following classification of conditions in the several sections of the air distribution system:

Table 5-1 Duct classifications

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

5.2 Low Velocity Low Pressure Ductwork

- 1) Except as noted, ducts and other sheetmetal work for air distribution shall be constructed and installed in accordance with:
 - a) Contract drawings.
 - b) Latest edition: "Low Velocity and Duct Construction Standards" by SMACNA or SANS 1238 2005 and 10173 2003.
- 2) Ducting and appurtenances shall be constructed of Galvanised Steel.
- 3) Bracing angles shall be compatible with the duct material.
- 4) Changes in dimensions, shape and direction of ducting shall be gradual, complying with SANS 1238 2005, Sections 5.4.
- 5) Elbows shall be of the standard radius ($R=W$) type. Short radius ($R=1/3W$) and vaned square elbows shall be used only where required to fit restricted space.
- 6) Air turns shall be installed in all non-standard radius elbows and shall consist of 'double thickness' type vanes, arranged to permit the air to make the turns without appreciable turbulence.

5.2.1 Branches and Take Offs

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

5.2.2 Sealants

- 1) All joints shall be sealed using an approved sealant.

- 2) Seal all openings in the surface, joints and seams of ducts in accordance with AS 4254 clause 2.2.1 and the Duct seal class table.
- 3) Duct seal class: Not lower than Class c to AS 4254 regardless of duct pressure or location
- 4) Sealant material: Use only sealants that:
 - a) Do not foster microbial growth.
 - b) Have a smoke developed index < 3 and a spread of flame index < 0 when tested to AS/NZS 1530.3
 - c) Will maintain their sealing performance for the life of the duct system.
 - d) Bond to the surface of application without primers.
 - e) Are resistant to oils, refrigerant and water after curing.
 - f) Are non-toxic.
 - g) Have high elasto-metric properties over a range of operating temperatures after curing.
 - h) Are suitable for application by gun or hand tools.
- 5) Adhesive duct tapes: Use only as a secondary sealant on joints sealed by other means such as mastic, liquids or gaskets.
- 6) Machine rolled flanges: Use mastic at corners.

5.2.3 Installation

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

5.2.4 Flexible Connections

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

- 2) Connections shall be attached at both ends by approved metal collars or frames.
- 3) The openings being connected shall be of equal size, aligned and parallel.
- 4) The flexible material shall be in folds to permit sufficient movement and the unfolded width and width of "gap" in the operating condition shall be as scheduled below:

Table 5-2 Flex connections

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

5.2.5 Flexible Ducting

- 1) Where indicated ductwork shall be connected to mixing boxes and integrally mounted ceiling diffusers by means of flexible ducting.
- 2) Flexible ducting shall consist of aluminium foil faced glass fibre fabric mechanically interlocked by a corrosion resistant metal spiral helix on the outside of the fabric.
- 3) Flexible ducting shall comply with local codes, NFPA Bulletin 90A and SANS fire resistance requirements.
- 4) Flexible ducts connected to diffusers of mixing boxes shall, unless otherwise shown or approved, not exceed 1,5m in length nor have more than (the equivalent of) two 90 degree bends. Bends shall be of the maximum possible radius without flattening or distorting the flexible.

5.2.6 Access Doors and Panels

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

5.2.7 Site Assembled Casings

- 1) Except as indicated, floor under site assembled casings shall serve as bottoms.
- 2) Walls and ceilings may only be used as part of the casings with the express approval of the Engineer. These shall be insulated and covered with galvanised sheetmetal as directed.
- 3) Casing shall not drum vibrate or leak.
- 4) Built-up casings shall be of the sandwich panel insulated wall type constructed with prefabricated panels.

- 5) Sandwich panel skins shall be constructed of galvanised steel of a gauge to suit operating conditions and finished with a vinyl based baked enamel painted to an approved colour.
- 6) Sleeves shall be provided where panels are pierced for the purpose of introducing services. Void and sleeves shall be filled with insulation and mastic compound.
- 7) Plenum chambers shall be braced with angles rivetted to sheet at 150 mm centres.
- 8) Casings shall be jointed to walls, plinths, floors or ceilings with angles secured with expansion bolts on 300 mm centres.
- 9) Doors in insulated casings shall be of double panel construction, panels minimum 1,2 mm thick and filled with insulation to the thickness of the casing insulation.

5.2.8 Testing

- 1) All duct work shall be leak tested and made airtight before ducts are insulated or concealed.
- 2) Calibrated equipment for leak testing shall include rotary blower, orifice section and U-type gauge board complete with cocks, rubber tubing and other appurtenances required for conducting tests, generally as described in the SMACNA "High Velocity Duct Construction Standards".
- 3) As installation progresses, suitable and approved sections of ducting including spigots for flexible ducts shall be temporarily sealed for testing.
- 4) Test pressure shall be 75 Pa. During the test period, the entire section of ducting tested shall be examined for leaks and noise. Leaks and noisy conditions shall be marked, repaired and re-tested. Noisy leaks shall be repaired under all conditions, even when leakage is within acceptable limits.
- 5) Test holes for instruments shall be 25 mm diameter and provided with an effective seal.
- 6) Reports on leak testing shall be submitted in a bound folder with all accompanying sketches, and shall indicate that the total of "operating" leakages inferred from tests on all sections of the system does not exceed the specified maximum of 4% of the (maximum) design air quantity for said system. (Note: Actual leakage quantities found in each test may be reduced in the ratio P_t/P_o where P_o equals design operation pressure and P_t the test pressure employed, to calculate the "operating" leakage).

7) The Sub-Contractor shall provide all facilities for measuring and testing.

5.2.9 Fire Rated Ducting

All fire rated ducting, where applicable and as indicated on the drawings, shall be 1.2mm galvanised mild steel ducting. A protective coating shall first be submitted for approval by the engineer before procurement and application. The ducting shall have a minimum 2hr fire rating.

1) All internal supports should be provided as required for the dimensions indicated.

5.2.10 High Velocity Medium and High-Pressure Ductwork

1) Except as noted ducts and sheetmetal work shall be constructed and installed in accordance with:

a) Sub-contract drawings.

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

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

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

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

a) High Velocity Medium Pressure Ducting: 1500 Pa

b) High Velocity High Pressure Ducting: 2500 Pa

5) The Sub-Contractor shall provide all facilities for measuring and testing.

5.2.11 Fire Dampers

1) Dampers shall be located as shown on the drawings.

- 2) Dampers shall be designed to close automatically and remain tightly closed upon the operation of an approved fusible link or other heat actuated device, located where readily affected by an abnormal temperature in the duct. Device shall have a temperature rating approximately 20°C above the maximum temperature that would normally be encountered when the system is in operation or shutdown.
- 3) The open or closed status of the damper shall be indicated outside the casing.
- 4) Dampers shall be sized so that the free air space when open is not less than the connected duct free air space.
- 5) Dampers shall be installed so as to form part of a continuous barrier to passage of fire when in a closed position. Where a fire damper cannot be fitted immediately adjacent to the fire wall, the section of ducting between damper and wall shall be of at least the same metal thickness and fire rating as the damper casing.
- 6) Dampers shall be self-supporting in case of duct destruction due to heat. Care shall be exercised that the frame be set so that the closing device will be accessible.
- 7) Suitable hand openings with tightly fitted covers shall be provided to make dampers accessible for inspection and maintenance.
- 8) Dampers shall comply with the requirements of local authorities and NFPA Bulletin 90A and SANS 193.
- 9) Dampers shall be selected for a minimum fire protection rating of two hours.

5.3 Fans

- 1) Supply and install as shown on drawings the propeller fans handling the specified air quantities as listed in the schedule.
- 2) The fan shall be a fully catalogued product and the documentation shall include sound power level spectrums, performance curves and/or tables for the expected range of operational conditions.
- 3) Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.
- 4) The Sub-contractor shall submit at time of equipment submission:

- a) Detailed system resistance calculation for minimum/maximum pressure drops.
 - b) Certified detailed selection shown on performance curves and/or tables for the specified conditions.
 - c) The service and maintenance instructions.
 - d) The estimated total expenditure on replacement of parts during the service life.
 - e) Installation, testing, balancing and commissioning instructions and trouble analysis guide.
- 5) Fan selection shall be in the stable part of the curve.
 - 6) The fan shall be engineered, and components selected when operated under normal building conditions with optimum servicing and maintenance for a minimum service life of 10 years with 6 000 operating hours per annum.
 - 7) The Engineer reserves the right to call for:
 - a) Test certificates and reports from the manufacturer's quality control laboratory or independent test laboratory such as SANS, and/or
 - b) Site inspections, customer reports/references and user's interviews, and/or
 - c) Full engineering, design and component selection details
 - d) to check the correctness of the claimed service life.
 - 8) Fan installation shall comply with local authority by-laws and with Occupational Health and Safety Act of 1993, as amended.
 - 9) Fan shall be complete with wire guard(s) if accessible from either side.
 - 10) Fan shall be installed in accordance with manufacturer's recommendations and shall be maintained in "as new" condition at start-up of installation.
 - 11) Fan and motor shall be weatherproof and shall be protected from wind, rain and insects.
 - 12) Fan shall be quiet in operation and shall be statically and dynamically balanced at the factory.

- 13) Bearings shall be of the permanently lubricated type.
- 14) Mounting plates shall not distort under any operating conditions.
- 15) Fan shall be mounted on vibration isolating mounting.
- 16) Power source to motors shall be through flexible conduit.

5.4 Sound Attenuators

- 1) Sound attenuators shall be manufactured by a reputable manufacturer regularly engaged in the manufacturing and testing of sound attenuators.
- 2) The sound attenuators shall be tested to BS 4718 as amended and test data shall be available for both static and dynamic insertion losses in octave frequency bands from 63 to 8000 Hz.
- 3) The sound attenuator shall be tested for pressure drops and tables of airflow vs pressure drop shall be available.
- 4) The attenuators shall be leak proof.
- 5) The attenuators shall have a Class 1 rating for surface spread of flame as measured to BS 476 Part 7.
- 6) The casing shall be manufactured from galvanised mild steel.

5.5 Extract/Return/Transfer Air Grille

- 1) Supply and install air grilles extracting/transferring the air quantities as shown on the drawings.
- 2) Unless otherwise indicated, the grille shall be complete with an air quantity adjustment device.
- 3) The grille shall be a fully catalogued product and the documentation shall include selection tables.
- 4) Submit certified detailed selection shown on these tables.

- 5) Special care shall be taken in transport, delivery, storage on site and installation to ensure that the grilles are installed and maintained in "as new" condition at start-up of the installation.
- 6) The grille shall be epoxy powder coated to an approved colour.

5.6 Manually Adjustable Air Damper

- 1) Supply and install the dampers of the opposed blade, 100% shut-off type suitable for the capacity listed in the schedule.
- 2) The damper, complete with frame and linkage, shall be a fully catalogued product of a manufacturer regularly engaged in the production of the high-quality dampers.
- 3) Damper with frame may be made up in one section up to 1200 mm in width and 2400 mm in height. Larger sizes shall be made up in sections for easy handling.
- 4) Special care shall be taken in transport, delivery, storage on site etc., to ensure that the dampers are installed and maintained in "as new" condition at start-up of the installation.
- 5) The damper and damper frame shall be installed level in both directions. There shall be no torsion or twist in the frame to prevent smooth operation of the damper. The blades shall not touch any adjacent material throughout the full travel of the blades and shall be capable of opening to a full 90 degrees.
- 6) The drive shaft for the linkages shall be suitable for manual operation and shall be lockable.
- 7) The dampers and linkage shall be cleaned of any debris or dirt that may cause binding.
- 8) Damper blades shall rotate on pivot assembly in permanently lubricated oilite bearings.
- 9) Pressure drop through the damper shall not exceed 50 Pa at 5 m/s velocity over the face area.
- 10) Damper frame and blades shall be manufactured of galvanised sheet steel.

5.7 Door Grille

- 1) Supply and install as indicated, door grilles transferring the air quantities stated as shown on the drawings.

- 2) The door grille shall be a fully catalogued product and the documentation shall include selection tables.
- 3) Submit certified detailed selection on these tables.
- 4) Special care shall be taken in transport, delivery and storage on site to ensure that the door grilles are installed and maintained in "as new" condition at start-up of the installation.
- 5) The door grille shall be of the "no sight core" type and shall be finished in an epoxy powder coating to an approved colour.

5.8 Intake/Exhaust Air Weather Louver

- 1) Supply and install as shown on drawings, outside air/exhaust air louvres for the air quantity at the static pressures.
- 2) The outside air/exhaust air louvres shall be fully catalogued product and the documentation shall include performance curves or selection tables.
- 3) Certified detailed selection shown on these performance curves or tables shall be submitted.
- 4) Special care shall be taken in transport, delivery, storage on site and installation to ensure that the outside air/exhaust air louvres are in "as new" condition at start-up of the installation.
- 5) The outside air/exhaust air louvres shall be installed as shown in principle on the drawings.
- 6) The louvres shall be finished in baked enamel to an approved colour or epoxy powder coated.
- 7) All outside air/exhaust air louvres shall be complete with mounting frames suitable to be built into the brick walls by the builder. All outside air/exhaust air louvres shall be vermin proofed.

6 Water piping systems

6.1 General

- 1) The Sub-Contractor shall supply and install the water piping systems in accordance with the layout as shown.

- 2) All components shall be fully catalogued products and documentation shall include selection tables or pressure drop data for the expected range of operation conditions.
- 3) The water piping shall be designed and engineered in detail in accordance with the design criteria laid down in:
 - a) The latest ASHRAE Publication, and/or
 - b) The latest CIBSE Publication, and/or
 - c) Carrier - Handbook of Air Conditioning System Design - Water Piping Design.
- 4) Water velocities and pressure drop in any part of the piping system shall not exceed 2 m/s except in or adjacent to control valves where high velocities and the associated high frictions may be needed to obtain stable control. Higher velocities are allowed for short periods of time in the event of partial pipe reticulation failure or maintenance only.
- 5) Full documentation and calculations shall be submitted for approval showing all detailed pressure loss and velocity calculations for the entire piping system and components both under full load and minimum load conditions.
- 6) The system shall be designed:
 - a) To ensure water flow and return to all sections of the installation. The requirements shall be met at full load and part load conditions.
 - b) To avoid the accumulation of dirt and other foreign matter in the system.
 - c) For all possible expansion and contraction in all parts of the water piping system.
 - d) For simple balancing.
- 7) The water piping system shall be designed, selected and installed to ensure no leakage during its operational life. The water piping system and components, including thermal insulation, hangers, support and vibration eliminators, shall be designed, selected and installed to ensure a minimum working life of 60 000 hours under actual operating and normal building service conditions. Piping shall be designed and installed within the space limitations shown or implied on the drawings.

- 8) The Sub-Contractor shall ensure that sufficient access is provided for inspection, testing and servicing.
- 9) The Sub-Contractor shall ensure that loads imposed on the building structure are evenly distributed and shall submit details of all loads imposed by the system on the structure via hangers, supports, bases, etc.
- 10) The minimum gradient for water piping shall be 1:500 up towards venting positions and drain pipes shall be 1:100.
- 11) Square tees shall be used where sweep fittings would cause air to be trapped in the system.
- 12) Eccentric reduction sockets shall be used where necessary on horizontal runs of pipe and concentric reduction sockets on vertical pipes.
- 13) Open or automatic air vents shall be provided at all high points in the system. The latter shall be preceded by stop valves, and the outlet piped to visible discharge over drain point.
- 14) The Sub-Contractor shall provide valves and caps or drains at all low points in piping system and at the bottom of each riser section for draining.
- 15) Due allowance shall be made for venting sections of pipe being drained, both to enable drainage to be complete, and to prevent collapse due to internal vacuum.
- 16) Piping shall be installed so as to allow for expansion and contraction. Connections to coils, pumps and other equipment shall be made in such a manner as to eliminate undue strain in piping and equipment. Necessary fittings and bends shall be furnished to avoid springing of pipes during assembly. Flexible connectors shall be provided where indicated, or if found necessary and may also be required to bridge expansion joints in the structure.
- 17) Piping shall be installed parallel or perpendicular to building construction, while maintaining the required gradients, where applicable.
- 18) System vibration isolation shall be in accordance with "Sound and Vibration Control" section.
- 19) Thermal insulation shall be in accordance with "Insulation" section.
- 20) All necessary pressure gauges, thermometer wells and thermometers shall be installed on the pipelines to check pressures and temperatures for monitoring the functioning of various components including possible blockage of strainers.

- 21) Flow meters and/or connections for portable flow meters shall be provided as shown.
- 22) Piping shall be complete with all necessary isolating valves to enable repairs to be done to any one section of the system without the necessity of shutting down and draining the remainder.
- 23) Components requiring regular inspections, cleaning and removal shall be isolated by shut-off valves to enable this to be done without draining the entire system.
- 24) Components shall be so connected and installed that removal and re-installation will not take longer than 2 hours by a qualified mechanic.
- 25) Relief valves shall be installed in all closed piping system in easily accessible positions. The discharge of each relief valve shall be visible and piped to drain.
- 26) When installing of the piping, 6 meter straight piping lengths are to be used wherever practically possible. To this end, the flange pairs as quantified in the bills of quantities are based on the premise that the abovementioned pipe lengths will be used.

6.2 Chilled Water Pumps

- 1) Supply and install as shown on drawings and as listed in the schedule, centrifugal pump sets of the base mounted direct coupled type with the specified duty.
(g)
- 2) Pumps shall be current catalogued products and documentation shall include performance curves or selection table for the expected range of operational conditions.
(h)
- 3) Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.
(i)
- 4) The flow rate at break-off point of the curve for the impeller selected shall be at least 1,5 times the specified flow rate.
(j)
- 5) The head at zero delivery of the curve for the impeller selected shall be at least 1,2 times the operating head.
(k)
- 6) The efficiency of the pump shall not be less than 70% but not more than 3% below the peak of the efficiency curve for the impeller furnished.
(l)
(m)
- 7) At the time of equipment submission, submit the following:
 - a) Certified details selection shown on performance curves or tables.

- b) Operating, testing, balancing and commissioning instructions.
 - c) Trouble analysis guide.
 - d) Detailed pressure drop and net positive suction head calculations for the system by one or more circulating pumps.
 - e) Full details of periodic and annual maintenance and service to be undertaken by the building maintenance staff in accordance with a preventive maintenance programme.
 - f) The service and maintenance instruction.
 - g) The estimated total expenditure on replacement of parts during the service life.
- (n)
- 8) The pump set shall be engineered, and components selected when operated under normal building conditions with optimum servicing and maintenance, for a minimum service life for 15 years with 3000 operating hours per annum.
- (o)
- 9) The Engineer reserves the right to call for:
- a) Test certificates and reports from the manufacturer's quality control laboratory or independent test laboratory such as SANS, and/or
 - b) Site inspections, customer reports/references and user's interviews, and/or
 - c) Full engineering, design and component selection details to check correctness of the claimed service life.
- (p)
- 10) Pump installation shall comply with local authority by-laws and with the Occupational Health and Safety Act of 1993, as amended.
- (q)
- 11) Pump set shall be installed in accordance with manufacturer's instructions and maintained in "as new" condition at start-up.
- (r)
- 12) Pump set shall be installed on a common vibration isolated steel and concrete base and levelled.
- (s)
- 13) Pump and electric motor shall be aligned to within 0,05mm, both radially and directionally to avoid vibration and pumps shall be statically, dynamically and hydraulically balanced within the design operating range.
- (t)
- 14) The required unobstructed space shall be left around the installation for maintenance and service of the equipment in accordance with the manufacturer's instructions.
- (u)
- 15) Pump set shall be designed and selected for quiet operation with a maximum permissible pump/motor speed of 1440 rpm.
- (v)
- 16) Water shall not be spilt over the plantroom floor; condensate and gland leakage shall be piped to nearest drain or gully and/or a galvanised drip tray shall be provided to each chilled water pump, outlet pipe to drain with galvanised piping.

(w)

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

(x)

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

(y)

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

(z)

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

(aa)

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

(bb)

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

(cc)

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

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

(dd)

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

(ee)

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

(ff)

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

(gg)

28) The pump shall be complete with mechanical seals.

6.3 Chilled Water Buffer Tanks

1) **General:** Furnish and install as shown on the plans thermal storage tanks having the capacity and features detailed herein and scheduled on plans. Thermal Storage Tank's selection shall allow a 10-minute storage capacity where N+1 redundancy is employed as the system type; or a 5-minute storage capacity where N redundancy is employed, unless otherwise indicated on drawings or schedule. Thermal Storage Tank selection shall be based on capacity, and dimensions as demarcated in the technical drawings.

- 2) **Description:** Thermal Storage Tank shall be a dished end pressure vessel.
- 3) **Pressure:** Thermal Storage Tank selection shall be rated for 1.5 times operating pressure but not less than 690kPa.
- 4) **Support:** Thermal storage tank shall be supported by a load spreading base ring.
- 5) **Connections:**
 - a) Thermal storage tank selection shall have the following connections to peripheral systems, and general openings:
 - b) Low level tangential chilled water **inlet and outlet** required.
 - c) Top central outlet
 - d) Bottom drain outlet
 - e) Side inspection opening
 - f) Selection shall account for connection placement and allow adequate access for installation, connection, and maintenance.
- 6) **Gauges:** Thermal storage tank selection shall have 3 x thermal wells as shown on the drawings and schematics allowing for installation (by others) of temperature sensors. The thermal wells will be 250mm above the bottom inlet to the tank, halfway up the tank and 250mm below the top inlet to the tank.
- 7) **Baffle:** Thermal storage tank selection shall contain a baffle between bottom inlet and outlet (or similar) to create serpentine flow within the vessel.
- 8) **Corrosion Protection:** Thermal storage tank selection shall have a cathodic protection system to prevent internal corrosion.
- 9) **Insulation:** Thermal storage tank insulation shall conform to EN 13501 – Fire Classification of construction products and building elements, or as prescribed otherwise within Division 23, whichever is more stringent. Insulation shall be as per standard specification piping diameter >300mm
- 10) **Lifting Lugs:** As per manufacturer specification, if the thermal storage tank is to be

prefabricated and moved to install, selection shall allow for transport and have lifting lugs capable of supporting total weight of the selection.

6.4 Strainers

- 1) Strainers shall be installed to ensure that all foreign matter is continuously removed from the system.
- 2) Strainers shall be of at least the same nominal bore as the pipeline in which they are fitted.
- 3) The filter medium shall be removable for cleaning purposes. Bolted end covers shall incorporate drain plug for blow down purposes.
- 4) Strainers shall be of the pot or angle type.
- 5) Strainers of 50 mm bore and smaller shall be taper screwed and shall have bronze, gunmetal or ductile iron bodies.
- 6) Strainers of 65 mm bore and larger shall be flanged and shall have cast iron bodies to BS EN 1561 GR 14, ductile iron to BS EN 1563 or cast steel to BS EN 10213 and its parts.
- 7) Screen shall be bronze, monel metal or stainless steel with perforation as follows:

Strainer Size	Perforation
20 - 50 mm	0,74 mm
65 - 150 mm	1,50 mm
200- 300 mm	3 mm

- 8) The open area of each screen shall be at least three times the area of the inlet pipe.
- 9) Strainers shall not be fitted in suction pipes feeding pumps unless ample static head (200 kPa minimum) is available in such suction pipes at the position of the strainers.

6.5 Piping

- 1) The following materials, grades and methods of construction shall be used for the applications listed:

Table 6-1 Piping

APPLICATION	NOMINAL SIZE/mm	MATERIAL AND GRADE	APPLICABLE STANDARD	JOINTS

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

Hot water closed circuit	Up to 50	Heavy grade black mild steel	BS 1387	Welded. Steam quality socket unions. Flanges.
>=	Over 150	>=	BS 1387	Welded. Flanges.
>=	Over 150	Black steel	BS 534	Welded. Flanges.

6.6 Jointing

- 1) No joints shall be made in thickness of walls, floor or ceilings. Pipework shall not be embedded in masonry.
- 2) Detachable joints shall be made to facilitate the maintenance and removal of piping and connected equipment. At least one detachable joint is required in each system of piping, of up to 10 m length.
 - a) Such detachable joints shall be as follows for the several types of piping. :
 - i) Copper tubing: flared compression joints.
 - ii) Steel piping up to 65 mm nominal bore: socket unions with ground metal-to-metal seating.
 - iii) Steel piping over 65 mm nominal bore: flanges or clamping bands onto grooved pipe ends (not for hot water).
 - iv) Rigid PVC: PVC socket unions.
- 3) Screwed joints in steel piping shall be taper-to-taper: screwed BSP, with PTFE tape applied to male pipe ends only. Pipes shall be cut and chamfered with approved cutters: hacksawing will not be permitted. Screwed threads shall be machine cut.
- 4) Clamped connections shall be made with approved forged steel or ductile cast iron clamps and resilient sealing rings.
- 5) Clamp and bolts shall be galvanised or other approved anti-corrosion treatment applied by maker.
- 6) Pipe ends shall be machine cut and grooved to the depth recommended by manufacturer.

- 7) Flanged joints shall be made up with one-piece gaskets not more than 1,6 mm thick. "Ring" gaskets, inside the bolts only, are preferred.
- 8) Materials for gaskets shall be:
 - a) For hot water piping : Compressed asbestos fibre, "Kingerit" or equal approved.
 - b) For chilled and cold : Rubber insertion water piping
 - c) Flanged joints between : Dupont "Teflon" or equal dissimilar metals.
- 9) Flanged joints between dissimilar metals shall have insulating gaskets, sleeves and washers between flanges, bolts and nuts respectively.
- 10) Gaskets shall be suitable for service, temperature and pressure of system and installed in accordance with manufacturer's recommendations.
- 11) Non-detachable joints shall be as follows for the different types of piping:
 - a) Copper tubing : Capillary soldering
 - b) Copper tubing : Silver soldering
 - c) Steel piping: Arc welding
 - d) Rigid PVC : Solvent Gluing and / or hot air welding.
- 12) Arc welding shall be in accordance with SANS 10044.
- 13) The Sub-Contractor shall allow for one in ten welded pipe joints to be cut for examination purposes. If any of the welds prove unsatisfactory, the Sub-Contractor shall be called upon to have all welds examined by X-ray and to have X-ray plates examined by the SANS or other approved authority.

6.7 Fittings

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

- 2) Fittings shall be specifically suited for the material and grade of piping to which they are connected, and have the same, or compatible, surface treatment.
- 3) Rigid PVC pressure piping may be used for drains where indicated. Bends only shall be used; no elbows.
- 4) Copper Fittings:
 - a) Soldering fittings shall be of the capillary type. Below 50mm flared or compression type may be used, as scheduled.
 - b) Fitting shall be non-dezinctifiable metal alloy.
- 5) Fittings of inert materials shall be interposed between copper and galvanised steel pipes to prevent electrolytic action.
- 6) Welding Fittings:
- 7) Fittings attached by welding shall be specifically suited for this purpose; to SANS 10044 or similar or similar approved.
- 8) Welded-on outlets to heaters shall be suitable reinforced by extra thickness or gusseting in order to obtain the same strength throughout the header.
- 9) Valves made for welding into pipelines shall not be used unless such usage is approved for each individual case.

6.8 Valves

- 1) Provide valves as indicated or required for operation of systems and control of apparatus, and as scheduled for the particular duty.
- 2) Where ever possible, valves shall be of same manufacture.
- 3) Valve bodies shall be of copper alloy for valves up to 50mm diameter, and of cast iron and steel for those over 50mm diameter.
- 4) Valves shall conform to the following material specifications:

a) Bronze : BS EN 1982

b)Cast Iron : BS EN 1562

- 5) Valve mating flanges shall correspond to valve pressure rating and valve flange diameter.
- 6) Handwheels for valves shall be of a suitable diameter to allow tight closure by hand with the application of reasonable force without additional leverage and without damage to stem, seat and disc. Handwheels operated valves shall close CLOCKWISE.
- 7) Seating surfaces shall be machined and finished to ensure tightness against leakage for service specified and shall seat freely.
- 8) All screwed valves shall be so designed that when the screwed connections are properly made, no interference with, nor damage to the working parts of the valve, can occur.
- 9) Gate valves shall have rising stems and split or solid wedge gates and shall have back seats to facilitate repacking under pressure, and shall be drop tight closing.
- 10) Copper alloy gate valves shall comply with BS 5154 and BS EN 1288. Cast iron gate valves shall be to SANS 664, and BS EN 1171.
- 11) Butterfly valves with flanged bodies, or of the "wafer" type, for fitting between flanges fixed to adjacent piping, may be used to isolating valves. These valves shall close drop tight against the prevailing pressure and be lever geared handwheel, electrical or pneumatically operated. Indicators showing "open", "closed" and "intermediate" positions shall be provided. The valve disc shall be hydrodynamically stable and seated against renewable resilient seats. The spindle seal shall be drop tight and renewable under pressure.
- 12) Diaphragm valves such as "Saunders" or equal approved or butterfly valves shall be used in lieu of gate valves, for isolating purposes, specifically in positions where the risk of leakage cannot be accepted (e.g., in false ceilings and computer room access floors).
- 13) "Sphere" or "ball" valves shall have a polished spherical metal closing element with renewable sealing rings incorporated in the body. The port shall have the same bore as the body. The operating spindle seal shall be renewable under pressure and drop tight.
- 14) Such valves shall normally be lever- or key operated and may be used as stop- and balancing valves by means of an adjustable top to the operating mechanism.
- 15) Globe valves shall conform to BS5154, or equivalent.

- 16) Globe valves shall have characterised plug discs. The discs shall be free to rotate, readily removable from the valve stem and renewable.
- 17) Valves shall permit control of flow rate from full flow to complete shut-off and suitable for repacking of stem gland under pressure.
- 18) Lubricated plug cocks shall be designed to prevent lubricant entering into the valve port opening. The port area shall be equal to 100% of the area of the pipe to which the valve is connected.
- 19) Check valves shall conform to BS 5154 or BS EN 13789 and shall be non-slamming, fully guided, spring closed type and silent operating.
- 20) Float valves up to 50 mm nominal bore shall confirm to BS 1212, of the "Portsmouth" type for high pressure duty; floats shall be of copper to SANS 752.
- 21) Above 50 mm nominal bore, balanced pressure float valves with flanged cast iron bodies, as VOSA Fig 730054 shall be used. These valves shall have a stilling pipe fitted to the outlet, with anti-syphoning hole above overflow level.
- 22) Drain cocks shall be of the screw and/or bolted down tapered plugs plug type. Plugs shall be tapered and ground into the body to form a tight seal under pressure. They shall be suitable for hose connection at outlet.
- 23) Gauge cocks on chilled and condenser cooling water shall be of the straight pattern, ground plug type with a lever handle.
- 24) Pressure relief valves shall be of the totally enclosed spring-loaded type with padlock and easing lever. The outlet shall be piped to the visible position where discharge will not cause damage or injury.
- 25) Schedule of Valve Applications

Table 6-2 Valve applications

TYPE OF VALVE	SIZE LIMIT	ISOLATION	BALANCING	POWER OPERATION	POSITION INDICATION	SPECIAL PURPOSE

Copper alloy gate valve	Up to 50mm	Yes	No	No	Rising stem type only	
Cast Iron gate valve	Over 50mm	Yes	No	Yes	Rising stem type only	
Diaphragm		Yes	No	On-Off	Yes	Drip
Butterfly		Yes	No	On-Off	Yes	Drip free
Sphere		Yes	Yes	On-Off		Combined stop and balance
Globe		Yes	Yes		Rising stem only	
Lubricated plug cock		Yes	No	Requires high torque	Yes	Gas tight
Special globe or plug valve		Yes	Yes	Yes	Yes	Combined/S top balance (and measure)
Special globe or plug valve		No	No		Yes	Proportional control
Special sleeve valve		No	No	Yes	Yes	Proportional control
Ball valves	Up to 65	Yes	No	No	No	No

6.9 Hanger and supports

- 1) Hangers for steel pipes shall conform to [obsolete – not replaced] BS 6700 or BS EN 806-2 where applicable.
- 2) Provide anchors and guides for all horizontal and vertical piping for proper control of thermal movement to prevent undue strain on branches and equipment and to provide proper performance of expansion joints and loops.
- 3) Provide all additional steel framing required for proper support, handling, anchoring and guiding of piping.
- 4) Hangers and supports shall be designed to support the full weight of piping, coverings and fluid conveyed.
- 5) All flexibly supported piping shall be sway-braced without interfering with thermal movement of piping.
- 6) Hangers and supports shall allow adequate adjustment.
- 7) Pipes of small and medium bore shall be supported by means of compatible clamps, clips, holder bats or hangers in the manner and at the maximum spacing laid down in BS 6700.
- 8) For larger piping, the proposed methods of supports shall be shown on the Sub-Contractor's drawings, for approval.
- 9) Provide additional hanger supports at vertical or horizontal changes in direction of piping, and at locations of concentrated loads due to valves, strainers, separators meters and other accessories.
- 10) Pipe hangers shall be of the springlex - positionable type.
- 11) Contact of dissimilar metals shall be avoided. Mild steel piping shall have steel contacts, galvanised piping shall have galvanised contact and copper piping shall have copper, plastic or copper alloy contacts.
- 12) Multiple pipe supports for pipes of differing sizes shall be spaced at intervals to the requirements of the smallest pipe.

- 13) Branches from risers shall not be used as a means of support for the riser, and shall be sufficiently flexible to absorb thermal movement.
- 14) All insulated piping shall be supported outside insulation at hangers as follows:
- a) Up to 50 mm bore : 1,25 galvanised steel shield
120 ° arc, minimum 0,3m long.
 - b) 65 to 150 mm bore : 2 mm galvanised steel shield
120 ° arc, minimum 6 diameters long.
- 15) The following is a schedule of the maximum permissible spacing between pipe supports for horizontal piping:-

Nominal Pipe Size (mm)	Support Space Metres	
	Steel Pipe	Copper Pipe
15	2,0	1,00
20	2,5	1,50
25	2,5	2,00
32	2,5	2,50
40	3,0	2,50
50	3,0	2,50
65	3,0	
80	3,5	
100 - 150	4,0	
200 - 400	5,0	
450	6,0	

6.10 Flexible connections

- 1) Flexible connections shall be of a reinforced rubber type with flanged ends suitable for the maximum working pressure and shall be selected for a 15 year life span.
- 2) Hoses shall be resistant to water treatment chemicals and seating, pressure shock and sweating.
- 3) Hoses shall be factory tested to 2.5 times the working pressure.
- 4) Hoses shall be stainless steel reinforced.
- 5) Suppliers shall guarantee hoses for at least 5 years.
- 6) Hoses shall be insulated with Armourflex.

6.11 Sleeves and plates

- 1) These shall be provided for building in by Principal Contractor for pipes passing through walls, partitioning and building structure.
- 2) Sleeves shall be not less than 5mm larger than the piping and its covering, if any.
- 3) Sleeves shall extend through the full depth of construction including final finishes.
- 4) Sleeves and packings through fire walls shall be in accordance with NFPA requirements and all authorities having jurisdiction, and shall have a fire rating at least equal to that of the structure in which they occur.
- 5) Sleeves in concrete work shall be flanged at the bottom or provided with temporary centring cap and securely nailed or screwed to shuttering.
- 6) Such sleeves will be placed by others, but the Sub-Contractor shall satisfy himself that all sleeves are correctly positioned and rigidly fixed, before concrete is poured.
- 7) Sleeves shall be of zinc-coated steel not less than 1,5mm thick, or of pitch fibre, asbestos cement, or heavy duty PVC piping.
- 8) Sleeves through exterior walls shall have "puddle" flanges, and the gap between sleeve and pipe shall be waterproofed by means of hemp and lead, or epoxy resin.
- 9) Exposed vertical pipes passing through floor shall be provided with floor plates and where ceiling is finished with ceiling plates. Pipes through waterproof floors shall be 'flushed' as specified below, for pipes through roofs.
- 10) Horizontal exposed pipes passing through finished walls shall be provided with wall plates.
- 11) Wall and ceiling plates may be split, and shall be securely fastened to the pipes or to the sleeves.
- 12) Sleeves in fire walls shall be packed with asbestos cotton, fibrous glass, or other approved incombustible material.
- 13) Pipes passing through roofs shall be "flushed" by a cowl fixed to the pipe overlapping and waterproof sleeve the top of which is at least 50 mm above top of roof covering.

6.12 Installation

- 1) The Sub-Contractor shall properly cap all open ends during installation so as to prevent the entrance of sand, dirt, etc.
- 2) The Sub-Contractor shall ensure that piping is clean, straight and free of defects before welding, insulation or painting.
- 3) Pipes shall be reamed after cutting and shall be free from burrs, rust and scale.
- 4) System components which do not function properly because of insufficient cleaning of the water piping system shall be replaced.
- 5) Pipes shall be cut accurately to measurements established on site and worked into place without springing or forcing, except that expansion of hot pipes may be (partly) allowed for by pre-calculated "cold springing" during installation.

6.13 Pressure tests

- 1) The system shall be filled, and air vented at least 24 hours before the actual test pressure is applied. The piping system shall be tested to a hydrostatic pressure of at least 1,5 times the maximum operating pressure but not less than 700 kPa.
- 2) The system shall maintain the test pressure for a minimum period of 2 hours without pumping.
- 3) A satisfactory pressure test will not absolve the Sub-Contractor from responsibility for leaks, which develop when the piping is operating under its normal working conditions, and also under any abnormal conditions, which may reasonably be expected to occur.

7 Refrigerant Piping

- 1) During the welding of refrigerant copper piping, a small amount of nitrogen must be passed through the pipes to avoid flaking of the inside of the piping.
- 2) Brazed joints shall be used instead of screwed or flared joints. The number of joints shall be minimized.
- 3) All refrigerant piping shall be well saddled and secured to minimize vibration of piping.

- 4) All pipes shall be de-burred and cleaned after being cut. Only circular pipe cutters shall be used, no sawing of pipes shall be allowed.
- 5) Pipe benders, flaring and swaging tools shall be used.
- 6) Sizing of refrigerant piping shall be done according to air-conditioning unit manufacturer's requirements, taking into account equivalent pipe length and height difference between evaporator and condenser.
- 7) All refrigerant piping must be pressure tested at 20% above operating pressure, using nitrogen and the refrigerant that will be used in the system. The system pressure must be observed, and any reduction in pressure means that there is a leak in the system. An approved leak testing method must be used to find leaks. After leak repair, the pressure test must be repeated.
- 8) All refrigerant piping systems are to be evacuated with a vacuum pump, to a pressure of 40 to 45 microns (electronic vacuum gauge). A two-stage vacuum pump must be used specially designed for this purpose.
- 9) The manifold valves shall be closed off and vacuum observed for at least 2 hours. If there are no movement on the gauge, then there are no leaks or moisture in the system. Gauges will indicate between -80 and -100 kPa.
- 10) If the vacuum reading moved above 45 microns in 2 hours, the system must be checked for leaks or further vacuum pumped to remove moisture.
- 11) Records of pressure testing and evacuation of each refrigerant piping systems must be kept and submitted to the mechanical engineer.

8 Electrical Systems

8.1 General requirements

- 1) The installation in its entirety shall be designed, engineered, installed and rendered serviceable in complete accordance with the following:
 - a) South African Bureau of Standards, Code of Practice 10142-(latest) for the Wiring of Premises.
 - b) All by-laws and ordinances of the relevant supply authorities.

- c) Any particular requirements of this specification and drawings attached hereto.
- d) The performance of the equipment offered shall be suitable for operation under the parameters detailed for:
 - i) Site Connections
 - ii) System Details
- 2) Any deviation from this specification shall be conditional upon the written approval of the Architect or his appointed representative.
- 3) The Sub-Contractor shall employ the services of an electrical specialist who shall be responsible for the application, engineering, documentation, supply, installation, commissioning and maintenance of the electrical system.
- 4) The installation in its entirety shall be in full conformity with the requirements of the local by-laws, supply authorities and with the requirements of all further authorities having jurisdiction.
- 5) Material and apparatus shall be in accordance with the relevant SANS or BS Standards. The former shall have precedence over the latter when both bodies have issued conflicting specifications or Codes of Practice.
- 6) The Sub-Contractor shall secure approval of all authorities as required for materials, equipment and installation.
- 7) The Architect or his representative reserves the right to call for test certificates and characteristic curves of every item of equipment to prove compliance with the standard to which it is built and to prove compliance with the specification regarding performance.
- 8) Test certificates shall be issued by a recognised testing authority and shall be submitted at the time called for.
- 9) Every care shall be taken to protect material, either fixed or unfixed, from damage.
- 10) All items shall be protected against the ingress of dust and moisture, so that no damage results to items and systems. All large items, requiring removal and exceeding 25 kg in weight, shall be fitted with lifting lugs or eyes.

- 11) All items of equipment mounted outdoors, equipment in air handling units and equipment mounted in a wet or possibly wet environment, shall be weatherproof.
- 12) Supply and installation shall include all equipment detailed on the approved shop drawings and wiring diagrams.
- 13) Commissioning shall include the validation of the systems as detailed on the shop drawings and wiring diagrams, and demonstrating that the electrical system does in fact provide the sequence of operation, control and safety operation as detailed on the approved wiring diagrams.
- 14) In addition, commissioning will involve the close co-operation of the electrical specialist contractor with the Sub-Contractor and operation and automatic control system contractor in adjusting the electrical system to provide the results intended.
- 15) The equipment, such as the starters, contactors, relays, etc., used in the electrical installation shall; be fully catalogued products and documentation shall include installation, testing, maintenance instructions and performance curves or selection tables for the expected range of operational conditions.
- 16) Methods of recording and presentation shall be suitable for incorporation in the Operating and Maintenance Manual, and for display in the plantrooms.
- 17) All items of the electrical installation shall be readily accessible for quick and easy replacement.
- 18) Adequate space shall be provided around all items for easy removal or parts.

8.2 Cabling

- 1) Particular care shall be taken with the selection and installation of cables to ensure that all parameters such as environment, fault level, voltage drop and group de-rating factors are given full consideration.
- 2) Precaution shall be taken to prevent the ingress of water into cables.
- 3) Bending radii for cables shall be as large as possible. No radius shall in any event, during installation or when permanently installed, be less than the following:
 - a) 11 000 V grade : minimum 17 x Outside diameter

- b) 3 300 V grade : minimum 17 x Outside diameter
 - c) 600/1 000 V grade : minimum 10 x Outside diameter
- 4) Where cables are clamped, cleated, strapped or bound to racks, the Sub-Contractor shall ensure that no sagging occurs, and that the pressure exerted by these fixing devices is not detrimental to the cable performance. Cables shall be clamped, cleated, strapped or bound to racks when in a vertical disposition at intervals not exceeding 0,5 metres whilst horizontally disposed cables shall be secured at intervals not exceeding 3 metres.
 - 5) Care shall be exercised in the laying of the cables to prevent excessive crossing.
 - 6) All cables shall be adequately supported during their installation to prevent undue internal stresses, particularly in the vertical configurations.
 - 7) Each and every cable shall have permanently attached to it, at each end and at every 10 metres throughout its length, a label to exclusively identify the cable. The label shall be of the light gauge alloy, adhesive backed, "Dyna" type.
 - 8) The characters embossed upon these labels shall be of a minimum of 3 mm high and shall correlate to the relevant cable number as depicted on the cable schedules.

8.3 Terminations

- 1) All terminations shall be carried out in a neat and orderly manner, particular care being taken to ensure that armourings form an effective earth path with all gland lock nuts, etc., being adequately tightened. Gland shrouds shall be fitted. All control cable cores shall be effectively identified by means of ferrules, the number correlating to the relevant inter-connection on the wiring diagram.
- 2) Where control connections are collectively marshalled in a common box, particular care shall be taken to ensure neat and orderly wiring looms with no undue crossing at the "crutch" points. Conductors shall be fitted with a "crimp type spade ferrule, before being inserted in the terminal box. The Sub-Contractor shall check that marshalling box identification labels correlate to the relevant diagrams.

8.4 Cable Testing

- 1) Upon completion of the installation of the cables, prior to actual termination, each and every cable shall be effectively tested for insulation breakdown and core continuity.

- 2) All cables shall be effectively tested for insulation breakdown with a 2 kV "Megger". Core and earth continuity tests shall be carried out.
- 3) Where control and power cables are terminated within equipment, every precaution shall be taken to ensure that the conductors are correctly terminated, to obviate cross connections of the power and control circuits.
- 4) All power connections to motors shall be checked, prior to dry running of machines, to ensure that the directional requirements of the equipment are correct.
- 5) All lugs fitted to cables shall be selected to ensure a good joint. Oversized holes and crimp tubes shall not be acceptable.
- 6) Lug barrels shall be sleeved where it is apparent that loose connections on motor/equipment studs could come into contact with each other or 'earth'.
- 7) The specialist Contractor shall ensure that all 'lock nuts' on equipment terminals are replaced and tightened.
- 8) Where it is apparent that vibration of equipment will occur, a loop of sufficient length shall be left between the static cable side and the equipment connection point.

8.5 Motors

- 1) Motors shall be liberally rated for the duty with due allowance made for temperature, altitude and possible variations in voltage. Motor ratings shall however, not exceed 120% of the required capacity.
- 2) Motor ratings shall not only be based on the full load requirements but motor capacity and starting characteristics shall be compatible with the requirements of the driven equipment. Motors shall be current catalogued products, preferably of South African Origin, and documentation shall include performance curves for expected range of operational conditions.
- 3) Motors shall comply with SANS 948, BS 2613 and/or BS 170 or other applicable standards of their country of manufacture.
- 4) Motors shall be protected against:

- a) Overloads - provide adjustable thermal overload protection in all three phase legs capable of positive tripping at full load.
 - b) Single phasing - provide single phasing protection operative down to 45% of motor rating, independent of overload setting.
 - c) Phase rotation relay shall ensure that when phase rotation is altered the motor shall not start-up.
 - d) Short circuit - MCCB for starter back-up protection and motor short circuit protection.
 - e) Motors in excess of 200 kW rating shall embody a device which directly monitors the winding temperature for the class of insulation employed.
- 5) All motors shall be equipped with power factor correction to a P.F of no less than 0,95 lagging under the operating conditions.
 - 6) Motors shall normally be of the totally enclosed fan cooled type.
 - 7) All motors of the air conditioning installation shall be of the same make or of the same interchangeable frame type. Variation in type and size shall be limited, wherever possible, to avoid duplication of spares.
 - 8) In case of imported motors on equipment not kept in stock in South Africa, one spare motor for each 10 of the same type and size of motor shall be supplied to the building owner.

8.6 Switchgear

8.6.1 Definition

- 1) Fault level - The specified design fault level shall be deemed to be the symmetrical fault power available under short circuit conditions to the incoming terminals of the switchgear and subsequent interrupters, conductors, current transformers and the line side of the limiting device.
- 2) Fault duration - Shall be considered as the maximum period for which the equipment will be subject to the abovementioned fault condition. For the purpose of this specification, the period of fault duration shall be assumed to be equal to one second.

8.6.2 Design

- 1) Whilst all equipment shall be designed and manufactured in accordance with the aforementioned standards and accepted codes of practice, the following practices may be adopted providing that the vendor submits full details of his proposals.
- 2) A control bus capable of being open circuited via an emergency stop operated relay shall be employed where an isolator is employed as an incoming device. This system shall be fail safe.
- 3) Where circuit breakers are employed, the 'Emergency Stop' shall cause a shunt trip mechanism to function.

8.7 Switchboards

Refer to detail distribution board specification.

8.7.1 Motor Starting Circuits

- 1) All line components associated with motor starting circuits shall have a rating at least 10% higher than the maximum imposed loads and in addition shall be rated for:
 - a) Over currents anticipated during the operating time of its own overload tripping device.
 - b) Fault currents (left through) by the circuit back-up protection device with due regard to the clearance time.
- 2) In starters employing more than one stage the changeover from initial to subsequent stages shall be automatic. Contactors shall be interlocked to prevent starting in the incorrect stage.
- 3) All motor starting contactors shall be fitted with thermal overload tripping devices with single phasing or differential characteristics.
- 4) Protective tripping device shall be of the manual reset type and shall provide for protection under all conditions of motor operation. The overload tripping device shall be adjustable within a range of 75 to 125% of motor rating. Alternative protection by electronic means incorporated overload trips and single-phase protection will be considered subject to approval.
- 5) Starters and contactors shall be current catalogued products and documentation shall include full performance data.

- 6) The following equipment or approved equal shall be used:
 - a) Sprecher and Schuh
 - b) Siemens
 - c) Telemecanique
 - d) Klockner Moeller
 - e) Allenwest
 - f) MTE
 - g) Cutler Hammer
 - h) Schneider
- 7) Starters mounted separately shall be of the duct, damp, vermin proof and totally enclosed metal clad type.
- 8) Each starter or contactor shall be complete with 3 current transformers for the ammeters in the integrated control panel. The ammeter shall be sized for the motor rating which shall not exceed 75% of the scale and be less than 25% of the scale. The ammeter shall be suitable to withstand the starting current and any fault current. Unless otherwise indicated, motors of 20 kW or more shall have Star Delta rating.
- 9) Starter and contactors shall have auxiliary contacts for remote fault condition, and status indication and interlocking required for the sequence of operation as specified.
- 10) The starter or contactor shall be so constructed and installed that either a sub-component replacement or total removal and re-installation of the entire starter or contactor will not take longer than one hour by a skilled electrician.
- 11) Wherever technically possible, all starters or contactors or relays shall be of the same make or type and size to reduce the number of spares.
- 12) The Electrical Contractor shall supply one spare contactor and relay for each 5 items of the same type and size.

- 13) Suitable section brass studs and lugs shall be supplied at both ends of the switchboard for incorporation into the earthing system.

8.8 General

8.8.1 Labels

- 1) Client specific requirements take precedence
- 2) Main designation labels shall be fitted to the centre of each complete MCC or distribution board.
- 3) Each cell or compartment shall have its function or reference indicated by a label. A circuit breaker supplying power for secondary services shall be separately labelled, and all power circuits shall be labelled with their relevant references.
- 4) Control circuit breakers, indication lamps and pushbuttons and other similar control devices shall be labelled in accordance with their respective functions.
- 5) Labels shall be of the engraved white on black Traffolyte type, and shall be affixed by self-tapping screws or a suitable adhesive.
- 6) Character sizes for the various labels will be as follows:
 - a) Main Labels : 25 mm
 - b) Cell, Circuit or Compartment labels : 12 mm
 - c) All other labels : 4 mm

8.8.2 Plenum Lights

- 1) Lights consisting of watertight bulkhead type fittings shall be provided in each section of the air handling plenum including the air washers.
- 2) The light shall be controlled by a switch on the outside of the plenum and on/off position indicated by a pilot light.

9 Instrumentation

- 1) The equipment and/or sub-system supplier/assembler shall provide under the overall responsibility of the air conditioning HVAC Contractor, all permanently installed instrumentation necessary for logging and monitoring of status and performance of equipment and components.
- 2) All instruments shall be of such dimensions and mounted in position so that they are easily and accurately readable by an operator standing on the floor.
- 3) Test instruments shall be checked for accuracy by the manufacturer or by an approved laboratory with certificates being submitted prior to site tests, showing the degree of accuracy over a life of 15 years.

9.1 Temperature Indication

- 1) All thermometers and temperature reading devices (direct reading or switched) shall 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.
 - a) Stem thermometers shall be approximately 150 mm long and dial type thermometers approximately 80 mm diameter.
 - b) Wells shall be set vertically or at an angle to retain oil. Pipes smaller than 80 mm bore shall be enlarged at points where wells are installed as per following table:

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

- c) The sensor element shall be at the centre of the pipe.

9.2 Pressure Indication

- 1) All dial pressure gauges shall be snubbed or glycerine filled to prevent pointer vibration. Gauges shall have an accuracy of 2%. The range shall extend to 150% of the maximum operating pressure.
- 2) All inclined manometer differential pressure gauges shall have an accuracy of 2%. The range shall extend to 150% of the maximum operating pressure, with graduation being in steps of 10 Pa.

- 3) All differential dial pressure gauges shall have an accuracy of 2% and shall not be less than 100 mm diameter. Zero pressure reading shall be in the centre, and the range of scale on either side shall extend to 150% of the maximum operating pressure, with provision being made for individual pressure reading.

9.3 Hygrometers

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

9.4 Flow Meters

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

9.5 Safety and Automatic Control Systems

- 1) Note that the sequence of operations document takes precedence.
- 2) The safety and control equipment for all sub-systems located in plantrooms and enclosures and as shown on the control schematic drawings shall be supplied by the equipment and/or sub-system supplier/assembler under the overall responsibility of the air conditioning sub-contractor.
- 3) All control equipment for the various sub-systems shall be supplied by a reputable firm properly established in country which has a proven track record of at least five years and which can demonstrate the reliability of the control systems offered.
- 4) The control systems as indicated on the control drawings shall include all controllers and controlling devices, specified or implied, to perform specified functions.
- 5) The control devices with their control action, performance and safety settings shall be installed and connected to perform the functions and operate in their required sequence as detailed on the control drawings.
- 6) At the time of equipment submission, the sub-contractor shall provide complete documentation for each component or assembly of components in the sub-systems.
- 7) The installation in its entirety shall comply with regard to electrical safety and supply interference suppression requirements, with SANS and/or local authorities by-laws, and/or Post Office regulations.

- 8) The equipment shall be so constructed, and components installed and connected and required spares available so that the maximum breakdown interference due to component replacement will be limited to one hour.
- 9) All items of the installation shall be readily accessible and connected for quick and easy replacement. Adequate space shall be provided around all items for easy removal of parts.
- 10) Every care shall be taken to protect material, either fixed or unfixed, from damage, ingress of dust and moisture. The entire installation shall be in "as new" condition at handover.
- 11) Each controller and control device for all sub-systems in plantrooms and enclosures shall be provided with instruments (pressure gauges, volt meters, pilot lights, etc.), to show at the controller or control device location, the condition of the power supply to the controller and control device, and the point within its control range at which the controller or control device is operating.
- 12) For equipment mounted in control panels, individual permanently mounted instruments may be supplied, or a single instrument may be mounted on each panel and provided with a suitable switching means to permit connecting the instrument to any controller on the panel. The panel instruments may also be arranged to connect to individually mounted equipment in lieu of portable instruments.
- 13) At each controller for which portable instruments are to be used, means shall be provided for attaching and disconnecting the instrument without the use of tools (other than for removal of covers) and without breaking control lines.
- 14) Pressure gauges for individually mounted controllers shall be stem mounted, 40 mm large in diameter, with black finished cases. Individual gauges for panel mounted controllers shall be 50mm in diameter with black or plated finish. Gauges for multiple indication or panel mounted controllers shall be 120 mm in diameter, with black or plated finish.
- 15) A thermometer pocket shall be installed at or near each insertion thermostat, located so that a calibrated thermometer inserted there will accurately indicate the temperature surrounding the sensing element of the thermostat.

9.6 Operation and Automatic Control Systems

- 1) The sub-contractor shall employ an automatic control contractor who is well established, is reputable and who shall be responsible for the design, engineering, documentation, supply, installation, commissioning and maintenance of an automatic control system to implement the sequence of operation as shown on the drawings.

- 2) All control equipment shall be supplied and installed by one firm.
- 3) Commissioning shall include the validation of the system as detailed on the drawings and shall prove that the system provides the sequence of operation shown on the drawings.
- 4) Include all compressors, transformers, piping, wiring, dampers, motors, valves, thermostats, humidistats, pressure controllers and other control devices to perform the specified duties.
- 5) The system shall be of the electronic type.
- 6) All controls shall be fully protected and shall be fail safe.
- 7) Submit:
 - a) Performance graphs, and engineering and selection details, selection points, setpoints differential and throttling ranges etc.
 - b) Installation, testing balancing and commissioning instructions.
 - c) Trouble Analysis Guide.
 - d) Maintenance instructions.
- 8) The system shall be engineered, and components selected for a minimum service life of 15 years with 3000 operating hours per annum.
- 9) All items shall be readily accessible for quick and easy replacement and maintenance and adequate space shall be provided.
- 10) All spares shall be readily and locally available.
- 11) The system shall conform with all local by-laws and suppression requirements of SANS or Department of Post and Telecommunication requirements.
- 12) Materials shall conform with SANS or BS.
- 13) Special care shall be taken in transport, delivery, storage on site and installation to ensure the system is "as new" at start-up.
- 14) Install instruments as shown on the control schematics.

- 15) Portable instruments shall be attachable and detachable without the use of tools.
- 16) Pressure gauges shall be suppressed, or glycerine filled. Minimum diameter shall be 50 mm.
- 17) A thermometer shall be installed on or near each duct pipe and tank mounted thermostat and located so that it will indicate accurately the temperature surrounding the sensitive element of the thermostat. Thermometer scales shall be right side up and located where they can be easily be read, by a man standing on the floor.
- 18) Thermometers shall be of the mercury, red liquid, vapour pressure, liquid filled or electric resistance type.
- 19) Remote transmitters having an accuracy of 0,5°C shall be provided for thermometers if remote transmitters are furnished for the corresponding thermostat.
- 20) Separate sockets shall be provided for thermometers installed in pipes and tanks.
- 21) Thermometer ranges shall be suitable for the service, generally not less than 15 °C above and below the thermostat settings.
- 22) Separate thermometers will not be required in connection with industrial type indicating or recording controllers.
- 23) Where two or more temperature indications are required on a panel, either individual continuous indication, multi-point single dial indication with selector, or a combination of both may be furnished.

9.7 Control Panels

- 1) Each sub system, as defined on the control drawings, shall be provided with their individual control panels. Sub systems include chillers, master chiller control, rooftop fan filter units, CRAC units etc.
- 2) Instruments, operating and adjusting mechanisms specified and as shown on the control drawings, and all controllers, relays, switches, indicators, instruments, voltmeters, ammeters, hour meters, control push buttons, etc. connected with the sub system shall be mounted on the panel.
- 3) All panels shall be totally enclosed, dust, damp and vermin proof. Panels shall be free standing floor mounted.

- 4) The Contractor shall note whether rear access to the board is available. In cases where no rear access is possible the panels shall be designed to enable all connection to be made and for all component parts to be accessible from the front.
- 5) All operating mechanisms, switches, etc. shall be mounted on hinged panel doors. Wiring, tubing shall be so disposed at the hinged side of the door to facilitate that opening and closing does not impose stress on wiring.
- 6) All small power and control wiring to external circuits shall be wired or tubed to numbered terminals.
- 7) Terminal blocks shall be suitable for mounting on standard channels and shall include at least 12 spare terminals for future extensions.
- 8) The channels shall be long enough to accommodate wiring and tubing for the said 12 spare terminals.
- 9) Each piece of equipment, instruments, etc. on the panel door or in the panel shall be identified by a nameplate and coded as shown on the sub system operation drawings.
- 10) Each panel shall be complete with mimic diagrams of the "sub system schematic" and "operating sequence" as indicated on the control drawings. The mimic diagrams shall be printed on high quality, non-deteriorating boards and framed behind non reflective clear Perspex. The control drawings shall be printed on non-deteriorating plastic sepias and framed behind non reflective clear Perspex on the writing top.

10 Equipment submittal

- 1) The contractor shall compile and submit three (3) booklets of the equipment selection and submittal to the Consulting Engineer within two weeks after appointment for approval.
- 2) The equipment submittal booklet shall consist of:
 - a) Cover page stating the project name, the client, the consulting engineer and the contractor with contact persons and details
 - b) The index page stating the contents and sections of the submittal with page numbers
 - c) General: a brief description of the project and the equipment offered

- d) Introduction: brief history of the contractor, experience, personnel proposed for the project with brief CV and project photos where the equipment proposed was used.
- e) Table of the equipment capacity of all equipment contained in the submittal showing the following:
 - i) Design conditions
 - ii) Equipment name and designation
 - iii) Area served
 - iv) Operating capacity
 - v) Dimensions (length, width, height and weight)
 - vi) Starting current, running current and voltage
 - vii) Noise level
 - viii) Compliance with specification
- f) Detailed of the equipment offered (this section is to be repeated for every single item of equipment offered).
- g) General: name of equipment offered, previous project where equipment was used with reference from the client
- h) The Equipment: all technical specifications, photos where applicable, service interval and estimated operating life in years of the equipment. The technical specifications as a minimum shall state:
 - i) Capacities
 - j) Material of manufacture and type of finishes
 - k) Make
 - l) Model number

- m) Manufacturer details
- n) Estimated delivery date
- o) Noise levels
- p) Operating conditions and performance curves where applicable
- q) Compliance with specifications
- r) Electrical requirements and loading
- s) Energy efficiency measures of the equipment offered
- t) Any special sustainable design and details included in the equipment
- u) The completed schedule of information in the tender document
- v) Manufacturer's catalogues
- w) Control system and electrical schematics for the equipment
- x) Any other relevant information
- y) Motivation for the proposed equipment
- z) Conclusion
- aa) Approval page for signature and date:
 - i) The contractors name and responsible person signature
 - ii) The consulting Engineers name and responsible person signature
 - iii) The client's signature and responsible person
 - iv) Approval stamp by consulting engineer.

11 Temporary use of equipment

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

12 Testing, balancing and commissioning

- 1) The client specific commissioning plan requirements as well as the requirements put out in the MEP general specification are to be adhered to.
- 2) Comprehensive pre-commissioning, commissioning as well as quality monitoring shall also be done on all the mechanical systems in a systematic manner and in exact accordance with CIBSE Commissioning Codes, as follows:
 - a) CIBSE Code A – Air Distribution.
 - b) CIBSE Code C – Automatic Controls.
 - c) CIBSE Code M – Management.
 - d) CIBSE Code R – Refrigerant Systems
 - e) CIBSE Code W – Water Distribution

12.1 Flushing

CIBSE flushing requirements shall be adhered to.

12.2 Tolerances

- 1) The indoor climate factors and air flow rates, heating, cooling and humidifying performances, electrical characteristics and other design data shall be measured at the ventilation system design air flow rate.
- 2) Tolerances of the measured values in respect of the selection of the measuring equipment are given in the following table:

Table 12-1 TAB tolerances

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

Air temperature in occupied zone	$\pm 1,5^{\circ}\text{C}$
A-weighted sound pressure level in the room	$\pm 3 \text{ Dba}$
* The uncertainties include the permitted deviations from the design values as well as any measuring error.	

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

13 Monitoring

- 1) The entire HVAC system shall be monitored on a **monthly basis** for a period of one year after practical completion. The monitoring process shall include:
- a) Verification that the systems are performing to their design potential during all variations in climate and occupancy.
 - b) Optimization of time schedules to best match occupant needs and system performance.
 - c) Alignment of the systems' operation to the attributes of the built space they serve.
 - d) The monthly monitoring outcomes shall be reported to the Project Engineer and Client on a quarterly basis (every three months) to allow corrective action to be taken. Corrective actions to the system shall be performed as stipulated by recommendations of the Project Engineer and Client.

14 Insulant ODP

- 1) All thermal insulation for pipes and ducts shall have no ozone-depleting substances (zero-ODP) associated with either the manufacture or composition of the product. Fibre-based woven insulation products (e.g., glass fibre, mineral wool, polyester etc.) and foil insulation which are not manufactured by using blowing agents may be used.
- 2) It is the Contractor's responsibility to maintain and submit the following documentation:

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

SECTION 4: COMPUTER ROOM AIRCONDITIONING UNIT SPECIFICATION

1 Introduction

This specification is to be read in conjunction with General specification forming part of this data pack.

- 1) This document provides the proposed scope, brief, project principal design, equipment, supply, testing, commissioning and documentation for supply of the chilled water CRAC units in the data halls and the UPS room, as well as the supervisory controllers (SC) for this project.
- 2) The requirements are for the supply and installation of chilled water CRAC and UPS units to support the current and future cooling loads and control to the areas mentioned.

1.1 Objectives

1. The intent of this specification is to:
 - a) Define the priorities and objectives that shall guide the design & documentation decisions.
 - b) Define the technical requirements for the equipment, installation, testing, commissioning & documentation.
 - c) Equipment requirements
 - d) Preparation of documentation
 - e) Factory Acceptance Testing
 - f) Delivery of equipment
 - g) Commissioning of equipment

1.2 Scope delineation

1. The following table confirms the scope of the supplier's responsibilities:

Table 1-1 Scope delineation

Delineation				
Item	Description	Responsible Contractor		
		Electrical	HVAC	Supplier
1	Manufacture, supply, deliver to site, offload Hall and UPS CRAC units on site	-	X-	X
2	Locate units in final position	-	X	
3	Manufacture, supply, deliver to site supervisory controller for system	-	X	X
4	Electrical connection to isolator within 1.5m of unit	-	X	-
5	Final piping connection to CRAC, including condensate drainage and chilled water	-	X	-
6	Communication connections to Supervisory controller/ CRAC units	-	X	-
7	Commissioning (as per RACI matrix)	-	X	X

1.3 Programme

Provide a programme of works.

1.4 Warranty

1) The warranty shall incorporate the following:

- a) Warranty means that all patent and latent defects will be rectified by the Supplier arising from defective materials, workmanship or design at his expense during the warranty period.
- b) Warranty excludes defects that may arise from the misuse or abuse by the Employer.
- c) Servicing of the unit is to be conducted during continuous operation, when the unit is in cold standby mode.

2 Design requirements

2.1 Industry Standards & Guidelines

1. All work shall meet all the requirements of national and local Statutory Authorities and shall be in accordance with the following:

Table 2-1 Industry standards

Standard Number	Description
ASHRAE 90.4	Thermal energy standard for data centres
ASHRAE TC9.9	Data centre powered equipment thermal guidelines best practices
SANS 10400	South African National Standards
OSH Act 1993	The occupational health and safety act of 1993, as amended
SANS 10142	Wiring of premises
	Government, Provincial and Local authorities' ordinances, regulations, by-laws, rules and other statutory requirements
SANS	Specifications and codes of practice issued by the South African Bureau of Standards and British Standards Institute. The former shall have precedence over the latter where both bodies have issued conflicting specifications or codes of practise.

3 Specification – CRAC units

3.1 General

- 1) The scope of equipment supply required as detailed in this specification is as follows:
 - a) A total of nine (9) chilled water top entry down-blow CRAC units for the data halls.
 - b) A total of two (2) chilled water side blow, top return CRAC units for the UPS room.
- 2) All chilled water CRAC units installed will form part of the secondary cooling water loop.
- 3) The equipment shall be designed such that all parts can be reached and replaced easily without affecting any other parallel systems. This shall be achieved taking cognisance of the fact that no work can be conducted on live equipment.
- 4) The plant will need to comply to Uptime Institute Tier III type requirements.

- 5) The tender shall meet the quality, functional and performance requirements of this specification.

3.2 Cooling Plant Arrangement

- 1) The cooling solution for the data halls is as per the data hall layout drawings. There is a 1 meter deep raised floor in the data halls.
- 2) The UPS room cooling solution is as per the UPS room layout drawings. There is no raised floor in the UPS room.
- 3) The cooling systems are designed to function in a N+1 configuration for the data halls. In the UPS rooms both units will operate simultaneously with no N+1 configuration.
- 4) The CRAC units are to be connected to a Supervisory Controller (SC), 1 controller per data hall area, which is to be included in the scope of the supply. These will function as the primary control to the data hall CRAC units via inputs from the data hall sensors and equipment. It will also be the primary communication to the future BMS to be installed.
- 5) Equipment shall be designed such, that all parts can be reached and replaced easily without affecting any other parallel systems. This shall be achieved taking cognisance of the fact that no work can be conducted on live equipment.
- 6) See included drawings for further reference.

3.3 Construction

3.3.1 General

- 1) The Air Handling Units should be designed and constructed to have an effective design life of 20 years. The units are to be constructed to operate in an indoor environment continuously. The units will provide process cooling to critical infrastructure and be constructed of high quality materials. Maximum availability, energy efficiency and continuous year-round operation is required for the application.
- 2) The units are to be selected to maximize capacity, minimize footprint and maximize efficiency.
- 3) All accessories and equipment shall be built to a high quality standard to minimize maintenance costs and reliability issues during life of the equipment

- 4) Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory. Certified detailed selection shown on these performance curves and tables shall be submitted.
- 5) The unit shall have capacity control to vary its capacity in response to varying load conditions.
- 6) Units shall be complete with the following per unit:
 - a) Cooling water coil
 - b) 2-way modulating pressure independent control valve (energy valves) located on the **outlet side** of the chilled water coil
 - c) Onboard powered motorized isolation valve on the **inlet side** of the chilled water coil. This valve, along with the modulating PIC valve must be pre-programmed to close upon unit leak detection
 - d) Leak detection systems x 2 off per unit
 - e) Non return valve on the outlet side of the units
 - f) EC supply air fans capable of variable air flow
 - g) Source selector (ATS)
 - h) All controls and control panels
 - i) BMS interface and points list
 - j) Supervisory controller interface
 - k) Master / slave control at 1 per 5 or other proposed by Supplier with master controlling the fan speeds of the slave units
 - l) CRAC unit sensors (standard supply air, return air, delta P, CHWS, CHWR, chilled water flow etc.). In addition, two calibrated temperature and two calibrated pressure sensors to be supplied with each CRAC unit. The unit must have available ports for these to be connected to the CRAC unit controller and thus monitored by the future BMS.
 - m) UPS unit sensors (standard supply air, return air, delta P etc.). In addition, two calibrated combination temperature / humidity sensors to be supplied with each UPS unit which will be located as shown on the floor layout.
 - n) Wiring
 - o) Internal piping and valves
 - p) G4 filter
 - q) Associated accessories.
 - r) All other components necessary to make a complete operating unit
 - s) Power factor correction

- t) Power source indicator lights
 - u) Supply temperature reset control.
 - v) Drip tray
 - w) Mesh closures on the back and sides of the raised floor fan outlet
 - x) Adjustable floors stand for 1000mm floor void (Data hall CRAC units only) inclusive of antivibration pads. Floor stands to be hot dipped galvanized or powder coated in the factory.
 - y) Automatic restart after loss of power supply
- 7) The Units should be designed and constructed to have an effective design life of 15 years at 24/7 operation. Maximum availability, energy efficiency and continuous year-round operation is required for the application.
 - 8) All accessories and equipment shall be built to a high quality standard to minimize maintenance costs and reliability issues during life of the equipment
 - 9) The units shall be labelled in accordance with UL or the comparable regional standard and certification agency. Client specific requirements take precedence.
 - 10) Units shall be factory fabricated and tested. The tested units shall include all of the unit sizes, capacities, and configurations, either as indicated or specified in the bid documents.
 - 11) All internal components specified herein or in the schedules or added by alternate price acceptance shall be factory furnished and installed. All of these components shall be part of the units' guarantees. They shall retain the units' applicable required agency and approvals. Units shall be completely factory assembled.
 - 12) CRAC Units shall ship in one (1) piece. If they are too large to ship in one piece, or if shipping them assembled creates an unacceptable breakage risk, the Supplier shall provide, at no additional cost to other parties, the labour and materials to completely reassemble the units on the Owner's jobsite by the scheduled delivery time. The Supplier shall coordinate the onsite work, having provided adequate notice to accommodate other work at the site, with the Owner's construction personnel.
 - 13) All elements vulnerable to harm and easily exposed to maintenance personnel's inadvertent stepping or access interference shall be protected by ridged metal guards capable of accepting the plausible forces without significant temporary or any permanent deflection.
 - 14) Units to come complete with a condensate drain at the lowest point.

- 15) Special care shall be taken in transport, delivery, storage on site and installation to ensure that the units are installed and maintained in 'as new' condition at start-up.
- 16) The unit shall comply with the Occupational Health and Safety Act of 1993, as amended, and with local authorities by-laws.
- 17) Units to come complete with a drain valve at the lowest point to be able to drain to the drain pan.
- 18) CHW Piping connections to be as follows:
 - a) Hall CRAC units – connections from below the unit (in false floor void)
 - b) UPS room CRAC units – connections to be from the side or top of the unit (exposed)

3.3.2 Casing

- 1) CRAC - The frame, cabinet and access panels shall be fabricated from steel/aluminium frame (or alternate approved) and powder coated to approved colour.
- 2) Casing shall not leak, vibrate or drum under operating conditions.
- 3) Casing panels shall be easily removable for access to the interior.
- 4) The unit shall have readily removable front hinged panels or access doors with all serviceable components accessible and removable for maintenance.

3.3.3 Chilled Water Coils and Control Valve

- 1) The chilled-water cooling coil shall be furnished and installed integral to the unit. The coil as configured within the air handling unit shall meet the performance requirements set forth in the schedule and as specified under other sections of this work.
- 2) The coil shall be constructed of copper tubes, aluminium fins.
- 3) The coils shall be attached to the unit and sealed. This attachment shall avoid any air bypassing the unit on the coils' top, bottom, and sides.
- 4) If the coils or any other tubes penetrate the sides of the unit, they shall be positively sealed to prevent air from passing through the unit's walls.

- 5) The chilled water pipework connections shall be supplied with bi-metal class 250 (PN16) flanges with open ends sealed for delivery.
- 6) Coils shall be fully catalogued products and the documentation shall include performance curves and/or selection tables for the expected range of operating conditions.
- 7) Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.
- 8) Submit certified detail selection shown on these selection curves and tables.
- 9) Complete coil including headers, connections and tubes shall be tested to 2,000 kPa and shall be rated for operating at 1700 kPa.
- 10) Coils having loose or damaged fins and distorted tubing or dents will be rejected and must be replaced with new coils.
- 11) Each coil shall be provided with its own drip tray to prevent flooding of lower coils due to condensate.
- 12) No moisture shall be carried beyond the sump under any operating condition.
- 13) Coil supports shall be copper or stainless steel.
- 14) Coils shall be arranged for counter flow of air to cooling medium and no by-pass of untreated air shall occur.
- 15) Suitable baffling of diffusers shall be provided, if required, to ensure uniform coil velocity.
- 16) Coils shall not distort or vibrate in operation.
- 17) Motorized valve shall be of the pressure independent control (PIC) type inclusive of a flow meter. If a flow meter is not included a flow meter is to be added to the costing and factory fitted.
- 18) The valve shall be OPEN in the failsafe position.

3.3.4 Supply Air Fans

- 1) Fan Section – The fan section shall consist of the electronically commutated fans. The fans shall be EC motors with associated controls.
- 2) Units shall be direct drive, dynamically balanced on all principal axis, airfoil shaped blade plug fans arranged in a fan array, or Owner approved equal.
- 3) Motors shall be designed for variable speed operation and shall be premium efficiency totally enclosed with sealed and locked bearings with a NEMA rated frame designed for quiet operation.
- 4) Motors shall be driven through VFDs. The motors shall be specifically designed for VFD operation (not 'acceptable for') and include grounded bearing protection rings grounded to the other components of the drive system to reduce bearing frosting, pitting and failure caused by VFD induced voltages and currents across the motor bearings and shaft.
- 5) The fans shall be capable of overcoming an external resistance as per the data sheet plus the resistance of all components associated with any ducted supply or return air top plenum sections.
- 6) Fan power shall be no higher than 0.72-0.9kW electrical of net sensible cooling flow at design capacity. For example, if the design flow for a unit is 1000l/s to meet the sensible capacity requirements, the fan power shall be no higher than 720-900W. It is noted the motor rating will potentially be higher than this value. If this is not possible the vendor is to bring it to the attention of the Engineer.
- 7) The fans are to be easily accessible and replaceable from the front of the unit.

3.3.5 Electrical

- 1) Units shall come complete with an automatic dual power source selector.
- 2) A non-fused disconnect shall be located on the control panel and accessible from the exterior for connecting building power to the unit.
- 3) All branch circuits shall be individually protected.
- 4) They and shall include a low-voltage control circuit transformer.

- 5) Motors shall be protected on all phases.
- 6) Units shall be provided with phase and brown out protection that shuts down all motors in the unit if the electrical phases are more than 10% out of balance on voltage, or the voltage is more than 10% under design voltage or the phases reverse. The units shall have an auto-restart function accompanied by an alarm to the remote BMS and the unit's control panel.
- 7) All connections and wires to be clearly labelled.
- 8) All units to be fitted with power factor correction.
- 9) Hand / Auto / Off indicator lamps to be visible on outside of CRAC unit.

3.3.6 Filters

- 1) Filter Chambers - Shall be integral to the unit, located at the return air face (rear or top of the unit) entrance, and easily serviceable. The filters shall be 30% - 100mm deep ASHRAE 53-76 minimum or G4 rated filter according to EN779 to comply with ASHRAE recommendations to achieve air quality. Initial filtration will be provided by the dedicated outdoor air handling unit which will be fitted with G4/F6 filtration. The filter fitted to these AHU's is merely for data hall filtration and to allow for minimal pressure drop.
- 2) Filter must be of the disposable type and be removable from the top of the unit.

3.3.7 Drain Pan

- 1) All cooling coils and fan section to be provided with an insulated stainless steel drain pan.
- 2) Pan to be installed under coil and extending past the end of coil. If there are stacked coil sections, the drain pan for each section shall be piped independently to the unit's lowest drain level.
- 3) The drain pan must be fitted with leak detection which is to be connected to the HLI.

3.4 Controls

3.4.1 General

- 1) The unit shall be provided with an advanced control processor with a front display panel and control keys for user inputs. The controls shall be menu driven on-screen prompts for easy

user operation. The system shall allow the user to review and program temperature and humidity set points alarm parameters, and setup selections, including the choice of control type. A password shall be required to make any system changes. For all user selections, the range of acceptable input (temperature, humidity, or time delay) shall be displayed on the monitor screen. The system shall provide monitoring of room conditions and display the operational status in % of each function, each component's run times, the date and time the variable was recorded, and four analogue inputs from sensors provided by others.

- 2) The unit controller shall be factory installed. The controller shall be fully capable of operating in a 100% stand-alone control mode. The controller shall be able to connect to the master unit, a supervisory controller and future BMS using BACnet. Minimum open protocol points are operation mode, supply air temperature, entering air temperature, supply air temperature set point, fan speed, common alarm.
- 3) The controllers supplied as part of the unit are to be of a reputable and recognised supplier. The controllers are to be locally and readily available as an ex-stock item/component, similar or equal to Carel, Tridium, Honeywell, Satchtech or equally approved make.
- 4) Control architecture shall be open allowing all functionality to be controlled remotely by any third party system without licensing requirements to change and control setpoints as described
- 5) Units must also have output directly to the future BMS for monitoring purposes only.
- 6) Units must be able to be connected as master / slave
- 7) All set points shall be adjustable from the individual unit control panel.
- 8) Each unit controller shall be able to collate and process as a minimum the following primary control signal from the Master controller/SC:
 - a) Unit Operational State
 - b) Global fan speed to meet air side delta T
 - c) Unit Supply Air Temperature Set-point (maintained locally at all times via CHW valve modulation)
 - d) Unit Fan Speed (should master or SC fail)
 - e) Unit Common Alarm
- 9) The unit shall come with a HAND/OFF/AUTO switch where:
 - a) OFF Unit is deactivated

- b) AUTO Unit is controlled by the CPC/BMS
 - c) HAND Unit runs on its unit local controller with no input into from the CPC/BMS
- 10) The HOA switch setting for each air handler will be sent to the BMS via BACnet communication channels.
 - 11) Normal Operating Modes shall be indicated by coloured LED's on the unit-mounted display panel.
 - 12) Temperature Sensors - Provide accurate and highly reliable temperature sensors factory mounted in the supply and return air stream of the unit. Provide an accurate and highly reliable humidity sensor factory mounted in the supply air stream. The supply air sensor shall be accessible and located in the unit discharge after the coil.
 - 13) Remote temperature sensors: the CRAC unit is to come complete with a remote temperature sensor to be located 3 meters from the outlet of the CRAC fans.
 - 14) In addition, the system shall provide the following internal controls:
 - a) System Auto-Restart - For start-up after power failure, the system shall provide automatic restart with a programmable (up to 9.9 minutes in at least 30-second increments) time delay.
 - b) The control system shall monitor unit operation and activate a BMS alarm in the event of the following factory pre-set alarm conditions: 1) Restricted Air Filters; 2) Loss of Airflow; 3) Custom Alarm; 4) Loss of water flow
 - c) Monitor Display Panel - All indicators shall be in language form. No symbols or codes without a language form shall be acceptable.
 - 15) Common Alarm
 - a) Common Alarm Terminals - The unit shall come equipped with two normally open, non-powered common alarm contacts for connection to a remote field supplied 24 volt alarm indication device (two sets required per unit).
 - b) A common alarm light shall be activated to indicate any common alarm and an alarm signal sent to the BMS.
 - c) Common alarms to include the following as a minimum:

- i. Missing filter alarm
- ii. Dirty filter alarm
- iii. Fan failure
- iv. HAND/OFF/AUTO

16) Password Protection. Each unit controller is to be provided with two different access levels.

17) All interconnecting field and network wiring between units are to be placed in a hot dipped galvanized steel conduit.

3.4.2 Supply air

- 1) Unit supply temperature will modulate to meet the supply air temperature based on local supply set point.
- 2) Supply air volume is to modulate as follows (and in this order):
 - a) Global fan speed input from SC
 - b) Master controller fan speed input
 - c) Local delta T control (air side) to maintain setpoint

3.4.3 Fire

The unit is to be such, that the unit will switch off in the event of receiving a fire alarm from others.

4 Performance

4.1 Sound Power Level

Refer to the returnables spreadsheet document for completion of the sound power levels for the systems.

4.2 Source Quality Control and Warranty

- 1) The CRAC units shall be factory performance tested under full load conditions in an ambient controlled test facility. The manufacturer shall supply a certified test report to confirm performance as specified.
- 2) A certified test report of all data shall be submitted to the Engineer/Owner prior to completion of the project. The factory certified test report shall be signed by an officer of the manufacturer's company. Pre-printed certification will not be acceptable; certification shall be in the original.
- 3) One year after start-up or 18 months after delivery warranty, whichever is later, continuing again after a defect is completely rectified. The repair period, from the time the defective behaviour is reported until it is repaired without recurrence, shall be added to the warranty's length. The defect will be considered rectified after Manufacturer's replacement or repair, including parts and labour at the Manufacturer's expense of the failed and malfunctioning components' that caused or will lead to a recurrence of the defect. The warranty shall cover all Manufacturer supplied equipment with an agreed 24 HOUR 7 DAYS PER WEEK response time. This warranty shall be included with the base proposal.

4.3 Final Inspection and Start-up Service

- 1) After the Mechanical Contractor has provided all water piping connections, and field control wiring, and Electrical Contractor has provided all the field power wiring, the factory-authorized service representative employed by the equipment Supplier shall inspect the installation. The Mechanical Contractor shall then perform the start-up of the equipment.
- 2) The Automatic Temperature Control (Building Direct Digital Control) Contractor shall be scheduled to be at the job site at the time of the equipment start-up
- 3) Under the guidance and supervision of the factory-authorized service representative employed by the equipment Supplier, the Mechanical Contractor, shall perform the following tests and services and submit a report outlining the results:

There has been no physical damage to the unit.

The unit is level.

Chilled water pipes have been connected to correct ports.

Labels and safety instructions are clearly visible.

Shipping skids, blocks, and straps have been removed.

Controls and safety interlocks have been installed and connected.

Check and record performance of protection devices.

Operate unit for run-in period as recommended by manufacturer.

5 Specification – Supervisory controller (SC)

5.1 General

- 1) The tender shall be submitted for the final design, manufacture, programming, supply, deliver to site of the SC as shown on the drawings and as listed in the schedule.
- 2) A total of two (2) SC's will be required as detailed in this specification.
- 3) The system is designed to function in a N + 1 configuration ie. no redundancy.
- 4) The SC's will be responsible for the primary control of the data hall air handling equipment.

5.2 Arrangement

- 1) Provide digital controllers (SC) with BACnet/IP high level interface to the future BMS. Complete points list including registers is to be provided to installation contractors.
- 2) The supplier is to provide an automatic control system that is fully compatible with the selected CRAC controllers/HLI's and that has been proven to control its equipment and can easily incorporate inputs from field instrumentation (in this case temperature and RH sensors) of various types.

5.3 System structure

- 1) The HMI / SC interfaces shall provide means to:
 - (a) Supervise the system performance and status in the form of dynamic graphics and point status lists
 - (b) Program cooling plant control philosophy, specifically fan speed
 - (c) To change set points and read the local set points of sub-system controllers
 - (d) To acknowledge and prioritize alarms and route messages to the future BMS
 - (e) To interface and communicate with other systems via BACNET / IP
 - (f) Each be capable of connecting via network connection to the future BMS
 - (g) Loss of communications to a SC is to be alarmed on the future BMS

- (h) Perform calculations on real time data
- (i) Record run-time totalization on monitored plant equipment

5.4 Password Protection

- 1) Access to the SC must be restricted through a password protection facility.
- 2) A minimum of 10 alpha-numeric passwords of up to 10 digits shall be provided. Each password shall be assignable to any of 10 levels of authority.
- 3) The system shall have the ability to track sessions to determine when each user was logged into the system, and changes each user made.

5.5 System Addressing

- 1) System point addressing shall be by English language text identifiers and operating selectors.
- 2) Multiple point addressing by plant, location or other set attribute shall be possible both as methods of interrogation and control.

5.6 Functional Operation

The functional operation described below sets out the minimum requirements for operation.

5.6.1 Supply air setpoint

Global supply air setpoint can be changed via the SC and relayed to the plant.

5.6.2 Fan speed

- 1) Global fan speed can be controlled based on the average delta T with a 1 degree variance.
- 2) It must also be possible to exclude the highest and lowest return air temperatures should these fall outside a set bandwidth. Should this happen, then it must be alarmed by the SC to the future BMS.

5.6.3 Monitoring of units

- 1) Realtime equipment information must be able to be remotely monitored from the SC.

5.7 Alarming

- 1) The SC shall alarm the following as a minimum:
 - (a) Loss of power / communications to SC (future BMS to indicate loss of communications)
 - (b) General alarm
 - (c) Master unit offline
 - (d) Slave unit offline

5.7.1 Power Failure

- 1) Should the power supply to the SC be lost the following is to take place:
 - (a) Alarm to future BMS
 - (b) Units to revert to master / slave control without affect to the data hall
 - (c) SC to be on UPS power supply (by others).

6 Testing and Commissioning

Along with the commissioning requirements referred to in the standard specification the following are equipment specific requirements.

6.1 Site Tests

- 1) Carry out the following witnessed site acceptance testing as a minimum for each individual element of the equipment as applicable (HVAC contractor with assistance by the Supplier):

Unique Test Reference	Test Requirement
1	Visual Inspection

	<p>Perform a visual inspection of the unit.</p> <ol style="list-style-type: none"> 1) Record the Serial Number of the unit and any ancillary components under test. Confirm a match with the factory inspection documents. 2) Confirm the following: <ol style="list-style-type: none"> a) Units are un-damaged b) Cabinets and Connections are clearly labelled. c) Doors and access panels open freely. d) Equipment positioning and clearances are in line with design drawings. e) Safety protection equipment such as fan guards etc. are in place. 3) Confirm cooling water balance has been satisfactorily carried out and secondary pump is in correct operation. 4) Record ambient temperature and humidity during the testing. 5) Remove temporary filter material and replace with final filters
2	<p>Functional Operation Tests</p> <p>Perform the following functional tests:</p> <p>Single Units:</p> <ol style="list-style-type: none"> 1) Flush, chemically clean and pre-treat system to AS 3666.1. 2) Unit startup using manual switch 3) Shutdown via manual/emergency stop switch 4) Confirm correct positioning of motorized dampers (where applicable) 5) Confirm correct operation of variable speed drive (where applicable) 6) Operate unit in cooling mode. Simulate conditions to force unit operation in cooling mode if necessary eg alter set-points 7) Confirm correct operation of unit controls in accordance with specified controls functionality Confirm correct operation of supply air fan 8) Confirm correct operation of supply air fan 9) Confirm total airflow achieved from each individual unit 10) Simulate all alarm functions and FCMS interfaces 11) Simulate loss of controls function. 12) Simulate fan speed automatically adjusts to change in underfloor pressure 13) Collate information and checks into a formal report and issue
3	<p>Performance testing</p> <p>Carry out the following performance tests once correct operation of each individual CRAH serving a given space has been confirmed.</p> <p>Parallel System:</p> <ol style="list-style-type: none"> 1) Once correct operation of all systems serving one area is confirmed carry out an air balance to the area(s). 2) Confirm correct air balance achieved with all air conditioning and ventilation systems serving the area of the building in operation
	<p>Outputs & Interfaces</p>

	<p>Perform the following output and interface tests:</p> <p>Test all nominated alarms by simulation of condition, verifying signal indication at FCMS (if available) or point of interface (only if FCMS is unavailable).</p> <p>Test all nominated equipment status indications and outputs by simulation of condition, verifying signal indication at FCMS (if available) or point of interface (only if FCMS is unavailable).</p>
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7 Computer Airconditioning Unit Specification

Schedules below indicate the specifications required for the CRAC units. Tenderers are to refer to the returnables spreadsheet document for which shall be completed and returned with the tender for each product Option as listed in the Specification document. Schedules to be resubmitted for reconfirmation for all subsequent purchase order confirmations.

Table 7-1 CRAC units equipment specification schedule

CHILLED WATER DATA HALL CRAC and UPS Units					
General	Unit Type		Data Hall Downblow CRAC		UPS Side blow CRAC
	Area Served		Data Halls all		UPS Room
	Number off		9		2
Capacities (CHW coil)	Gross sensible cooling capacity/unit	kW	166		85
	Net sensible cooling capacity/unit	kW	160		80
	On Coil Temperature	DB (°C)	30		30
	RH at on coil temp	%	30		30
	Off Coil Temperature	DB (°C)	20		20
	CHWS	°C	16		16
	CHWR	°C	24		24
	Chilled water flow	l/s	5.1		2.5
	Chilled water connection diameter	mm	65/80		50

	Coil pressure drop (including for full scope of supply)	kPa	<45		<45	
Motorised Valves	Type	Outlet side	PICV		PICV	
		Inlet side	Motorized isolation valve		Motorized isolation valve	
	Energy meter		Included or separate flow meter		Included or separate flow meter	
Fan	Supply Air Quantity (@ design Delta T)	m ³ /s	15.3		TBC	
	Design delta T over unit (fan speed control)	°C	10		10	
	Number of fans	No	TBC		TBC	
	Minimum efficiency	%	75		75	
	Maximum coil velocity	m/s	2.5		2.5	
	Fan Static Pressure (external)	Pa	150		150	
	Fan Type		EC		EC	
Filters	Dry media filter mass arrestance (EN 779)	Pre Filter	G4		G4	
Dimensions	Height x Width x Length (excluding base module)	mm	2000 x 890 x 3300		2000 x 890 x 2400	
	Weight	kg	1200		900	
Electrical	Voltage / phase / frequency	V/A/Hz	400/3/50		400/3/50	
	ATS fitted		Yes		Yes	
	Fan Absorbed Power	kWe	10		5	
	Fan Motor Size	kWe	TBC		TBC	

	Unit Total Power Max	kWe	TBC		TBC	
	Power factor correction		Yes		Yes	
Controls	Local control	PICV valve control	Supply air temperature control		Supply air temperature control	
	SC / Master / Local control	Fan speed	Delta T over unit		Delta T over unit	
	Supply air temperature and pressure sensors (in addition to off coil sensor)	No	2, to be supplied with unit		2, to be supplied with unit	
	Availability to connect in master/slave layout		Yes		N/A	
Other	Raised floor plenum unit stand and antivibration mounts per specification to 1000mm raised floor	No	9		N/A	
	Piping connection		Flanged		Flanged	
	Remote sensors with inputs available to controller		2		2	
	Internal piping insulation		Factory fitted		Factory fitted	
	Antivibration pads	Sum	Yes		Yes-	

SECTION 5: CHILLER UNIT SPECIFICATION

1 Introduction

- 1) This document provides the proposed scope, brief, project principal design, equipment, supply, testing, commissioning and documentation for supply of the Air-Cooled Chillers and Cooling Plant Controllers (CPC) for this project.
- 2) The requirements are for the final design, manufacture, supply, delivery, rigging into position, installation onto spring dampers (supplied) and commissioning of Air-Cooled Chillers and CPC to support the data hall areas current and future building cooling loads.

1.1 Objectives

- 1) The intent of this specification is to:
 - a) Define the priorities and objectives that shall guide the design & documentation decisions
 - b) Define the technical requirements for the equipment, installation, testing, commissioning & documentation
 - c) Equipment requirements
 - d) Preparation of documentation
 - e) Factory Acceptance Testing
 - f) Delivery of equipment
 - g) Commissioning of equipment

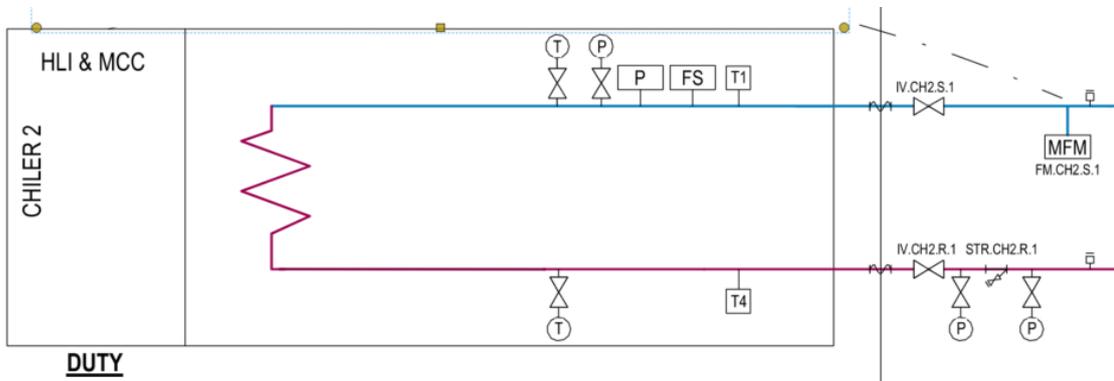
1.2 Scope Delineation

The following table confirms the scope of the chiller supplier's works:

Table 1-1 Scope delineation

Delineation of scope				
Item	Description	Responsible Contractor		
		Electrical contractor	HVAC contractor	Chiller Supplier
1	Manufacture, supply, deliver to site, rig chillers into final position onto spring mounts	-	X-	X
2	Electrical connection to chillers	X	-	-
3	Communications between chillers and pumps	-	X	-
4	Final piping connection to chillers	-	X	-
5	Manufacture, supply and deliver to site CPC	-	-	X
6	Install and commission CPC	-	X	Assist
8	Communication connections between future BMS, plant & field sensors to CPC	-	X	-

The schematic below indicates the Typical connection details for the Chiller units. Note suppliers' responsibility and HVAC contractors' responsibility in this



regard: **DUTY**

Scope delineation on chiller schematic

1.3 Warranty

- 1) The warranty shall incorporate the following:
 - a) Warranty means that all patent and latent defects will be rectified by the Vendor arising from defective materials, workmanship or design at his expense during the warranty period
 - b) Warranty excludes defects that may arise from the misuse or abuse by the Employer.

c) Servicing of the unit is to be conducted during continuous operation, when the unit is in cold standby mode.

2 Design Requirements

2.1 Industry Standards & Guidelines

All work shall meet all the requirements of national and local Statutory Authorities and shall be in accordance with the following:

Table 2-1 Industry standards:

ASHRAE 90.4	Thermal energy standard for data centres
ASHRAE TC9.9	Data centre powered equipment thermal guidelines best practices
SANS 10400	South African national standards
OSH Act 1993	The occupational health and safety act of 1993, as amended
SANS 10142	Wiring of premises
	Government, Provincial and Local authorities' ordinances, regulations, by-laws, rules and other statutory requirements
SANS	Specifications and codes of practice issued by the South African Bureau of Standards and British Standards Institute. The former shall have precedence over the latter where both bodies have issued conflicting specifications or codes of practise.

3 Specification – Air cooled chiller with free cooling

3.1 General

- 1) A total of three (3) air cooled chillers will be supplied and installed as is detailed in this specification.
- 2) The system is designed to function in a N+1 configuration.
- 3) Chillers shall be designed such that all parts can be reached and replaced easily without affecting any other parallel systems. This shall be achieved taking cognisance of the fact that no work can be conducted on live equipment.
- 4) This plant will need to comply to Uptime Institute Tier III type requirements.

- 5) The chillers are to be connected to an “A” (duty) and “B” (standby) central plant controlling (CPC) system which is to be included in the scope of supply. This will be responsible for controlling the cooling generation plant (chillers, secondary pumps, primary pumps, motorised shutoff valves, buffer tanks) via inputs from the field sensors (magnetic flow meters, temperature and differential pressure sensors).
- 6) The tender shall meet the quality, function and performance requirements of this specification.

3.2 Cooling Plant Arrangement

- 1) The chillers will be located in the onsite approximate positions as indicated below. Special note must be taken as to the limited space available for the placement of the chillers, as well as any hoisting and rigging constraints. Any deviation in spatial requirements must be brought to the attention of the Engineer.
- 2) **Chillers are to be supplied complete with integrated free cooling coils.** The chillers will form part of a primary / secondary chilled water system with thermal energy storage tanks in the decoupler for ride through capacity in the event of a power failure.
- 3) Cooling water is to be distributed to the field via numerous secondary pumps through a ring main system. CRAC units located within the data halls and limited other areas are connected to the secondary chilled water ring main system.

3.3 Construction

3.3.1 General

- 1) The chillers will provide cooling to critical infrastructure and are to be constructed of high quality materials. Maximum availability, energy efficiency and continuous year-round operation is required for the application.
- 2) The chillers should be designed and constructed to have an effective design life of 20 years while operating at 24 hours a day, 7 days a week.
- 3) The chillers are to be constructed to operate in an outdoor environment continuously. Extreme ambient temperatures, high and low humidity ranges, weather events such as storms, hail and high winds are to be considered in the design and construction of the chiller.

3.3.2 Chassis

Fully welded, galvanized rigid steel base frame designed to support the chiller with lifting lugs for hoisting and transporting. High stability and rigidity to minimize the transfer of mechanical stress to the chiller housing structure, as well as deflection during transport. Engineer certified crane eyelets for transporting the machine to its final location shall be included in the product package and removed after transport.

3.3.3 Cover panels and fixings

- 1) Galvanized and powder coated steel sheet for all panels exposed to the weather. The panels shall resist all bending greater than $L/200$ during normal operation and wind loading.
- 2) Electrical and controls enclosure shall be isolated from the compressors to limit vibration and heat transfer.
- 3) Vibration Isolators: Chiller manufacturer to provide suitable isolators to reduce transmission between the chiller and structure. These are to be spring type and not pads.
- 4) All fixings shall be stainless steel and designed for long life and serviceability. All access doors shall be hinged.

3.3.4 Cleaning

- 1) The chillers will be exposed to atmospheric dust during their operation. Provide systems and components that are designed for cleaning and serviceability.

3.3.5 Piping and support

- 1) The Contractor shall familiarise himself with the proposed location of the chillers, and shall be responsible for ensuring that sufficient access and structural support is available on site to allow the machine to be brought into position and shall ensure sufficient space for air flow is available.
- 2) Any piping systems shall be adequately supported so that no strain is imposed on the chiller.
- 3) Piping connection shall be by means of flanged bends to provide access to the tubes without dismantling the piping system. Air vent and drain cocks shall be provided.
- 4) No Victaulic type fittings to be used.

3.4 Refrigeration system

3.4.1 General

Each Chillers shall have **two** (2) independent refrigeration circuits, each with a separate single compressor arranged for lead/lag operation. Any deviation to the aforementioned is to be brought to the attention of the Engineer for approval.

3.4.2 Circuits

- 1) Chillers shall have two refrigerant circuits consisting of copper or stainless steel pipework
- 2) For each (min 2) refrigerant circuits provide:
 - a) Suction and discharge line shutoff valves
 - b) Liquid line sight glass and moisture indicator
 - c) Electronic expansion valve sized for maximum operating pressure
 - d) Liquid line pressure regulation
 - e) Refrigerant charging valve
 - f) Hot gas shutoff valve
 - g) Discharge and oil line check valves
 - h) High and low side pressure relief valve
 - i) High pressure switch
 - j) Low pressure monitor
 - k) Full operating charge of R-134A (or alternate) and oil. Gen 5 refrigerants are preferred.
 - l) Unit factory assembled, leak and proof tested to support high and low side rated pressures.
 - m) Filter dryer of the replaceable core type.

- n) Glycerine dampened high- and low-pressure gauge for monitoring the suction and discharge pressures.
- o) Temperature sensors

3.4.3 Pressure regulation

- 1) Provide automatic system pressure stabilisation systems in each refrigerant circuit for control of low condensing temperatures. These systems shall optimise free cooling whilst protecting the compressor from low pressure safety trip. Such systems include:
 - a) Head pressure regulating devices or to allow for maximum condenser fan operation in low load, mixed mode operation.
 - b) Liquid line receiver pressure regulating devices to ensure stable control of electronic TX valve and suction temperatures.

3.5 Motors

- 1) Provide continuous duty rated motors in accordance with NEMA MG 1 (or similar approved) and of sufficient size to drive load at specified capacity without exceeding the nameplate rating of the motor. Provide premium efficiency inverter duty rated motors for use with variable frequency drives
- 2) Fan Motors: Three-phase, integral overload protection, and permanently lubricated bearings, TEFC. Motors shall be permanently lubricated, ball bearing > 100,000 hr L10 life, vertical shaft type.
- 3) The motors shall not operate within their service factor at design or any lower speed. The entire condensing unit, unless otherwise specified, shall have a single point of electrical connection
- 4) Reduced-in-rush motor starters (33% of LRA inrush) with a 65,000 amp short circuit withstand rating shall be provided.
- 5) Power factor correction (>0.95) is to be fitted to the chillers by the chiller supplier.

3.6 Compressors

3.6.1 General

- 1) Compressor(s) shall be semi-hermetic helical rotary screw type with rotors of high grade steel or cast iron alloy. Screw compressor shall be of horizontal design and shall have both a male and a female rotor. Alternatively, oil free magnetic bearing chillers can also be considered pending capacity at design conditions can be maintained.
- 2) Rotating parts shall be statically and dynamically balanced.
- 3) Locate compressors within an acoustically treated enclosure.

3.6.2 Lubrication

- 1) Provide pump-free oil lubrication system with oil charging valve, temperature sensor and fine mesh oil filter to ensure adequate lubrication during starting, stopping and normal operation. The system is to be fitted with a self-regulating electric oil heater to ensure optimal viscosity. Include sight glass, filling connection and filter with magnetic plug.
- 2) Lubrication (if not oil free) system shall include crankcase heaters, suction and sufficient discharge line service valves to remove any compressor during the operation of the other refrigeration circuits, mounted on vibration isolators.

3.6.3 Capacity Control

Provide compressor with automatic capacity reduction equipment consisting of capacity control slide valve (if screw type) to infinitely vary the capacity from 12.5 - 100%. Compressor must start unloaded for soft start on motors. Provide an electronic expansion valve controlled by the chiller to ensure optimal gas pressure and temperature.

3.6.4 Motors

Provide constant speed 50 rps compressor motors, suction gas cooled with solid state sensor and electronic winding overheating protection designed for closed-transition soft type starting.

3.7 Evaporator

3.7.1 General

- 1) Evaporator shall be multi-pass shell and tube type seamless or welded steel construction with cast iron or fabricated steel heads, seamless internally finned copper tubes, roller expanded

into tube sheets. The use of shell and tube heat exchangers is preferred, plate to plate heat exchangers must be approved by the Engineer.

- 2) Evaporators shall be rated on the basis of 0.0044m²K/kW fouling factor in accordance with ARI 550/590-98 and not less than 3K sub-cooling
- 3) Optimised design and size for use with R134a (or next generation refrigerants, preferred) and high evaporating temperatures associated with process water supplied in the 20 – 30°C range.
- 4) Water velocities through evaporator tubes shall not be more than 2.5m/sec (or such lower figure as the manufacturers may recommend) or less than 1.5m/sec.

3.7.2 Design Pressure

- 1) Flooded evaporator shall be rated to 110% of the minimum pressure defined by ISO-5149 for the refrigerant used. Design, test and stamp evaporator refrigerant side for recommended pressure rating. Minimum pressure ratings as follows:
 - (a) Water side 1,000kPa
 - (b) Refrigerant side 1,700kPa

3.7.3 Insulation

Insulate and vapour seal the evaporator, evaporator heads and suction lines (all cold surfaces) with UV resistant insulation with maximum K value of (0.26). The insulation values shall be maintained if the insulation is wet or dry. All ancillaries including valves, gauges, ports, etc that are attached to an insulated pipe shall themselves be insulated.

3.7.4 Heater

Factory-installed electric heater with capacity to protect evaporator to the coldest temperature n=20 year extreme. The evaporator heater shall have an option for separate power connection.

3.7.5 Miscellaneous

Provide water drain connection, vent and fittings for factory installed leaving water temperature control and low temperature cut-out sensors.

3.8 Condenser

3.8.1 General

- 1) Air cooled condensers shall be constructed from copper tubes and aluminium fins.. Coils must be designed for low pressure drop with a maximum of one row in depth to minimise pressure loss.
- 2) Factory test coils for leaks to 110% of the minimum pressure defined by ISO-5149 for the refrigerant used.
- 3) Optimised design and size for use with R134a (generation 5 refrigerants preferred) and minimising condensing temperatures to achieve high efficiency for the operating range within the design conditions.
- 4) The units are to be supplied complete with expanded mesh or similar approved hail guards protecting the condenser coils from hail damage.

3.8.2 Design Pressure

Design, test and stamp condenser for recommended pressure rating. Test system to a maximum pressure of 1,700kPa.

3.8.3 Condenser Fans

3.8.3.1 General

- 1) Directly driven, noise and energy optimized axial electronically commutated (EC) external rotor fans.
- 2) Fans shall be constructed to a minimum protection rating: IP 54.
- 3) The airflows of the condenser modules shall be separated to prevent short circuits of air in the event of fan failure. Specific cleaning and maintenance procedures for condenser fans and coils shall be provided.
- 4) Prevent short circuiting of discharge air by increasing the effective plume height. Hail guards to protect the fans are to be included as part of the cope.

3.8.3.2 Motor

- 1) All variable speed condenser fan motors shall be direct drive with TEFC motors and bearings specifically made for VFD use and not merely high efficiency motors "suitable" for VFD use.
- 2) EC external rotor motor minimum efficiency class: IE5. Provide motors with maintenance free ball bearings and long-lasting lubrication.
- 3) Motors shall be soft start and have integral speed controllers for infinite control by the chiller's control system to optimise operation. On communications loss, operate the fans at a fixed pre-set speed.
- 4) Motor impeller shall be balanced statically and dynamically to a balance quality grade G 6.3 in accordance with DIN ISO 1940.

3.8.3.3 Impellers

- 1) Maximise the size of impellers to minimise energy usage. Provide engineered and aerodynamically proven impeller and housing optimised for energy efficiency and acoustics.
- 2) Manufacture blades from high strength materials such as aluminium alloys or glass reinforced plastics.

3.8.3.4 Guards

Provide fan guards for safety and protection from hail. Fan guards must be hinged and easily removable for maintenance access to fans without tools.

3.8.3.5 Discharge attenuators

- 1) Provide discharge attenuators (if required) to meet the chillers maximum acoustic limits as required in the Performance Schedules.
- 2) Include any additional pressure drop associated in the energy usage performance data submitted.

3.8.4 Electrical protection

- 1) Provide the following integrated safety devices:
 - a) Anti-lock protection

- b) Phase loss detection
- c) Mains under voltage detection
- d) Electronics and motor over temperature detection
- e) 20kA Short-circuit protection
- f) Motor current limitation

3.9 Cooling water pipe system

3.9.1 General

- 1) Provide an internal copper pipe hydraulic system incorporating external pipe connections, internal copper pipework connections to the free cooling system.
- 2) Electronic flow meters are to be provided (by others) and connected to the chiller controller for monitoring by the HLI. Allowance must be made in the HLI for this connection.
- 3) Temperature sensors are to be provided for monitoring and control of inlet and outlet temperatures.

3.9.2 Connections

Provide Table 'E' type flanged water connections for the chiller. The chiller shall have only one entering and one leaving connection. Free cooling and DX hydraulic systems shall be internally connected.

3.9.3 Pipework

Pipework shall be copper with filling, drain and air vent valves. Pipework shall be fitted with insulation and rigidly bracketed to the chassis.

3.9.4 Integral Primary Chilled Water Pump

3.10 Separate standalone primary pumps will be provided. No integral pumps are required. Free Cooling

3.10.1 General

- 1) Provide a free cooling system consisting of water-cooling coils, changeover valves, hydraulic circuits with automatic switching and control systems for regulating process cooling water in full free cooling, mixed mode operation and full DX mode. The chiller is to control the free cooling via its own unit controller.
- 2) During an emergency start, the chiller is to go to full compressor cooling until temperatures are met. Once reached, the chiller can resume its free/hybrid cooling mode should the ambient allow.
- 3) Restart time to be <300s
- 4) It must be possible to disable the free cooling on the chiller at any time.

3.10.2 Water cooling coils

- 1) Construct free cooling coils from copper tubes and aluminium fins.
- 2) Optimise design of cooling coil to minimise water and air side pressure loss.

3.11 Electrical

3.11.1 General

- 1) Chillers shall be provided with external interface connections including the following:
 - (a) Chiller sub-mains supply,
 - (b) High- and low-level interfaces to remote monitoring systems and,
 - (c) Chiller interconnecting communications wiring.
- 2) Provide low harmonic VFD's with no greater than 5% Total Harmonic Distortion (THiD) for the entire unit.
- 3) Provide compressor motor current-overload protection.

- 4) Provide integrated electrical meters for each compressor and condenser fans circuit for HMI monitoring.
- 5) Provide power factor correction to each chiller.

3.11.2 Wiring

- 1) All power wiring associated with chillers shall be run on cable tray or in steel conduit to provide adequate protection from damage. All switchgear shall be 4-Pole.
- 2) All wiring shall be securely and neatly attached to the chiller.
- 3) All control wiring shall be run in cable duct or steel conduit or anaconda flexible conduits. Flexible or corrugated PVC conduit is not acceptable for the chiller or ancillaries.
- 4) Provide submains connection lugs for a single 3P+N+E supply.

3.11.3 Electrical Cabinet

- 1) Each chiller shall be provided with an electrical cabinet in a fully separated Form 2 design with separate compartments for mains and extra-low voltage controls. The cabinet shall have a minimum ingress protection rating of IP56
- 2) The cabinet shall house the electrical switchgear, ATS (where applicable), safety switches and controls.
- 3) An HMI is to be provided within the electrical cabinet.
- 4) The electrical cabinet is to be temperature controlled to a maximum of 40C ambient or supplier specific requirement based on design conditions. Alternatively, temperature control can be omitted if design of components and cabinet ventilation is suitable for 50C ambient. The responsibility for climate control of this cabinet lies with the supplier.
- 5) The electrical cabinet shall house the integrated controls UPS.
- 6) The electrical cabinet shall also house a breaker to power the associated secondary pump. These are to be 25Amp three phase.

3.12 Controls

3.12.1 General

- 1) The chillers are to be furnished complete with a **standalone** microprocessor based control system with controls in a locked enclosure, factory mounted, wired and tested per chiller.
- 2) The controls system is to be fully factory tested and include all necessary devices such as flow switches, temperature sensors, pressure sensors, interlocks and pressure control devices to form a fully functional stand-alone system capable of delivering the supply water setpoint regardless of the changes to load or ambient conditions. All equipment must be easily accessible and able to be repaired / replaced within one hour.
- 3) A touch screen HLI is to be provided with the controls. The HLI shall have a graphical display and allow for monitoring, set point adjustment and diagnosis of systems connected to the chiller controller.
- 4) The controls system power supply is to be connected to the building UPS to ensure the chiller controls stay fully powered in the event of power failure.
- 5) The chiller will be able to run in standalone / local mode should communications with the CPC be lost.
- 6) Chiller controller is to allow for one additional point for a flow meter (provided by others).
- 7) The chiller is to auto restart to 100% after power failure.

3.12.2 Interfaces

Provide separate interface drawings which clearly identify and nominate all connections and interfaces to be provided by others. Reference to generic documents or standard drawing sheets will not be accepted.

3.12.3 Monitoring points

- 1) The chiller is to make available all points on the controller to the HLI including all virtual points required as part of the functional logic requirement such as alarms, operational speed, capacities, status and faults of all major equipment.
- 2) As a minimum, provide 40 virtual points via the HLI.

3.12.4 Status Display

- 1) Include the following as a minimum:
 - a) Date and time.
 - b) Operating or alarm status.
 - c) Operating hours.
 - d) Entering-chilled-water temperature.
 - e) Leaving-chilled-water temperature.
 - f) Evaporator refrigerant temperature.
 - g) Evaporator pressure.
 - h) Condenser pressure
 - i) Electronic expansion valve position
 - j) Compressor/s capacity

3.12.5 Control Functions

- 1) Include the following as a minimum:
 - (a) Leaving-chilled-water temperature reset from entering-chilled-water temperature.
 - (b) Electric demand limiting through compressor lockout.
 - (c) Anti-recycling timing-out to prevent rapid compressor cycling.
 - (d) Automatic lead-lag switching.
 - (e) Chilled-water temperature reset based on outdoor-air or space temperature.
 - (f) Start primary pump and run during low ambient air temperature less than 2 degrees C.
 - (g) Activation / deactivation of free cooling setpoints
 - (h) Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
 - i.Refrigerant low pressure.
 - ii.Evaporator low temperature.
 - iii.Refrigerant high pressure.
 - iv.Low oil flow or pressure.
 - v.Control device failure.
 - vi.Low control voltage.

3.12.6 Factory testing and commissioning

- 1) Factory performance test sheets shall be submitted in compliance with the following:
 - a) All routine tests specified by supplier
 - b) Rapid restart testing proving start-up times to full load within the specified
 - c) Full operational checks of all accessories
- 2) Provide type test certificates for the following:
 - a) Noise level

3.13 Chiller Sound Power Level

Tenderers are to refer to the returnable spreadsheet document for completion by the Tenderer pertaining to the sound power level

3.14 Source Quality Control and Warranty

- 1) The chiller shall be factory performance tested under full load conditions in an ambient controlled test facility per ARI 550/590-2001. The manufacturer shall supply a certified test report to confirm performance as specified. Proper ARI certification documents for the test loop shall be made available upon request from the manufacturer for inspection. The performance test shall be conducted in accordance with ARI Standard 550/590-98 procedures and tolerances. The test conditions are for the ARI rating point of 20C leaving the evaporator, 30C entering the evaporator, and 40C ambient only.
- 2) The performance test shall be run with clean tubes in accordance with ARI 550/590-98 to include the following:
 - (a) A downward temperature adjustment shall be made to the design leaving evaporator water temperature to adjust from the design fouling to the clean tube condition.
 - (b) An adjustment of the ambient temperature to adjust from design elevation to test facility elevation. This adjustment is to maintain the same saturated condensing temperature at design conditions to those at test conditions.
 - (c) The factory test instrumentation shall be per ARI 550/590-98, and the calibration of all instrumentation shall be traceable to the National Institute of Technology.
 - (d) For regions where other equipment rating standards apply the performance tests shall be modified to match the performance test standards for that region

- 3) The owner or his representative shall be notified 14 days in advance or another mutually convenient period to witness the factory performance test. If the owner or his representative desires to witness the performance test, all travel expenses will be the owner's responsibility.
- 4) A certified test report of all data shall be submitted to the Engineer/Owner prior to completion of the project. The factory certified test report shall be signed by an officer of the manufacturer's company. Pre-printed certification will not be acceptable; certification shall be in the original.
- 5) One year after start-up or 18 months after delivery, whichever is later, continuing again after a defect is completely rectified. The repair period, from the time the defective behaviour is reported until it is repaired without recurrence, shall be added to the warranty's length. The defect will be considered rectified after Manufacturer's replacement or repair, including parts and labour at the Manufacturer's expense of the failed and malfunctioning components' that caused or will lead to a recurrence of the defect. The warranty shall cover all Manufacturer supplied equipment with an agreed 24 HOUR 7 DAYS PER WEEK response time. This warranty shall be included with the base proposal.

3.15 Final Inspection and Start-up Service

- 1) After the Mechanical Contractor has provided all water piping connections, and field control wiring, and Electrical Contractor has provided all the field power wiring, the factory-authorized service representative employed by the chiller Manufacturer shall inspect the installation. The Mechanical Contractor shall then perform the start-up of the equipment.
- 2) The BMS Contractor shall be scheduled to be at the job site at the time of the equipment start-up
- 3) Under the guidance and supervision of the factory-authorized service representative employed by the Chiller Manufacturer the Mechanical Contractor shall perform the following tests and services and submit a report outlining the results:
 - (a) There has been no physical damage to the unit.
 - (b) The unit is level.
 - (c) Chiller vibration isolation and flexible pipe connections are installed, and the springs are free floating.
 - (d) Clearances have been maintained and piping is installed for easy removal for service and tube cleaning.
 - (e) Chilled water pipes have been connected to correct ports.
 - (f) Labels and safety instructions are clearly visible.

- (g) Oil levels are those recommended by manufacturer.
- (h) Refrigerant charge is sufficient, and chiller has been leak tested.
- (i) Shipping skids, blocks, and straps have been removed.
- (j) Controls and safety interlocks have been installed and connected.
- (k) Pumps are installed, connected, and operational.
- (l) Check and record performance of chiller protection devices.
- (m) Check and record performance of chilled water flow and low temperature interlocks.
- (n) Operate chiller for run-in period as recommended by manufacturer.
- (o) Check the static deflection of vibration isolators, if used, including the deflection during chiller start-up and shutdown to assure that they are at least as much as the specified deflection while leaving the designed distance between coils.

4 Specification – Cooling Plant Controller (CPC)

4.1 General

- 1) The tender shall be submitted for the design, manufacture, supply, deliver to site of the CPC as listed in the schedule.
- 2) A total of two (2) CPC's will be required as detailed in this specification.
- 3) The system is designed to function in a N+N configuration. Thus, should one CPC fail the standby CPC is to instantly take up control.
- 4) The CPC's will be responsible for the primary control of the entire cooling generation chilled water plant.
- 5) The CPC's will both be connected and interfaced to a future BMS system by others, and must not have integration difficulty. Proof thereof is required.
- 6) The tender shall meet the quality, function, and performance requirements of this specification.

4.2 Arrangement

- 1) Provide two digital controllers (CPC) with BACnet/IP high level interfaceable with the future BMS. Complete points list including registers is to be provided to installation contractors.

- 2) The supplier is to provide an automatic control system that is fully compatible with the selected chiller controllers/HLI's and associated plant herein discussed that has been proven to control its equipment and can easily incorporate inputs and outputs to field instrumentation and other controllers (in this case pump VSD's, Fresh air units etc) of various types.

4.3 System Structure

- 1) There shall be two HMI / CPC interfaces providing means to:
 - a) Supervise the system performance and status in the form of dynamic graphics and point status lists
 - b) Program cooling plant control philosophy
 - c) To change set points and read the local set points of sub-system controllers
 - d) To acknowledge and prioritize alarms and route messages to future BMS
 - e) To interface and communicate with other systems via BACNET / IP
 - f) Each be capable of being connected via network connection to the future BMS
 - g) The two CPC's are to be interconnected to operate as duty / standby. Should CPC A fail, CPC B will keep control and the loss of CPC A will be alarmed to the future BMS and vice versa
 - h) Schedule stop/start, set point changes and form of running ie. Chiller free cooling optimization
 - i) An option start algorithm based on the schedules, previous day ambient temperature profile, day of the week and month
 - j) Perform calculations on real time data
 - k) Record run-time totalization on monitored plant equipment

4.4 Password Protection

- 1) Access to the CPC must be restricted through a password protection facility.

- 2) A minimum of 10 alpha-numeric passwords of up to 10 digits shall be provided. Each password shall be assignable to any of 10 levels of authority.
- 3) The system shall have the ability to track sessions to determine when each user was logged into the system, and changes each user made.

4.5 System Addressing

- 1) System point addressing shall be by English language text identifiers and operating selectors.
- 2) Multiple point addressing by plant, location or other set attribute shall be possible both as methods of interrogation and control.

4.6 Functional Operation

The functional operation described below sets out the minimum requirements for operation.

4.6.1 Enable/Disable

- 1) Chillers can be manually enabled by an operator at the chiller's controls cabinet. Conversely, a chiller can be disabled manually. A disabled chiller cannot be called to run by the CPC.
- 2) The chiller may now be called to run manually from the control panel or on Stage-Up function via chiller inter-communications.

4.6.2 Start-up

On chiller start signal from the CPC, the chiller controller sends start signal to the primary pump and motorised valve return line. Once flow has been confirmed the chiller starts. The chiller then operates as described under Normal Cooling Operation.

4.6.3 Normal cooling operation

4.6.3.1 Cooling control

The chiller controller operates all systems associated with the free cooling and DX refrigeration system to achieve a constant supply water leaving temperature. The chiller controls shall be optimised to minimise overall energy usage based on ambient conditions and return water temperature and use of the onboard free cooling.

4.6.3.2 Free / Hybrid cooling

The CPC is to be able to determine what the most efficient combination of chillers and free cooling coils should be.

4.6.4 Power Failure

- 1) There are two conditions under which the chiller power supply will be lost:
 - a) Supply from power string failed or failure of ATS on chillers equipped with these
 - b) Site wide power loss and transfer to generator supply

Supply from power string failed

On power string failure the chiller power supply will be lost. The chiller controls are to continue to operate on internal UPS. The loss of power is detected by the chiller controller and communicated to the chiller network which may require a chiller Stage Up. The chiller controllers are not UPS supported except for the onboard capacity. Thus, after a prolonged loss of power string the chiller controller will need to start up.

Site wide power loss

- 1) On Site wide power loss all chillers will lose power. The chiller controls continue to operate on internal UPS until generation power is restored.
- 2) Power will be generally restored in a maximum of 20s. Once power is restored, the chillers are to enter a rapid restart mode:
 - a) Chiller generator power on within 20s and provides full cooling capacity within <280s.
 - b) All chillers operate at full cooling until the following conditions are met:
 - i. High level chilled water buffer tank (in at least one tank) temperature <22C is reached
 - ii. Time delay has exceeded 300s (adjustable) Chiller controls then revert to normal cooling operation via CPC

4.6.4.1 Sequencing

The chillers sequencing will be 1,2,3. This sequence will rotate to 2,3,1 and so on a weekly basis.

4.6.5 Shutdown

- 1) A chiller can be shutdown in the event of the following:
 - (a) If a chiller is manually disabled at its control panel for maintenance etc.

- (b) If the chiller has been called to stage down
- (c) If the chiller has disabled on a fault condition

Chiller manually disabled

- 1) The chiller operates as follows:
 - a) Chiller enters internal shutdown procedure and shuts down the primary pump

Chiller Stage Down

If a Stage off signal is received by the chiller through its internal communications, the chiller will shutdown as per chiller manual disable description.

Chiller Fault

- 1) If a fault requiring chiller shutdown occurs, the chiller will shutdown as per chiller manual disable description. The fault shall be communicated via the chiller bus and stage another chiller on if required.
- 2) Provide low level fault relays for the following:
 - (a) General fault / chiller shutdown event
 - (b) Primary pump fault

5 Testing and Commissioning

Along with the commissioning requirements referred to in the standard MEP specification the following are equipment specific requirements.

5.1 Site Tests

Carry out the following witnessed site acceptance testing as a minimum for each individual element of the Chillers and for parallel systems as applicable (HVAC contractor with assistance by the Supplier):

Unique Test Requirement
Reference

1	Visual Inspection
	Perform a visual inspection of the unit. 1) Record the Serial Number of the unit and any ancillary cabinets under test 2) Confirm the following:

	<ul style="list-style-type: none"> a) Units are undamaged b) Cabinets and Connections are clearly labelled c) Doors and access panels open freely. d) Safety protection equipment etc are in place e) General construction and standard of finishes are acceptable f) Levelling and alignment of units are correct and acceptable g) Anti-vibration mounts are in place and equipment is properly mounted h) Warning labels and signage fitted i) Confirm sufficient pressure/temperature/flow test points have been included within the pipework serving the chiller to facilitate full and adequate measurement of relevant data. <ul style="list-style-type: none"> 3) Record ambient temperature and humidity during the testing. 4) Confirm pressure test of all pipework has been carried out prior to system charging 5) Check all unit settings against type test script requirements and results 6) Provide photographic evidence of unit status 7) Collate information and checks into a formal report and issue
2	Functional Operation Tests
	<p>Perform the following functional tests:</p> <ul style="list-style-type: none"> 1) Unit start-up using manual or test option on panel control 2) Unit start up using remote switching contacts 3) Manual Shutdown 4) Flush, chemically clean and pre-treat system

	<p>5) Demonstrate correct functionality and reporting of unit control and alarm parameters. This should include, but not be limited to:</p> <ul style="list-style-type: none"> - Alarm functions (all alarms) - Alarm Handling - Local control and user interface operation and display - Remote monitoring (all functions) - Conduct power failure restart tests (confirm re-start times) - Compressor safeties (high pressure, oil pressure etc) - Chiller safety alarms (low flow, high pressure etc) - Compressor staging <p>6) Re-start unit</p> <p>7) Simulate all alarm functions and FCMS interfaces</p> <p>8) Simulate loss of controls function.</p> <p>9) Water side of each heat exchanger shall be hydrostatically tested to 1.5 times the rated working pressure</p> <p>10) Collate information and checks into a formal report and issue</p>
3	Performance testing
	<p>Perform the following performance tests to prove the overall performance of the unit at various load conditions and operational modes.</p> <p>1) Record ambient temperature and humidity conditions</p> <p>2) Provide as much load to the chillers as possible given available AHU/CRAC's and heat loads. Demonstrate that the unit can maintain constant water temperature. Record ambient, supply air and return air conditions throughout the test.</p> <p>3) Demonstrate correct operation of free-cooling system (where applicable)</p>

	<p>4) Monitor and record electrical and water use throughout the test. As a minimum the following shall be recorded:</p> <ul style="list-style-type: none"> a) Chiller total cooling capacity (kW) <ul style="list-style-type: none"> ■ b) Evaporator water flow rate inlet/outlet (L/s) c) Evaporator CHW Pressure drop (kPa) d) CHW temperature Inlet/Outlet (°C) <ul style="list-style-type: none"> ■ ■ e) Oil pressure all circuits (kPa) (if applicable) <ul style="list-style-type: none"> ■ f) Compressor discharge pressure (kPa) g) Compressor suction pressure (kPa) h) Condensing pressure (kPa) i) Compressor running current (Amps) j) Voltage between each phase k) Current each phase (A) l) Power consumption motor (kW) m) Sound level criteria n) Trend log of stable control temperature o) Percentage heat balance p) kW/kWR
4	Outputs & Interfaces
	Perform the following output and interface tests:

1) Test all nominated low level alarms by simulation of condition

6 Performance

6.1 Energy Consumption

- 1) A key requirement of the chillers is to provide robust, energy efficient cooling. While the energy consumption tables to be completed in the returnable spreadsheet document, the supplier is to take into consideration that the secondary pumps will also be controlled via the CPC and multiple chillers can in some cases provide greater efficiency (via various control strategies) and therefore provide any alternate control logic should it differ from that described in this document.
- 2) Tenderers are to complete the energy consumption tables in the returnable spreadsheet document in full relating to the energy consumption of the systems offered.

7 Chiller Specification

The air cooled chiller specification are as per the table below.

Tenderers are to refer to the returnables spreadsheet document to be completed and returned with the tender for the chiller options as listed in the Specification document. Schedules to be resubmitted for reconfirmation for all subsequent purchase order confirmations.

AIR COOLED CHILLER			
GENERAL	Service		Building Cooling
	Identification		CH 01,02,03
	Cooling type		DX + Integrated free cooling
	Quantity	Duty (N)	2
	Configuration	Standby (N+1)	1
	Total Nr of chillers	Total	3
	Design max condenser entering air temperature (100% load)	°C	37,6
	Minimum ambient temperature	°C	-1.7
	Total Nett Cooling Capacity (per chiller)	kW	1000
	EER value (AHRI)		>3.5
	Eurovent Class		A
	Chilled Water Temperatures	Supply (°C)	16
		Return (°C)	24
	Refrigerant		R134a (or alternate Gen 5) Must be future proofed for retrofitting
	Number of circuits	No	2.0
	Dimensions (L/W/H)	<mm	12000l X 2,400w X 2,700h
Operating Weight	<kg	<14,000kg	
EVAPORATOR	Number of compressors	No	>2
	Entering air temperature	DB (°C)	37,6
	Pressure Drop	Pa	-TBC
	Full load water flow per Chiller	l/s	29,9
	Max water flow	l/s	TBC by supplier
	Min water flow	l/s	TBC by supplier

CONDENSER	Fan Type		EC
	Number of fans	No	TBC by supplier
	Air volume	m ³ /s	TBC by supplier
	Total Face Area	m ²	TBC by supplier
	Hail Guard		Yes
	Fan Static Pressure	Pa	TBC by supplier
	Fouling factor (max)	m ² K/kW	0.00044
	Cooling/Condenser Coil Construction		Copper with aluminium fins
ELECTRICAL	Voltage / phase / frequency	V/A/Hz	400/3/50
	Total Running Power	<kW @ EER	295
	Total Running Current	Amp	500
	Total Starting Current	Amp	VSD
	Starter (Compressor)		VSD
COMPRESSORS	Number of Compressors	No	2
	Capacity Steps	No	Variable
	Unloading Capacity (minimum)	%	12.50%
	Compressor Type		Screw Type / centrifugal
SOUND	Sound Power Level (dBa) to Eurovent	Sound Pressure (dBa)	<95
	Sound Pressure Level (dBa) to Eurovent	Sound Power @ 10 m (dBa)	< 55
FREE COOLING	Configuration of free cooling		To supplier proposal (Series / Parallel)
	Head	kPa	TBC by supplier
OTHER	Coil treatment		N/A
	Piping Connection Size	mm	125

	Glycol Percentage	%	0
	Power factor correction	-	Fitted
	Backup power supply	-	Allow for central plant UPS power supply to controller and secondary pump
	Heat exchanger	-	Shell-and-tube preferred
	Controller	HMI	Supplier controller with touch panel
		Protocol	BACNet preferred
	AV Mounts	-	Spring type included in supply

SECTION 6: FRESH AIR ROOFTOP DX UNIT SPECIFICATION

1 Introduction

This specification is to be read in conjunction with the General specification

The requirements are for the final design, manufacture, supply, delivery, rigging into position and commissioning of a Full fresh air DX rooftop unit to satisfy the fresh air requirements of the Data Halls.

1.1 Objectives

- 1) The intent of this specification is to:
 - a) Define the priorities and objectives that shall guide the design & documentation decisions
 - b) Define the technical requirements for the equipment, installation, testing, commissioning & documentation
 - c) Equipment requirements
 - d) Preparation of documentation
 - e) Factory Acceptance Testing
 - f) Delivery of equipment
 - g) Commissioning of equipment

1.2 Scope delineation

The following table confirms the scope of the suppliers supply:

Table 1-1 Scope delineation

Delineation				
Item	Description	Responsible Contractor		
		Electrical	HVAC	Supplier
1	Manufacture, supply, deliver to site, offload	-	X-	X

2	Electrical connection to unit		X	-
3	Ducting connections, ducting installation	-	X	-
4	Communication connections to SC	-	X	-
5	Commissioning (as per RACI matrix)	-	X	X

1.3 Warranty

The warranty shall incorporate the following:

- 1) Warranty means that all patent and latent defects will be rectified by the Vendor arising from defective materials, workmanship or design at his expense during the warranty period.
- 2) Warranty excludes defects that may arise from the misuse or abuse by the Employer.
- 3) Servicing of the unit is to be conducted during continuous operation, when the unit is in cold standby mode.

2 Design Requirements

2.1 Industry Standards & Guidelines

All work shall meet all the requirements of national and local Statutory Authorities and shall be in accordance with the following:

Table 2-1 Industry standards

ASHRAE 90.4	Thermal energy standard for data centres
ASHRAE TC9.9	Data centre powered equipment thermal guidelines best practices
SANS 10400	South African national standards
OSH Act 1993	The occupational health and safety act of 1993, as amended
SANS 10142	Wiring of premises
	Government, Provincial and Local authorities' ordinances, regulations, by-laws, rules and other statutory requirements

SANS	Specifications and codes of practice issued by the South African Bureau of Standards and British Standards Institute. The former shall have precedence over the latter where both bodies have issued conflicting specifications or codes of practise.
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3 Specification-Fresh Air Package Unit (FAU)

3.1 General

- 1) Supply and install as shown on drawings and as listed in the schedule an air-cooled, self-contained DX full fresh air rooftop unit complete with compressor(s), coils, spray humidifier, fan(s), filter(s), safety controls, refrigerant and lubrication.
- 2) The unit shall be fully protected and fail safe.
- 3) Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory. Certified detailed selection shown on these performance curves and tables shall be submitted.
- 4) The unit shall have capacity control to vary its capacity in response to varying load conditions.
- 5) Units shall be complete with:
 - a) DX Condenser coil (dual circuit)
 - a) DX Evaporator coil (dual circuit)
 - b) Heat pump type variable capacity DX scroll (or similar approved) compressors
 - c) Spray Humidifier
 - d) EC supply air fans
 - e) Source selector (ATS)
 - f) All controls and control panels
 - g) Sensors
 - h) Wiring
 - i) Internal piping and valves
 - j) Tubing
 - k) G4 filter
 - l) F7 filter
 - m) Associated accessories
 - n) All other components necessary to make a complete operating FAU package
 - o) Power factor correction

p)Automatic restart after power failure

(jj)

- 6) Minimum safety protection shall be provided for the following, complete with manual reset after fault occurrence.
 - a)High discharge pressure.
 - b)Low suction pressure.
 - c) Low oil pressure differential.
 - d)Combined thermal overload and phase failure for three phase motors.
 - e)Thermal overload for single phase motors.
- 7) The Air Handling Units should be designed and constructed to have an effective design life of 15 years at 24/7 operation. Maximum availability, energy efficiency and continuous year-round operation is required for the application.
- 8) All accessories and equipment shall be built to a high quality standard to minimize maintenance costs and reliability issues during life of the equipment
- 9) The units shall be labelled in accordance with UL or the comparable regional standard and certification agency. Client specific requirements take precedence.
- 10) Units shall be factory fabricated and tested. The tested units shall include all of the unit sizes, capacities, and configurations, either as indicated or specified in the bid documents.
- 11) All internal components specified herein or in the schedules or added by alternate price acceptance shall be factory furnished and installed. All of these components shall be part of the units' guarantees. They shall retain the units' applicable required agency and approvals. Units shall be completely factory assembled.
- 12) Units shall ship in one (1) piece. If they are too large to ship in one piece, or if shipping them assembled creates an unacceptable breakage risk, the Vendor shall provide, at no additional cost to other parties, the labour and materials to completely reassemble the units on the Owner's jobsite by the scheduled delivery time. The Vendor shall coordinate the onsite work, having provided adequate notice to accommodate other work at the site, with the Owner's construction personnel.
- 13) All elements vulnerable to harm and easily exposed to maintenance personnel's inadvertent stepping or access interference shall be protected by ridged metal guards capable of accepting the plausible forces without significant temporary or any permanent deflection.
- 14) Units to come complete with a condensate drain at the lowest point.
- 15) Special care shall be taken in transport, delivery, storage on site and installation to ensure that the units are installed and maintained in 'as new' condition at start-up.
- 16) The unit shall comply with "Safety Code for Mechanical Refrigeration", ASA-B9.1.

- 17) The unit shall comply with the Occupational Health and Safety Act of 1993, as amended, and with local authorities by-laws.
- 18) Refrigerant shall be R410a or generation 5 refrigerant
- 19) Exposed condenser coils shall be complete with hail guards.

3.1.1 Casing

- 1) The frame, cabinet and access panels shall be fabricated from steel/aluminium frame (or alternate approved) and cromadek and resist all bending greater than L/200 during shipping, testing and normal operation and loading. The unit shall have easy access to all internal components. Colour shall be as per Suppliers' standard unless otherwise indicated by client requirements.
- 2) Casing shall not leak, vibrate or drum under operating conditions.
- 3) Water shall not condense or leak onto the floor of the casing.
- 4) Casing panels shall be easily removable for access to the interior.
- 5) Casings shall be :
 - a. Sectional construction rigidly braced and bolted. Single skin insulated. All parts shall be hot dipped galvanised - epoxy coated to an approved colour.
 - b. Where units are exposed to the weather casing shall be fully protected and waterproofed.
 - c. All openings through the casing shall have grommets.
 - d. Access to controls, piping and supply fans shall be through panels with locks and lift tabs. Filters shall be rear mounted unless noted otherwise in the specifications.
 - e. The unit shall have readily removable front hinged panels or access doors with all serviceable components accessible and removable for maintenance.
 - f. The unit shall be of robust construction, completely insulated and of double skin construction to prevent condensation of moisture.

3.1.2 General

- 1) Coils having loose or damaged fins and distorted tubing, or dents will be rejected and must be replaced with new coils.
- 2) Condensate trays shall stainless steel with drain connections.
- 3) The bottom condensate tray shall be installed on 25 mm thick insulation with thermal conductivity of not more than 0,04 W/m °C.
- 4) Insulation shall be resistant to decay and mildew and shall be water impervious.
- 5) No moisture shall be carried beyond the sump under any operating condition.

- 6) Airtight access doors shall be provided before and after the coil.
- 7) Sufficient space shall, be allowed upstream and downstream of the coil bank for cleaning purposes.
- 8) Sufficient space shall be available adjacent to the air handling unit for coil removal and installation.
- 9) Coils shall be arranged for counter flow of air to cooling medium and no by-pass of untreated air shall occur.
- 10) Suitable baffling of diffusers shall be provided, if required, to ensure uniform coil velocity.
- 11) Coils shall not distort or vibrate in operation.

3.1.3 DX Heat Pump

- 1) The DX heat pump coil shall be furnished and installed integral to the unit. The coil shall be sized and configured within the air handling unit to meet the performance requirements set fourth in the schedule and as specified under the other sections of this work.
- 2) The coil shall be constructed of copper tubes, aluminium fins and galvanized steel casing or Owner approved alternative.
- 3) The coils shall be attached to the unit and sealed. This attachment shall avoid any air bypassing the unit on the coils' top, bottom, and sides.
- 4) If the coils or any other tubes penetrate the sides of the unit, they shall be positively sealed to prevent air from passing through the unit's walls.
- 5) Any element external to the unit shall be insulated and completely free of external condensation during operation.
- 6) Minimum safety protection shall be provided for the following and require manual reset after fault occurrence.
 - a) High discharge pressure.
 - b) Low suction pressure.
 - c) Low oil pressure differential.
 - d) Combined thermal overload and phase failure for three phase motors.
 - e) Thermal overload for single phase motors.
- 7) The refrigerant piping system shall be adequately supported so that no strain is imposed on the components.
- 8) The unit shall be so constructed and installed, and sufficient spares be available to limit the:
 - a) Maximum routine service to 1 hour.
 - b) Maximum annual service to 4 hours.
 - c) Maximum breakdown to 1 day.

- 9) The compressor shall be hermetically factory sealed against moisture and dirt. The unit shall have at least two compressors and two independent refrigeration circuits. Coils shall have copper tubes and aluminium fins with corrosion treatment as mentioned elsewhere. Fin spacing shall be more than 2,5 mm.
- 10) During the welding of refrigerant copper piping, a small amount of nitrogen must be passed through the pipes to avoid flaking of the inside of the piping.
- 11) All refrigerant piping shall be well saddled and secured to minimize vibration of piping.
- 12) Brazed joints shall be used instead of screwed or flared joints. The number of joints shall be minimized.
- 13) All refrigerant piping must be pressure tested at 20% above operating pressure, using nitrogen and the refrigerant that will be used in the system. The system pressure must be observed, and any reduction in pressure means that there is a leak in the system. An approved leak testing method must be used to find leaks. After leak repair, the pressure test must be repeated.
- 14) All refrigerant piping system are to be evacuated with a vacuum pump, to a pressure of 40 to 45 microns (electronic vacuum gauge). A two-stage vacuum pump must be used specially designed for this purpose.
- 15) If the vacuum reading moved above 45 microns in 2 hours, the system must be checked for leaks or further vacuum pumped to remove moisture.
- 16) Records of pressure testing and evacuation of each refrigerant piping systems must be kept and submitted to the mechanical engineer.

3.1.4 Spray humidifier

- 1) Supply and install as shown on the drawings and as listed in the schedule, a self-cleaning spray humidifier complete with casing, straightening vanes, spray nozzles, pump, eliminator and sump.
- 2) The humidifier shall be a standard catalogued product of a reputable manufacturer and shall be fully factory tested. The documentation shall include performance curves and selection tables for the expected range of operational conditions.
- 3) Performance curves and selection tables shall be based on a reproducible and certified test in an approved laboratory.
- 4) Submit certified detailed selection shown on these performance curves and tables.
- 5) The capacity shall be automatically controlled as shown on the drawings. The water level shall be automatically controlled.
- 6) Submit:
 - a) Installation, testing, balancing and commissioning instructions.
 - b) Trouble analysis guide.

c) Number and details of periodic service of the recommended preventive maintenance programme.

- 7) The washer and all its components shall be readily accessible for maintenance and component replacement without dismantling of panels and other items of equipment.
- 8) The unit shall be selected for a minimum service life of 10 years, operating for 3000 hours per annum under normal building operating conditions.
- 9) The required unobstructed space shall be left around the installation for access, maintenance and service of the equipment in accordance with the manufacturer's instructions.
- 10) A see-through access door shall be provided for regular inspection of the spray nozzles.
- 11) The humidifier shall be so installed so as not to leak water onto the floor. The necessary sump and drip trays piped to the plantroom drain shall be provided for this purpose.
- 12) The washer shall be suitable for an operating voltage of 380 V +/- 10%.
- 13) The humidifier shall be connected to untreated mains water supply. Variation in pressure of water supply shall not affect the humidifier.
- 14) The humidifier shall be complete with inlet straightening vanes and discharge eliminator. No water droplets shall carry over between 0 and 120% of design air flow. Only vaporized saturated air shall leave the humidifier. Blade material shall be PVC.
- 15) The casing shall be of rigid and durable construction and shall be manufactured of stainless steel, fibreglass or fibreglass reinforced plastic.
- 16) Casing shall not leak, drum or vibrate under any operating condition and water shall not condensate or leak onto the floor of the casing.
- 17) Sufficient damp proof and robust lighting shall be provided at the various operating sections in the casing for the purposes of inspection, maintenance and repairs. Light switches shall be on external face of casing.
- 18) The washer assembly shall fit into the space as shown on the drawing.
- 19) The chamber shall be suitable to operate at an internal pressure of 600 Pa. without leakage or distortion.
- 20) Nozzles shall be plastic spray nozzles with stainless steel inserts to ensure fine atomization of water particles. Nozzles shall be attached to pipes with quick release clamps.

3.1.5 Supply air fans

- 1) The fans shall be EC motors with associated controls.
- 2) Units shall be direct drive, dynamically balanced on all principal axis, airfoil shaped blade plug fans arranged in a fan array, or Engineer approved equal.
- 3) Motors shall be designed for variable speed operation and shall be premium efficiency totally enclosed with sealed and locked bearings with a NEMA rated frame designed for quiet

operation. Motors shall be driven through VFDs. The motors shall be specifically designed for VFD operation (not 'acceptable for') and include grounded bearing protection rings grounded to the other components of the drive system to reduce bearing frosting, pitting and failure caused by VFD induced voltages and currents across the motor bearings and shaft.

- 4) The fans shall be capable of overcoming an external resistance as per the data sheet plus the resistance of all components associated with any ducted supply or return air sections.
- 5) FAU's fan power shall be no higher than 0.72-0.9W electrical of net sensible cooling flow at design capacity. For example, if the design flow for a unit is 1000l/s to meet the sensible capacity requirements, the fan power shall be no higher than 720-900W. It is noted the motor rating will potentially be higher than this value. If this is not possible the vendor is to bring it to the attention of the Engineer

3.1.6 Electrical

- 1) Units shall come complete with a dual power source selector (ATS).
- 2) All electrical wiring shall be brought to a numbered terminal strip within the panel.
- 3) A non-fused disconnect shall be located on the control panel and accessible from the exterior for connecting building power to the unit.
- 4) All branch circuits shall be individually protected.
- 5) They shall include a low-voltage control circuit transformer.
- 6) Motors shall be protected on all phases.
- 7) Units shall be provided with phase and brown out protection that shuts down all motors in the unit if the electrical phases are more that 10% out of balance on voltage, or the voltage is more than 10% under design voltage or the phases reverse. The units shall have an auto-restart function accompanied by an alarm to the remote BMS and the unit's control panel.
- 8) All connections and wires to be clearly labelled.
- 9) Units to be fitted with power factor correction.

3.1.7 Filters

- 1) Supply and install as shown on the drawings and as listed in the schedule, filters passing the air quantity at the specified maximum face velocity, pressure drops, efficiency and dust loading capacity.
- 2) Filter Chambers - Shall be integral to the unit, located at the rear/inlet air face of the unit and easily serviceable. The filters shall be 30% - 100mm deep ASHRAE 53-76 minimum or F7 and G4 rated filter according to EN779 to comply with ASHRAE recommendations to achieve air quality.

- 3) Air filters shall be a current catalogued product with complete documentation, including tables and graphs listing efficiency, loading capacity and pressure drop, for the expected range of operating conditions.
- 4) Certified detailed selection shown on these performance tables or curves shall be submitted
- 5) The filter bank shall be so constructed and installed and necessary access provided to make it possible to change one filter element in five minutes.
- 6) Filter materials shall be fire resistant.
- 7) Filters shall be adequately protected against dirt during construction and shall not be operated until system is thoroughly cleaned.
- 8) Special care shall be taken in transport, delivery, storage on site and installation to ensure that the filters are installed in 'as new' condition.
- 9) After all the adjustments etc., are completed and before the filters are accepted for regular operation, these shall be cleaned and provided with additional new media to put them in new condition
- 10) Filters must be put in regular operating conditions before the fans are operated for any purpose, such as temporary ventilation or adjusting.
- 11) The filter frame shall be suitable for standard commercial range of filter media available
- 12) An air filter gauge shall be installed on each filter bank. The gauge shall be connected to static pressure taps of approved design, so that it will indicate correctly the resistance to the air flow of the filter.
- 13) Connection shall be made with copper tubing and shall be provided with three-way cocks.
- 14) Gauges shall be carefully levelled and adjusted.
- 15) Each filter bank shall be provided with an identification plate mounted in a location readily visible after installation
- 16) Plate shall show serial number, model number and all other data necessary for ordering the new media.
- 17) Filter elements shall be either removable from sides of unit or front of filter bank.
- 18) Adequate personnel access shall be provided in front of filter bank if filter elements are removed from front.
- 19) The filter elements and filter frame shall be fully corrosion protected. Construction of filter frame, and method of holding down filter elements shall ensure no passage of unfiltered air through filter bank.
- 20) One spare set of filters shall be provided for each filter bank.

3.1.8 Drain Pan

- 1) All cooling coils, humidifier and fan section to be provided with an insulated stainless steel drain pan.
- 2) Pan to be installed under DX, humidifier and chilled water coil and extend past the end of coil. If there are stacked coil sections, the drain pan for each section shall be piped independently to the unit's lowest drain level.

3.2 Controls

3.2.1 General

The unit shall be provided with an advanced control processor with a front display panel and control keys for user inputs. The controls shall be menu driven on-screen prompts for easy user operation. The system shall allow the user to review and program temperature and humidity set points alarm parameters, and setup selections, including the choice of control type. A password shall be required to make any system changes. For all user selections, the range of acceptable input (temperature, humidity, or time delay) shall be displayed on the monitor screen. The system shall provide monitoring of room conditions and display the operational status in % of each function, each component's run times, the date and time the variable was recorded, and four analog inputs from sensors provided by others.

The unit controller shall be factory installed. The controller shall be fully capable of operating in a 100% stand-alone control mode. The controller shall be able to connect to the CPC or BMS using BACnet. Minimum open protocol points are operation mode, supply air temperature, entering air temperature, supply air temperature set point, fan speed, common alarm.

Control architecture shall be open allowing all functionality to be controlled remotely by any third party system without licensing requirements.

All set points shall be adjustable from the individual unit control panel.

Each unit controller shall be able to collate and process as a minimum the following primary control signal from the CPC/BMS:

Unit Start/Stop

Unit Operational State

Unit Supply Air Temperature Set-point

Unit Fan Speed

Unit Common Alarm

The unit shall be capable of being controlled to maintain supply air temperature and humidity.

Humidity control will be based on input via the BMS from the data hall RH sensor. The activation/deactivation of either dehumidification or humidification will also determine supply air conditions as shown on the drawings.

The unit shall come with a HAND/OFF/AUTO switch where:

- a) OFF FAU is deactivated
- b) AUTO FAU is controlled by the CPC/BMS
- c) HAND FAU runs on its unit local controller with no input into from the CPC/BMS

The HOA switch setting for each FAU will be sent to the BMS via BACnet communication channels.

Normal Operating Modes shall be indicated by coloured LED's on the unit-mounted display panel.

Unit shall be capable of auto restarting without human intervention following normalization of any trip condition including power transient events (power loss, voltage sag, voltage spike, etc.).

Unit shall be capable of automatically starting and loading to 100% in less than 2 minutes.

Air Sensors - Provide accurate and highly reliable temperature sensors factory mounted in the supply (x1) air stream of the unit. Provide an accurate and highly reliable humidity sensor factory mounted in the supply air stream. The supply air sensor shall be accessible and located in the unit discharge after the coil.

In addition, the system shall provide the following internal controls:

System Auto-Restart - For start-up after power failure, the system shall provide automatic restart with a programmable (up to 9.9 minutes in at least 30-second increments) time delay.

The control system shall monitor unit operation and activate a BMS alarm in the event of the following factory preset alarm conditions: 1) Restricted Air Filters; 2) Loss of Airflow; 3) Custom Alarm.

Monitor Display Panel - All indicators shall be in language form. No symbols or codes without a language form shall be acceptable.

Common Alarm

Common Alarm Terminals - The unit shall come equipped with two normally open, non-powered common alarm contacts for connection to a remote field supplied 24 volt alarm indication device (two sets required per unit).

A common alarm light shall be activated to indicate any common alarm and an alarm signal sent to the BMS.

Common alarms to include the following as a minimum:

- Missing filter alarm/Dirty filter alarm
- Fan failure
- HAND/OFF/AUTO

Password Protection. Each unit controller is to be provided with two different access levels

3.2.2 Supply air

- 1) Unit supply temperature will modulate to meet the supply air temperature based on supply/dehumidification/humidification set point and data hall humidity requirements.

- 2) Unit airflow will be variable with the fan speed only adjusting up to compensate for dirty filters and for commissioning purposes.
- 3) Supply air temperature control shall be primarily achieved by using the 2 port Pressure Independent Control Valve (PICV) installed on the chilled water coil with trimming, reheat and dehumidification done by the DX coil.

3.2.3 Fire

Unit to turn off in the event of a fire signal from any of the data halls.

4 Performance

4.1 System Conditions

1. The table below outlines the package unit conditions required for the project.

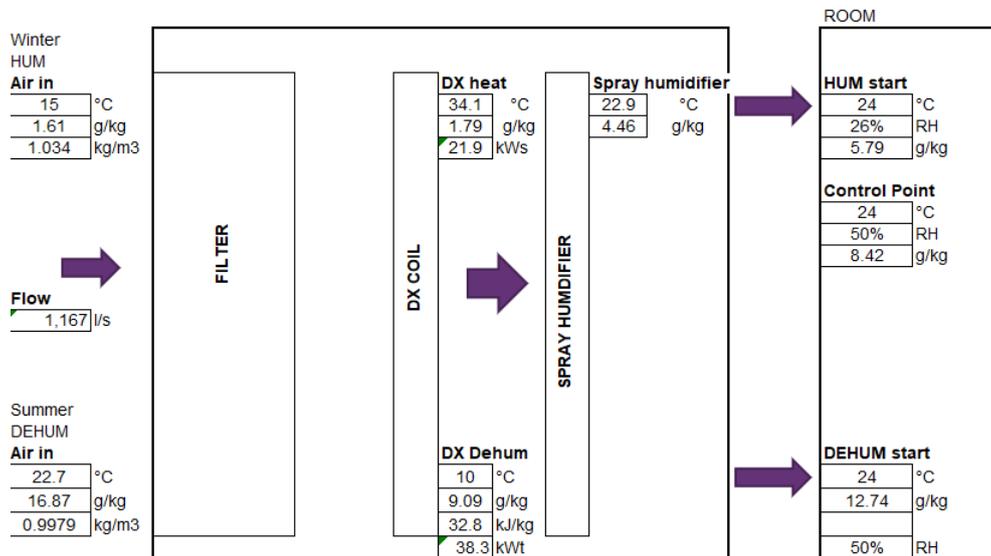


Figure 4-1 Unit design conditions

Table 4-1 Unit capacities (to be completed)

FRESH AIR HANDLING UNIT			
			Specified
1	Location		Roof
2	Number off		1
Capacities (DX coil)			
DEHUMIDIFICATION			
3	Total Cooling Capacity (Dehum)	kW	38,3
4	On Coil Temperature	DB(°C) (0,4%)	22,7°C
5		WB(°C) (0,4%)	20,3°C

6	Off Coil Temperature	DB(°C)	10°C
7	Design Cooling Supply Temp	°C	24C
8	Dehumidification rate	kg/hr	28,0
HUMIDIFICATION			
9	Total Sensible Capacity (HUM Reheat)	kWs	21,9
10	On coil temperature	DB(°C)(99,6%)	15
11		WB (°C)	4,1
12	Abs Humidity	g/kg	1,61
13	Off coil temperature	°C	34,1
Humidifier			
14	Steps	No	3-4
15	Capacity	kg/hr	12,4
Fan			
16	Supply Air Quantity	m ³ /s	1,167
17	Return Air Quantity	m ³ /s	0
18	Fresh Air Quantity	m ³ /s	1,167
19	Number of fans	No	TBC
20	Maximum coil velocity	m/s	2.5
21	Fan Static Pressure (external)	Pa	250
22	Fan Type		EC
Filters			
23	Dry media filter mass arrestance (EN 779)	Pre Filter	G4
24		Filter	F7
Heating Coil			
25	Design Heating Supply Temp	°C	35
Dimensions (approx)			
26	Height x Width x Length	mm	2000 x 2000 x 3000
27	Weight	kg	TBC
Electrical			
28	Voltage / phase / frequency	V/A/Hz	400/3/50
29	Fan Absorbed Power	kWe	0,8
30	Fan Motor Size	kWe	-
31	Compressor EER		>3

32	Compressor Absorbed Power	kWe	15,3
33	Humidifier pump	kWe	TBC
34	Unit Total Power Max	kWe	16,1
35	Starter (auto restart after power outage		VSD

4.2 Source Quality Control and Warranty

- 1) A certified test report of all data shall be submitted to the Engineer/Owner prior to completion of the project. The factory certified test report shall be signed by an officer of the manufacturer's company. Pre printed certification will not be acceptable; certification shall be in the original.
- 2) One year after start-up or 18 months after delivery warranty, whichever is later, continuing again after a defect is completely rectified. The repair period, from the time the defective behaviour is reported until it is repaired without recurrence, shall be added to the warranty's length. The defect will be considered rectified after Manufacturer's replacement or repair, including parts and labour at the Manufacturer's expense of the failed and malfunctioning components' that caused or will lead to a recurrence of the defect. The warranty shall cover all Manufacturer supplied equipment with an agreed 24 HOUR 7 DAYS PER WEEK response time. This warranty shall be included with the base proposal.

4.3 Final Inspection and Start-up Service

- 1) After the Mechanical Contractor has provided all water piping connections, and field control wiring, and Electrical Contractor has provided all the field power wiring, the factory-authorized service representative employed by the equipment vendor shall inspect the installation. The Mechanical Contractor with input from the supplier shall then perform the start-up of the equipment.
- 2) Under the guidance and supervision of the factory-authorized service representative employed by the equipment vendor, the Mechanical Contractor, shall perform the following tests and services and submit a report outlining the results:
 - a) There has been no physical damage to the unit.
 - b) The unit is level.
 - c) DX coils are in as new condition
 - d) Humidifier are in as new condition
 - e) Labels and safety instructions are clearly visible.
 - f) Shipping skids, blocks, and straps have been removed.
 - g) Controls and safety interlocks have been installed and connected.
 - h) Check and record performance of protection devices.

i) Operate unit for run-in period as recommended by manufacturer.

5 Testing and Commissioning

1) Along with the commissioning requirements referred to in the standard MEP specification the following are equipment specific requirements.

5.1 Site Tests

1) Carry out the following witnessed site acceptance testing as a minimum for each individual element of the Chillers and for parallel systems as applicable (HVAC contractor with assistance by the Supplier):

Unique Test Reference	Test Requirement
1	Visual Inspection
	<ol style="list-style-type: none"> 1. Perform a visual inspection of the unit. 2. Record the Serial Number of the unit and any ancillary components under test. Confirm a match with the factory inspection documents. 3. Confirm the following: <ol style="list-style-type: none"> a. Units are undamaged b. Cabinets and Connections are clearly labeled c. Doors and access panels open freely. d. Equipment positioning and clearances are in line with design drawings e. Safety protection equipment such as fan guards etc are in place 4. Record ambient temperature and humidity during the testing. 5. Remove temporary filter material and replace with final filters
2	Functional Operation Tests
	<ol style="list-style-type: none"> 1. Perform the following functional tests: 2. Single Units: 3. Unit startup using manual switch 4. Shutdown via manual/emergency stop switch 5. Re-start unit 6. Confirm correct operation of supply air fan 7. Confirm correct operation of supply air fan variable speed drive 8. Confirm total airflow achieved from each individual unit 9. Confirm correct operation of associated humidifier and motorized damper(s) 10. Confirm correct operation of cooling/de-humidification coil/valve in response to associated space sensor(s)

	<ol style="list-style-type: none"> 11. Confirm correct operation of individual FAU fan speed in response to associated pressure sensor(s) 12. Confirm correct operation of unit in response to duct mounted smoke detector and appropriate signal to FIP
3	Performance testing
	<p>Carry out the following performance tests once correct operation of each individual FAU serving a given space has been confirmed.</p> <ol style="list-style-type: none"> 1. Once correct operation of all systems serving one area is confirmed carry out an air balance to the area(s). 2. Confirm correct air balance achieved with all air conditioning and ventilation systems serving the area of the building in operation
4	Outputs & Interfaces
	<ol style="list-style-type: none"> 1. Perform the following output and interface tests: 2. Test all nominated alarms by simulation of condition, verifying signal indication at FCMS (if available) or point of interface (only if FCMS is unavailable). 3. Test all nominated equipment status indications and outputs by simulation of condition, verifying signal indication at FCMS (if available) or point of interface (only if FCMS is unavailable).

SECTION 7: SEQUENCE OF OPERATIONS SPECIFICATION

List of acronyms

AHU	Air Handling Unit
AO	Analog Output
BMS	Building Management System
BO	Binary Output
CRAC	Computer Room Air Conditioner. Also referred to as AHU in the content of this report
FAC	Fire Alarm System
FWU	Fan Wall Unit
HCS	Hydraunic Coil Set
HLI	High level interface
HVAC	Heating Ventilation and Air Conditioning
MxC	Max Cooling Mode
FAU	Outdoor Air Handling Unit
PICV	Pressure Independent Control Valve
PID	Proportional Integral Derivative
RAT	Return Air Temperature
SAT	Supply Air Temperature (this is the temperature measured after the AHU cooling coil and the fan)
SC	Supervisory controller
SOO	Sequence of Operations
ULC	Unit Level Controller

1 Overview

1) Sequence of Operation (SOO) is provided for the following:

a) Data Halls

b) UPS Rooms

c) Fresh Air Handling Unit

2 Data Hall

2.1 Overview

1) The total design IT cooling load is as follows:

a) Data hall combined 2000kW

b) UPS Room combined 170kW

2) The mechanical cooling for the data halls are defined as follows:

a) Data halls use *Cooling to Raised Floor Plenum with Cold Aisle Containment in Full Recirculation* design (no direct air economisation or use of outdoor air purging to achieve cooling in any shape or form) via the use of CRAC air handling units.

3) The control layers for the CRAC units will be as follows for setpoint change and control:

Supervisory controller (SC) → *Master unit level controller (MLC)* → *Local unit level controller (ULC)*

4) A single supervisory controller (SC) shall act as primary control to modulate the equipment per hall to maintain the data hall temperatures within the specified range.

5) For every 1 in 5 CRAC or FWU's there shall be one master unit which is linked to the SC. This unit will be responsible for collectively controlling the fan speed of the linked slave units to meet the worst case (highest) delta T over the CRAC / FWU supply vs return air temperature.

6) All HVAC air handling equipment shall be further referred to as AHU's in this document.

3 Supervisory Controller

1) All Proportional-Integral-Derivative (PID) calculations to determine AHU fan speed and AHU supply temperature reset shall be performed by the SC.

2) The SC shall be able to process:

a) an average of up to four (4) temperature sensor readouts provided within the data hall (where one (1) sensor is provided for every ten (10) IT Racks)

- b) the analog, binary and digital IO's of the data hall air handling units' individual Unit Level Controllers (ULC) (via master ULC) within each area / quadrant (viz. off-coil supply air temperature, on-coil return air temperature, CHW supply temperature, CHW supply flowrate, rAir flow supply rate)
- 3) Proportional and Integral tuning parameters for PID controls shall be defined external to the program logic for tuning within the SC. Appropriate hardware and software security shall be applied to lock out tuning by unauthorised parties.
- 4) The Data hall space will be maintained to the following conditions:
 - a) Cold Aisle Setpoint Temperature $\leq 20^{\circ}\text{C} \pm 1.0^{\circ}\text{C}$
 - b) Humidity Range 30.0 - 70.0%
 - c) Server Inlet Temperature Upper Limit 26.0°C .

4 CRAC Air Handling Unit

4.1 Overview

- 1) The data halls are each served by five (5) + four (4) chilled water coil *Computer Room Air Handling Units* (CRAC), also referred to as AHU, with the redundant units in hot-standby as indicated on the drawings. The CRAC / AHU's will be connected in sets of 1 master unit hard connected to 4 slave units. The master unit ULC is hard connected to the SC.
- 2) The data hall AHU's will consist of the following sections:
 - a) the Hydronics Coil Section (HCS) consisting of a CHW Cooling Coil with MERV 8 Filter Assembly
 - b) the EC Plug Fan Array Section
 - c) the Unit Level Controller (ULC)
- 3) The SC shall command the data hall Master AHU's to operate as required to maintain the temperature and fan speed set-point in the data hall. Control signals shall be passed to the data hall master AHU ULC's via hardwired channels. The Master AHU ULC's will pass the setpoints to the slave ULC's via hard connection.

- 4) Each Master ULC will be able to collate and process the following primary control signals to / from the SC via:

- 5) Hardwired Control Signals:
 - a) Data Hall AHU Supply Air Temperature Set-point

 - b) Data Hall AHU Fan Speed

 - c) Data Hall AHU General Alarm

- 6) All additional monitoring and alarm signals shall be capable of relaying via BACnet/IP communication connection channels to the future BMS.

- 7) Upon cold start the integral AHU controls system will gradually (within 30s adj.) ramp up the AHU fan speed to match the control signal provided by the SC. If loss of SC occurs in this condition, then the AHU fan speed will ramp up gradually to the maximum design speed (80% adj).

- 8) Each data Hall AHU will be equipped with a HAND/OFF/AUTO (HOA) switch, where:
 - a) OFF Data Hall AHU is deactivated

 - b) AUTO Data Hall AHU is controlled by the SC

 - c) HAND Data Hall AHU runs on its ULC with no input into from the SC

- 9) The HOA switch setting for each Data Hall AHU will be sent to the BMS via BACnet communication channels.
 - a) The data hall AHU will be operating to the following conditions:

 - b) CHW Supply/Return 16.0 / 24.0°C

 - c) Supply Air Setpoint Temperature 20.0°C (adj.)

 - d) Return Air Temperature Range 30.0°C (adj.)

 - e) Net Sensible Cooling Capacity (Normal Mode) ≤ 166kW

f) Net Sensible Cooling Capacity (Failover Mode) ≤ 160kW

5 Data Hall Operational State

- 1) During automatic operation (AUTO), the SC shall send one digital signal D1 to each of the data hall master air handling units (AHU) within its area to set the operational state based on psychrometric points with the onboard ULCs to operate the equipment. The Master ULC shall then control the slave ULC's in its domain in parallel to ramp up fan speed. Each AHU in the data hall shall operate in such a way as to condition the cold aisle it serves under normal SC/ ULC conditions.
- 2) The data hall AHUs may be manually deactivated by the HAND/OFF/AUTO (HOA) switch provided at the ULCs.
- 3) Data Hall AHU staging decisions:
 - a) All data hall Master AHUs in a given area shall be commanded by the SC.
 - b) Unneeded data hall AHUs in a given area may be turned off manually at the individual ULC. The manual-off signal shall be reflected at the SC.

6 Data Hall Temperature Control

- 1) Each AHU comes complete with the following sensors hard wired to the AHU ULC:
 - a) Return air temperature sensor (RAT)
 - b) Three (3) x Supply air temperature sensor (SAT) located as shown on the drawings in addition to an off-coil SAT sensor
- 2) The AHU ULC shall send the AHU supply and return air temperature values to the SC. The SC shall adjust the supply air temperature set-point to all the data AHUs via hardwired connection.
- 3) Each AHU ULC will control the supply air temperature locally via modulation of the 2-port PIC valves on the chilled water return side of the AHU.
- 4) Each AHU ULC will modulate its control valve to treat the highest cold temperature sensor in its domain.
- 5) The SC shall adjust the SAT supply temperature based on the following:

- a) The SC shall command a setpoint to the AHU ULC's via Master ULC's. The AHU PIC valve's adjust to maintain a supply air setpoint of 20.0°C.
- 6) The supply air setpoint is only to be adjusted by the SC if the AHU fan speed exceeds the following:
 - a) Adjust supply temp upward by 0.5°C every 10 minutes to a maximum of 21°C if the fan speed drops below 30% (as calculated in Data Hall Fan Speed Control section)
 - b) Adjust supply temp downward by 0.5°C every 5 minutes to a minimum of 18°C if the fan speed exceeds 90% (as calculated in Data Hall Fan Speed Control section)
 - c) A dead band shall be used to control the AHU supply air temperature. The dead band shall allow for a 1.0°C (adj.) drift above or below set point (e.g. the supply air temperature for each AHU will be allowed to "float" between 19.0-°C and 21.0°C without affecting the CHW PICV position (subject to which mode the AHU is in).
- 7) If a sensor is failed or reads out of range it shall not be used in the calculation. A temperature sensor is considered failed or out of range if it is below -6.7°C or above 40.0°C.
- 8) The SC shall send the supply air temperature set-point to the Master AHU ULC via hardwired connection. The Master AHU ULC will control the slave AHU's to the same setpoint.

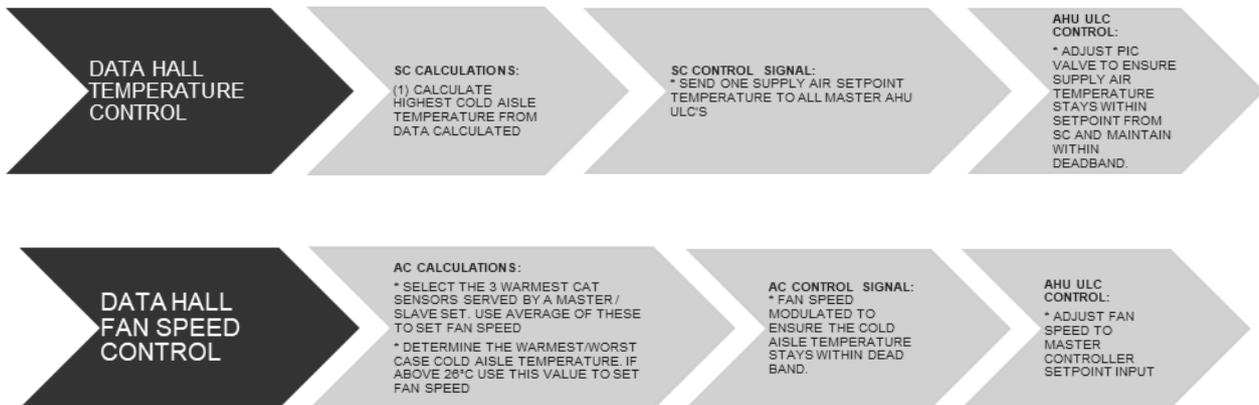
7 Data Hall Fan Speed Control

- 1) There shall be three (3) temperature sensors connected directly to the SC. The SC shall select the 3 warmest CAT sensors served by a master / slave set and use the average of these temperatures to set the fan speed. Should the highest of these exceed 22°C the SC will set fan speed to meet this demand.
- 2) In AUTO mode, the SC shall calculate PID control loop to maintain the cold aisle temperature as follows:
 - a) The SC shall adjust the fan speed setpoint based on the following:
 - i) The SC shall increase the fan speed setpoint of the AHU by 5% (adj) per minute (60 seconds) if the warmest/worst case cold aisle temperature exceeds the dead band upper limit until the cold aisle temperature returns to the set point.

- ii) The SC shall decrease the fan speed setpoint of the AHU by 5% (adj) per minute (60 seconds) if the warmest/worst case cold aisle temperature drops below the dead lower limit until the cold aisle temperature returns to the set point.
- 3) If a sensor is failed or reads out of range it shall not be used in the calculation. A temperature sensor is considered failed or out of range if it is below -6.7°C or above 40.0°C.
- 4) Initial cold aisle temperature set-point shall be 20.0°C (adj.).
- 5) Modes of operation:
 - a) AUTO – the data hall and AHU temperature sensors connected to the SC are to be used by the SC to control the AHU fan speed to maintain 10°C delta T settings.
 - b) HAND – the AHU fan speed shall default to 75% (adj). The AHU ULC will then take over and control fan speed to a maintain a delta T ($T_{RA}-T_{SA}$) of 10°C (adj) until restoration of AUTO control

8 Operational States

8.1 Normal Operation



- 1) On automatic operation (AUTO), the SC shall send one digital signal, D1 to the data hall Master AHU ULCs to set the operational state.
- 2) Each data hall AHU shall modulate independently to maintain the supply air temperature and as per inputs from its Master ULC to control fan speed set-point received from the SC in all operational states.

3) The data hall AHUs may be manually deactivated by the HOA switch provided at the ULCs, wherein:

a) All AHU plug fans are commanded OFF

b) All AHU valves are closed

c) Hand Operation



1) A manual operation (HAND) shall be available for operating the unit locally at the HOA switch, where:

a) HAND mode shall be activated by the HOA switch provided at each data hall AHU ULC.

b) When mode is activated, a notification alarm signal will be relayed to the BMS via BACnet communication channels, signalling that the unit control has been overridden locally.

c) The data hall AHU shall ramp up to 80%. The percentage is adjustable from the local HLI panel at the ULC. The percentage will be set to the design air flow conditions during testing and balancing to correspond to providing up to 80% of cooling (adj.).

d) Local supply air temperature set-point shall be 20.0°C (adj.) and can be adjustable via the onboard ULC panel.

2) In this mode:

a) Data hall AHU operational state will be available as an operator selectable value at the ULC panel as an emergency override of the unit control sequence.

b) The unit will control based on the temperature sensors located in the cold aisle hardwired to the AHU ULC.

3) The data hall AHU shall return to Master control once the HOA switch is turned back to AUTO.

4) Should there be a failover of the SC the unit will default to Master ULC control mode. Should the Master ULC be put in HAND, the remaining slave ULC's will default to local control until the

master is restored. The unit will control based on the abovementioned until control is restored to the SC. Once the SC is restored the unit will revert back to AUTO and resume automated control.

8.2 Failover Operation

8.2.1 Mechanical



- 1) When there is a fault/failover of a duty data hall AHU fan (or if either system needs to be taken offline for maintenance), the remaining active and redundant data hall AHUs will ramp up to meet the required projected load. The ramp up will be determined by the SC or Master ULC based on the cold aisle temperatures (see fan speed control section).
- 2) Where there is a fault/failover of a duty data hall AHU PIC valve the valve will fail to open.
- 3) Where there is a water leak locally at the data hall AHU:
 - a) The data hall AHU is complete with Point Leak Detectors which will relay an alarm until the water leak alarm is reset
 - b) Should the AHU leak detector be activated the AHU will proceed to close the PIC valve as well as the motorized valve on the supply side of the coil
- 4) Where the filters are loaded-up/choked at the data hall AHU HCS:
 - a) The filter section of the data hall AHU HCS is complete with a Differential Pressure Sensor which will relay an alarm to the BMS until the high pressure alarm is reset. The unit will continue to run.

8.2.2 Electrical



- 1) Where there is a fault/failover of the local mechanical electrical panel for a data hall AHU:
 - a) The AHU's are fitted with Automatic Transfer Switches (ATS) and will revert to the active mechanical electrical panel
- 2) Where there is a fault/failover of the AHU ATS:
 - a) The AHU will lose power and the remaining units will ramp up to meet demand.
- 3) The BMS will be alerted (through the SC) upon a failover mode of this nature.

8.2.3 Controls



- 1) Where is a fault/failover of the data hall AHU ULC:
 - a) There is only one (1) ULC to one (1) data hall AHU. Should one AHU ULC fail/freeze, the remaining active and redundant data hall AHUs will ramp up to meet the required projected load. The data hall AHU ULC tied to the fault/failover/freeze and not receiving any command/control signal, will *Hold Last*. Upon (re)establishing of command/control, the ULC will override the *Hold Last* function and resume operation of the data hall AHU to meet the required projected load based on temperature readings at the cold aisles (feedback through the SCs).
- 2) The future BMS will be alerted upon a failover mode of this nature (by way of say, a heartbeat timeout function).

9 Fire Alarm Operation

All equipment shall continue to run in the fire mode operation.

10 Special Requirements

- 1) The following components are to be provided by equipment supplier:
 - a) Point-type Water Leak Detection (WLD) System

b) Unit Level Controller (ULC)

c) Dedicated Temperature Sensors in addition to standard AHU ULC onboard temperature sensors. This is specifically three (3) cold aisle combination temperature and RH sensors to be located in the cold aisle being served by the AHU). These are to be independent the SC.

2) The following components are to be coordinated:

a) Connection to Supervisory Controller (SC)

b) Master / slave AHU layout

c) Unit electrical connections

3) General Alarm Activation (see complete list of points in the BMS documentation)

4) The Following conditions will trigger the General Alarm point to be activated:

a) EC plug fan assembly failure alarm

b) Incoming power loss alarm

c) Failure of any sensor

d) Supply air high temperature alarm (adj.): Alarm shall be triggered if the supply air temperature (off fan) exceeds 24.0°C (adj.)

e) CHW valve switch does not prove flow within 30 seconds (adj.).

f) Condensate drainage pan overflow alarm

g) HOA switch has been set to HAND or OFF

5) Any alarm condition activating the general alarm cannot be reset at the BMS and must be manually reset at the ULC.

6) Other Monitoring and Alarm Points:

a) Dirty Filter Detection (by AHU supplier)

- i) Each data hall AHU filter bank is monitored using a 4.0-20.0mA differential pressure transmitter. As the filter bank becomes loaded and the pressure drop across the filter bank exceeds the set-point 125.0Pa (adj.), the data hall ULC will relay an alarm signal about the dirty filter condition at the operator workstation alarm screen and on the HMI.

b) Leak Detection (by AHU supplier)

- i) Spot leak detectors are installed on the base in the data hall AHU HCS. If these detectors register a wet condition, an alarm is generated and sent to the BMS operator workstation. The default delay is 5.0 seconds (adj.) for the leak alarm and this can be adjusted at the local HMI
- ii) An additional spot leak detector is shipped loose, wired to the data hall ULC and field installed at the floor level. If these detect a wet condition at the floor level, an alarm is generated and set to the BMS operator workstation.

11 UPS Room CRAC

11.1 Overview

- 1) The UPS system is by two (2) chilled water CRAC units located in the UPS room.
- 2) Each unit is sized to be able to provide sufficient cooling while running in parallel for the full load of the room at highest load (UPS discharging). During UPS economy mode the capacity of the units is at N+1.
- 3) The rooms CRAC units (top return, front supply) will consist of the following configuration:
 - a) the Hydronics Coil Section (HCS) consisting of a CHW Cooling Coil with MERV 8 Filter Assembly
 - b) the EC Plug Fan Array Section
 - c) the Unit Level Controller (ULC)
- 4) The Master AHU is to operate as required to maintain the temperature and fan speed set-point in the UPS room. The Master AHU ULC's will pass the setpoints to the slave ULC's via hard connection.

- 5) Each Master ULC will be able to collate, process and communicate the following primary control signals via:
 - a) Hardwired Control Signals:
 - b) UPS room AHU Start/Stop
 - c) UPS room AHU Supply Air Temperature Set-point
 - d) UPS room AHU Fan Speed
 - e) UPS room AHU General Alarm

- 6) All additional monitoring and alarm signals shall be capable of relaying via BACnet/IP communication connection channels to the future BMS.

- 7) Upon cold start the integral AHU controls system will gradually (within 30s adj.) ramp up the AHU fan speed to match the control signal provided by the SC. If loss of SC occurs in this condition, then the AHU fan speed will ramp up gradually to the maximum design speed (100% adj).

- 8) Each UPS room AHU will be equipped with a HAND/OFF/AUTO (HOA) switch, where:
 - a) OFF UPS room AHU is deactivated
 - b) AUTO UPS room AHU is controlled by the master
 - c) HAND UPS room AHU runs on its ULC with no input into from the master
 - d) The HOA switch setting for the UPS room AHU will be capable of being sent to the future BMS via BACnet communication channels.

- 9) The UPS room AHU's will be operating to the following conditions in unison:

a) CHW Supply/Return	16.0 / 24.0°C
b) Supply Air Setpoint Temperature	20.0°C (adj.)
c) Return Air Temperature Range	30.0°C (adj.)

d) Net Sensible Cooling Capacity (Normal Mode) $\leq 85\text{kW (N+1)}$

e) Net Sensible Cooling Capacity (Failover Mode) $\leq 80\text{kW (N)}$

12 UPS Room CRAC Operational State

- 1) During automatic operation (AUTO), the master ULC shall send one digital signal D1 to the slave AHU within its area to set the operational state based on psychrometric points with the onboard ULCs to operate the equipment. Each AHU in the LV & UPS room shall operate in such a way as to condition the room it serves under normal ULC conditions.
- 2) The LV & UPS room AHUs may be manually deactivated by the HAND/OFF/AUTO (HOA) switch provided at the ULCs.

13 UPS Room CRAC Temperature Control

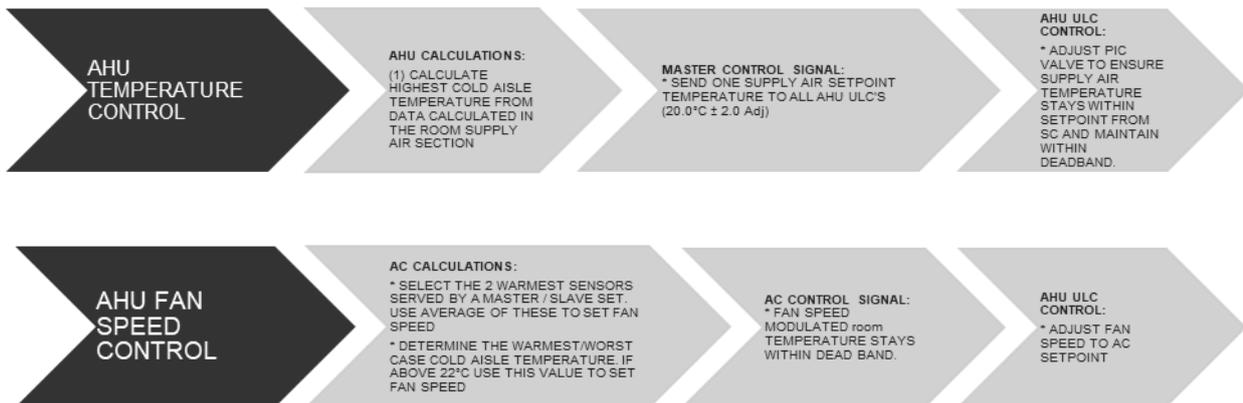
- 1) Each AHU comes complete with the following sensors hard wired to the AHU ULC:
 - a) Return air temperature sensor (RAT)
 - b) Two (2) x Supply air temperature sensor (SAT) within the room in addition to an off coil SAT sensor
- 2) Initial temperature set-point shall be 20.0°C (adj.).
- 3) The AHU ULC will control the supply air temperature via modulation of the 2-port PIC valves on the chilled water return side of the AHU.
- 4) If a sensor is failed or reads out of range it shall not be used in the calculation. A temperature sensor is considered failed or out of range if it is below -6.7°C or above 40.0°C .
- 5) Modes of operation:
 - a) AUTO – the system is to operate as per the description above.
 - b) HAND – the AHU is to maintain the last supply air temperature setpoint received from the master unit and adjust the CHW PIC valve to maintain the temperature within the deadband.

14 UPS Room Fan Speed Control

- 1) The supply air temperature sensors along with the return air temperature sensor are to be used to calculate the delta T over the coil. This value will be used to ramp the fans up and down.
- 2) In AUTO mode, the slave unit shall ramp up and down to the same speed as determined by the master ULC to maintain a 10°C delta T over the AHU unit coil.
- 3) If a sensor is failed or reads out of range it shall not be used in the calculation. A temperature sensor is considered failed or out of range if it is below -6.7°C or above 50.0°C.
- 4) Modes of operation:
 - a) AUTO – the AHU temperature sensors onboard the AHU's are to be used by the master to control the AHU fan speed to maintain 10°C delta T settings.
 - b) HAND – the AHU fan speed shall default to 90% (adj). The AHU ULC will then take over and control fan speed to a maintain a delta T ($T_{RA}-T_{SA}$) of 10°C (adj) until restoration of AUTO control

15 CRAC Unit Operational states

15.1 Normal Operation



- 1) On automatic operation (AUTO), the master ULC shall set the operational state.
- 2) Each AHU shall modulate independently to maintain the supply air temperature and as per inputs from its Master ULC to control fan speed all operational states.
- 3) The AHUs may be manually deactivated by the HOA switch provided at the ULCs, wherein:

a) All AHU plug fans are commanded OFF

b) All HCS valves are closed

15.2 Hand Operation



1) A manual operation (HAND) shall be available for operating the unit locally at the HOA switch, where:

a) HAND mode shall be activated by the HOA switch provided at each UPS room AHU ULC.

b) When activated, a notification alarm signal will be relayed to the future BMS via BACnet communication channels, signalling that the unit control has been overridden locally.

c) The AHU shall ramp up to 90%. The percentage is adjustable from the local HMI panel at the ULC. The percentage will be set to the design air flow conditions during testing and balancing to correspond to providing up to 90% of cooling (adj.).

d) Local supply air temperature set-point shall be 20.0°C (adj.) and can be adjustable via the onboard ULC panel.

2) In this mode:

a) AHU operational state will be available as an operator selectable value at the ULC panel as an emergency override of the unit control sequence.

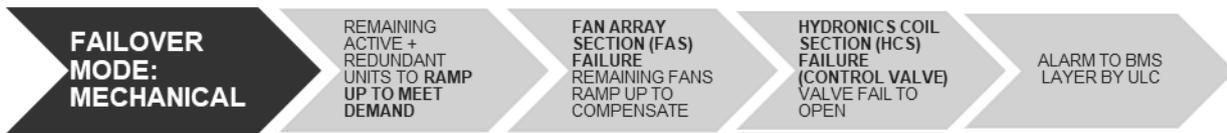
b) The unit will control based on the onboard supply air sensors located in the cold aisle directly connected to the AHU ULC.

3) The AHU shall return to Master control immediately when the HOA switch is turned back to AUTO.

4) Should the Master ULC be put in HAND, the remaining slave ULC's will default to local control until the master is restored. The unit will control based on the abovementioned until control is restored to the Master.

15.3 Failover Operation

15.3.1 Mechanical



- 1) When there is a fault/failover of a duty AHU HCS or fan array (or if either system needs to be taken offline for maintenance), the remaining active and redundant AHUs will ramp up to meet the required projected load.
- 2) Where there is a fault/failover of a duty AHU HCS PIC valve the valve will fail to open.
- 3) Where there is a water leak in the room AHU HCS:
 - a) The AHU HCS is complete with Point Leak Detectors which will relay an alarm to the BMS until the water leak alarm is reset
- 4) Where the filters are loaded-up/choked at the LV & UPS room AHU HCS:
 - a) The filter section of the AHU HCS is complete with a Differential Pressure Sensor which will relay an alarm to the BMS until the high pressure alarm is reset. The unit will continue to run.

15.3.2 Electrical



- 1) Where there is a fault/failover of the local mechanical electrical panel for an AHU:
 - a) The AHU's are fitted with Automatic Transfer Switches (ATS) and will revert to the active mechanical electrical panel
- 2) Where there is a fault/failover of the AHU ATS:

a) The AHU will lose power and the remaining unit will ramp up to meet demand.

3) The BMS will be alerted upon a failover mode of this nature.

15.3.3 Controls



1) Where is a fault/failover of the AHU ULC:

a) There is only one (1) ULC to one (1) AHU. Should one AHU ULC fail/freeze, the remaining active and redundant AHU will ramp up to meet the required projected load. The AHU ULC tied to the fault/failover/freeze and not receiving any command/control signal, will *Hold Last*. Upon (re)establishing of command/control, the ULC will override the *Hold Last* function and resume operation of the UPS room AHU to meet the required projected load based on temperature readings at the cold aisles (feedback through the SCs).

16 Fire Alarm Operation

All equipment shall continue to run in the fire mode operation.

17 Fresh Air Handling Unit

17.1 Overview

1) Each Fresh Air Handling Unit (FAU) is a variable volume air conditioning unit that provides pre-treated outdoor air to the two data hall areas.:

2) The FAU shall consist of:

a) An air plenum section a primary filter rack to hold both the pre-filter (MERV 8) and final filter (MERV 14).

b) A DX cooling for dehumidification of outdoor air supply.

c) Chilled water coil for pre heating and heat recovery

b) Supply air flow	1,000l/s
c) Total Cooling Capacity DX	≤ 61kW
d) Sensible Cooling Capacity CHW	≤ 38kW
e) Humidification start	<30%
f) Humidification stop	>57%

18 Operational States

18.1 Normal mode



- 1) Each FAU shall modulate independently to maintain the supply air temperature, pressure and humidity set point during a normal operational state based on requirements from the respective data halls it serves
- 2) Each FAU shall independently phase in/out the DX cooling coil as needed to maintain humidity setpoint.
- 3) HAND mode: A manual operational state (HAND) shall be available for operating the unit locally at the HOA switch.
- 4) HAND Operation shall be activated by a HOA local switch at each AHU controller.
- 5) When activated, HAND mode shall send a notification alarm signal to the BMS via BACnet communication notifying it that unit control has been overridden locally.

18.2 HAND Operation:

- 1) FAU mode shall be locally determined based on OAT and RH conditions of onboard OAT and RH sensor.

- 2) Unit operational state while in HAND mode will be available as an operator selectable value at the HLI panel as an emergency override of the unit control sequence.
- 3) FAU shall return to BMS-directed control immediately when HOA switch is turned back to AUTO.

19 Supply Air Temperature Control

- 1) Overview: The FAUs shall modulate based on supply air temperatures set during commissioning (adj) for normal / humidification / dehumidification to maintain the supply air temperature setpoint . The supply air temperature sensors are to be located after the coil.
- 2) Supply air temperature is determined from local onboard set points when in AUTO/HAND Operation (see HAND Operation for local control details).
- 3) The average of two FAU supply air temperature sensors shall be calculated and the average shall be used as the FAU supply temperature. If one sensor is failed, it shall not be used in the averaging calculation. In the event of a SAT sensor failure the FAU ULC general alarm will be activated.
- 4) If SAT sensors are out of acceptable range (less than -1 or above 55) then sensor is removed from averaging calculation.
- 5) If both SAT sensors are failed or out of range the unit shall default to full cooling by commanding the fans to full speed, and the DX cooling coil. The FAU ULC will send a fault signal to the BMS via BACnet communication.
- 6) If the FAU ULC fails an alarm signal is sent to the BMS and the unit maintains last setpoint.

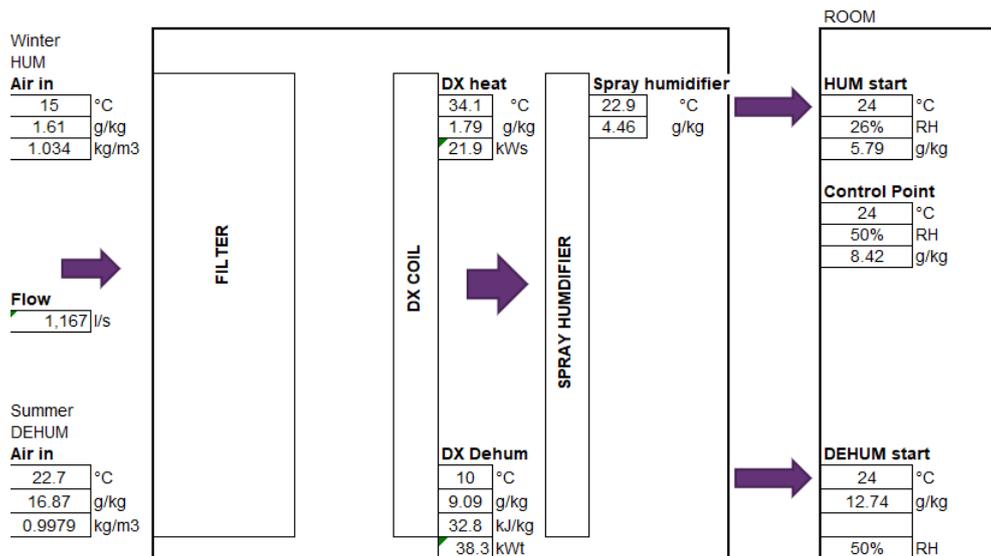


Figure 19-1 FAU control setpoints

20 Relative Humidity Control

- 1) Overview: The FAUs shall modulate based on direct control signals from the unit RH supply air sensors (supplied by supplier) to maintain the supply air relative humidity as required by the data hall. This shall be set to default RH of 45% at a supply temperature of 20°C (adj).
- 2) Supply air RH set point is determined from the requirements of the data hall AUTO Operation and via default settings when in HAND.
- 3) The average of two FAU supply air RH sensors shall be calculated and the average shall be used as the FAU supply RH. If one sensor is failed, it shall not be used in the averaging calculation. In the event of a RH sensor failure the FAU onboard controller general alarm will be activated.
- 4) If the humidity as measured by the FAU RH sensor reading exceeds the acceptable range (ie >20% of the setpoint) then the unit shall default to full dehumidification by commanding the DX cooling coil to maximum cooling until the setpoint is once again attained. The unit will then maintain the setpoint within the dead band range (setpoint \pm 20% adj).
- 5) If the RH goes above the dead band range an alarm is also to be sent to the BMS.
- 6) The FAU is fitted with spray humidifiers to provide humidification should the data hall call for it (via input from the BMS).

- 7) The air will be pre heated by the chilled water coil and further heated by the DX coil to ensure a 57% RH air provision to the data hall. Once the RH has been reached the ULC will turn off the spray humidifiers.

21 Fire Operation

- 1) The FAU is not to run when the Fireman's switch is active. The FAUs shall be interlocked with the fire system to allow shutdown in the event of a fire based on a fire signal generated by others. Upon clearing of a fire signal the unit ULC is to restart to assist with smoke purge makeup air.

22 General Alarm Activation

- 1) The following conditions will trigger the General Alarm point to be activated:
 - a) Fan VFD failure alarm
 - b) Supply fan failure alarm
 - c) DX Cooling/Heating Coil failure alarm
 - d) Main Power Lost alarm
 - e) Failure of both Supply Air relative humidity sensors
 - f) Failure of both Supply Air temperature sensors
 - g) Supply Low Temperature Alarm (adj. at HMI)
 - h) Supply High Temperature Alarm (adj. at HMI)
 - i) Humidifier failure alarm
 - j) s
- 2) Alarm shall be sent if supply air temperature is 5 degrees C or more below setpoint.
- 3) Alarm signal shall be delayed 2 minutes during normal operating conditions.

- 4) Alarm signal shall be delayed 5 minutes after a change of cooling mode.
- 5) Alarm shall be sent if supply air temperature is 2 degrees C or more above setpoint.
- 6) Alarm signal shall be delayed 2 minutes during normal operating conditions.
- 7) Alarm signal shall be delayed 5 minutes after a change of cooling mode.
- 8) Any alarm condition activating the general alarm shall not be able to be reset by the BMS and must be manually reset at the unit controller.
- 9) Future BMS Failure Modes:
 - a) The FAU unit controller shall be equipped with default failsafe modes in the event that an input from the future BMS is lost or fails to send valid setpoints/values. In each situation, the unit controller reacts only to the lost signal; all valid BMS signals that continue to be input into the unit controller will continue to be used in the AHU operation.
 - b) The FAU unit controller shall generate an alarm on any loss of input signal from the BMS.
- 10) Signal Loss Responses:
 - a) Loss of unit operational state: The FAU will switch operational state to local control operation and determine its own operational state based on outside air conditions. See HAND mode description above for further details.
 - b) Loss of Supply Air Temperature set point: The FAU will default to its last known supply temperature set point.
 - c) Loss of Fan VFD Speed: The AHU will default to its local VFD speed design max flow.
- 11) Upon a restoration of the BMS signal, and the unit HOA switch is set to AUTO, the AHU will return that aspect of its control to normal BMS control immediately.

23 Other Monitoring and Alarming Points

- 1) Dirty Filter detection
 - a) Each FAU pre and final filter bank is monitored using a 4-20 mA differential pressure transmitter. As the filters become dirty and the pressure drop across the filter exceeds the

set point (125Pa, adj.), onboard controller sends out an alarm about dirty filter condition at the operator workstation alarm screen and on the HMI.

Water side sequence of operations

1 Overview

- 1) Water-side sequence of operation (SOO) is provided for the following:
 - a) Chilled water generation system
 - b) Chilled water distribution
 - c) Central plant controller
- 2) The chilled water generation system schematic forms part of the drawing pack.

2 Chiller water generation system

- 1) Chilled water for the facility will be generated by the chilled water generation system located on and around the mechanical platforms as indicated on the drawings and will be reticulated throughout the facility via the chilled water distribution system providing cooling for the CRAC systems.
- 2) At peak design condition the chilled water generation system will be responsible for providing 2.0MW_{TC} final cooling at 16°C chilled water supply temperature (CHWS) and 24°C chilled water return temperature (CHWR).
- 3) The chilled water system consists of:
 - a) Two (2) + One (1) 1,000kWc air cooled chilled water blocks in an N+1 configuration.
 - b) Ancillaries:
 - i) Two (2) manual chemical dosing water treatment systems
 - ii) Two (2) pressure maintenance and stabilization (PMS), degasser and make-up water systems (DMWS) for the chilled water system
 - c) Primary loop chilled water reticulation including valves and associated sensors and meters

- 3) Each chiller will be equipped with a local HOA (HAND/OFF/AUTO) switch.
- 4) When the switch is set to OFF, the unit is deactivated.
- 5) When the switch is set to AUTO, the unit is controlled by its HLI with input from the Area Controller.
- 6) When the switch is set to HAND, the unit runs on local control in the operating mode detailed in the sequence of operation with no input into the unit from the CPC.
- 7) The HOA switch setting for each unit will be sent to the future BMS via the CPC to alert the future BMS on position.
- 8) The chiller capacity shall be “demand led”. Chiller cooling / free cooling capacity shall be varied by the chillers integral capacity controls to maintain a constant chilled water supply temperature under fluctuating load conditions. The design chilled water supply temperature is 16°C. The chilled water supply and return circuits shall operate at a nominal temperature differential of 10°C.
- 9) Chiller sequencing shall be determined by the CPC and is influenced by:
 - a) Emergency conditions
 - b) Maintaining a supply temperature setpoint
 - c) Chiller loading
 - d) Chiller sequencing / rotation
 - e) TES temperatures
 - f) Decoupler leg flow

4 Ancillaries

- 1) The ancillaries consist of the following :
 - a) Two (2) manual chemical dosing water treatment systems
 - b) Two (2) pressure maintenance and stabilization (PMS)

- c) Two (2) degasser and make-up water systems (DMWS)
- 2) CHW system accessories are “packaged” units with integrated controllers. Those units shall be self-controlled. The CPC shall provide monitoring only.

5 Chilled water distribution

- 1) Chilled water for the facility will be distributed by the chilled water distribution system and reticulated throughout the facility providing cooling water for the various air handling units. The chilled water distribution shall consist of:
- a) Four (4) VSD secondary pumps Two (2) large pump sets and a combined set of two(2) small pumps.
 - b) Three primary pumps of equal size.
 - c) Two (2) thermal energy systems (TES) consisting of two (2) 18,000 litre 100% capacity thermal storage tanks
 - d) Chilled water pipework
 - e) Sensors and meters linked to CPC

6 Secondary and primary pumps

- 1) The secondary pump sets shall consist of the following:
- a) Two (2) 29,9l/s pumps complete with VSD, and two 15,0l/s pumps complete with VSD's.
 - b) Sensors linked to the CPC
- 2) The VSD will support the following 'status' input signals from the CPC (BACnet) as a minimum to aid in pumping operations:
- a) Pump on/off status
 - b) VSD frequency / pump speed
 - c) Flow confirmation over pump via differential pressure sensor

d) General Alarm

e) Pump status shall be transmitted to the CPC via hardwired connection.

3) The primary pump sets shall consist of the following:

a) Three (3) 29,9l/s pumps constant flow.

b) Sensors linked to the CPC

4) The following 'status' input signals from the CPC (BACnet) as a minimum to aid in pumping operations:

a) Pump on/off status

b) Flow confirmation over pump via differential pressure sensor

c) General Alarm

d) Pump status shall be transmitted to the CPC via hardwired connection.

7 Thermal Energy Storage System

1) The chilled water generation system is supported by a Thermal Energy Storage (TES) system that will support low-load operations by 'buffering' temporary load drops in the chilled water system and continuity of chilled water cooling capacity during electrical line-up switchover / utility failover.

2) The Thermal Energy Storage System and component configuration(s) are as follows:

a) Two (2) 18m³ stratified CHW storage tanks:

b) At Duty Capacity (two (2) 18m³ storage tanks online)

i) System Storage Volume equivalent to 200% (2.0MW_{TC}) of Total IT Cooling Load for **5.0 minutes** storage, or

c) During TES tank maintenance or with single tank offline (One (1) 18m³ Stratified CHW Storage Tank):

i) System Storage Volume equivalent to 100% (1.0MW_{TC}) of Total IT Cooling Load for **5.0 minutes** storage

3) Chilled water pipework

4) Temperature sensors linked to CPC

5) Each TES tank shall be furnished with sparge pipes in the tanks as well as six (6) temperature sensors equally spaced from top to bottom to monitor the chiller water temperature at different levels of the tank. Three (3) of these temperature sensors are to be installed on the piping at the outlet/inlet of each TES. All temperature sensors are to be hard wired to the CPC to confirm TES status and also monitored by the BMS.

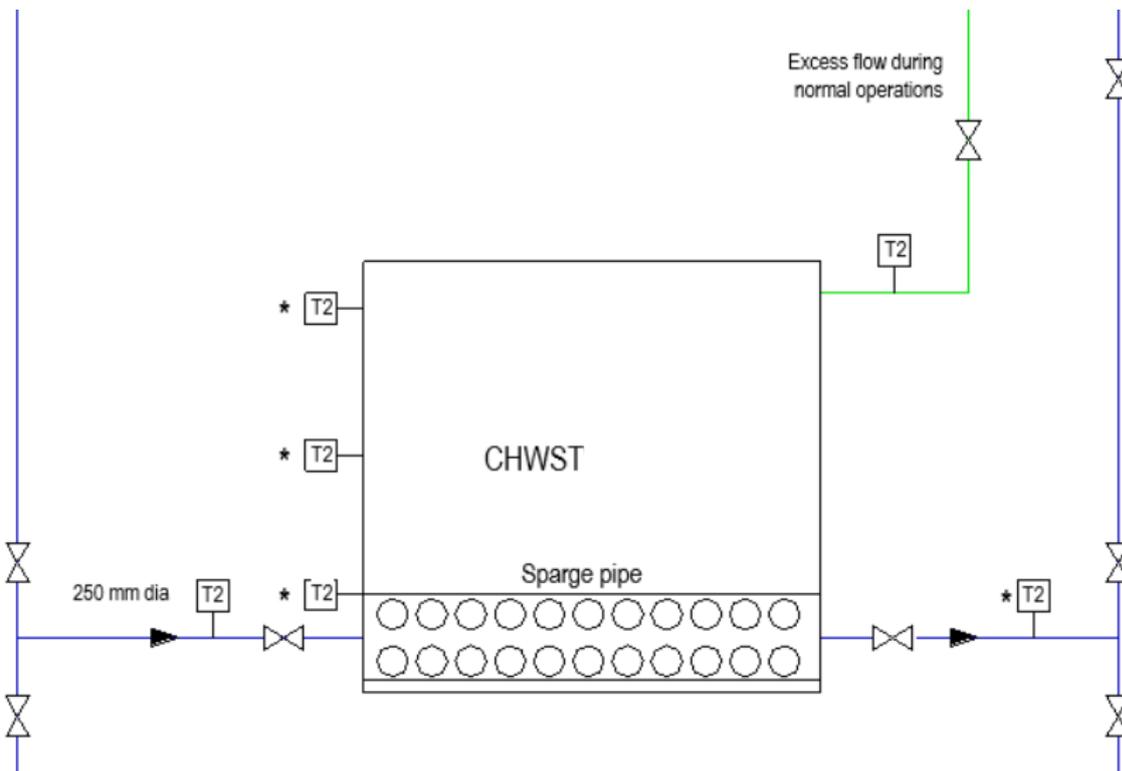


Figure 7-1 Thermal energy storage tank schematic

8 Central plant controller (CPC)

1) The chilled water generation, distribution and fresh air system to the plant rooms and system shall be controlled via central plant controller (CPC) with monitoring via the BMS. This CPC will communicate with the future BMS for reporting and receive no input from the BMS unless otherwise stated. The ancillaries (chemical treatment, DMWS and PMS) are standalone systems and are to be hard wired to the CPC which in turn reports/alarm to the future BMS via BACnet.

- 2) **A duty / standby CPC will be installed** such that should one CPC fail, the standby CPC shall take over control. Should both CPC's fail, local control will be restored as discussed further in this document.
- 3) The CPC shall command the various components within its control sphere to operate as required to maintain the various set points (as discussed further in this document) thus controlling the performance of the central chilled water generation system. Information shall be passed from the field equipment and instruments to the CPC via both hardwired and BACnet communications as indicated further in this document.
- 4) The sequence of operations layout for the CPC is included in the appendix.
- 5) The following are to be linked to the CPC via hard wire connection:
 - a) Chiller HLI
 - b) FAU HLI
 - c) Secondary pump VSD's
 - d) Primary pumps
 - e) Motorised valves
 - f) TES temperature sensors
 - g) Flow meters
 - h) Differential pressure sensors for pump speed control
 - i) Differential pressure sensors for pump flow confirmation
 - j) Flow meters
 - k) Pressure maintenance set
 - l) Degassing and make up water

9 Mode of operation and system level control

- 1) The chillers are sequenced and controlled by the CPC as mentioned previously. The CPC provides full operational control of the chillers and pumps under normal conditions.
- 2) If the duty CPC loses communication with the plant the following are to be default processes until the CPC is restored:
 - a) Each active chiller's HLI continues to operate on local control to maintain a chilled water flow temperature of 16°C.
 - b) The secondary pumps VSD's all ramp up to 80%
- 3) The table below depicts the various operating scenarios for the facility namely:
 - a) Normal
 - b) Emergency (generator power)
 - c) Post Emergency (recharge of buffer tanks on generator power and recharge once mains power is restored)
 - d) Normal

Table 9-1 Facility operating scenarios

	Mode of Operation	Transition Times (s)
A	Normal (generator operations)	N/A
B	Emergency (emergency operations)	300s (adj)
C	Post emergency charge (recharging the thermal energy storage system after emergency , after return to mains or after maintenance was conducted on the thermal energy storage tank)	Tank recharge in 615s (adj)

- 4) The default mode during controller reinitialization is Emergency (generator power).

10 Chiller Staging

- 1) The CPC shall manage the chiller staging control. This system shall be provided by the manufacturer.

- 2) The number of chillers that shall be enabled shall be determined by the outdoor environmental conditions and the instantaneous cooling demand as determined by the CPC. The CPC is to use a delay (adj) before staging the next chiller, whether it be adding or subtracting. This will be to ensure staging in and out is not subject to rapid change.
- 3) CHW cooling enable signal shall be given to the CPC via hardwired interface as described in the data Hall and Electrical Room Sequence of Operations documents.
- 4) Upon receiving the CHW cooling loss , the CPC shall command the chillers to operate in sequence.
- 5) The CPC shall enable or disable cooling stage as below:
 - a) One (1) chillers (day 1) is to be operational when initial cooling demand requirement is received (standby provided by thermal storage tank buffer).
 - b) Enable the 2nd Chiller, when instantaneous cooling demand (kW) > [80(adj)] % of the operating chiller capacity for [5] minutes
 - c) Enable the 3rd Chiller, when efficiency allows (based on supplier recommendation) for it as well as to enable a N+1 efficiency (hot standby)
 - d) Disable the 2nd chiller when instantaneous cooling demand (kW) < [25(adj)] % of the total operating chiller plant capacity for [5] minutes
 - e) When in a mode for chiller operation the CHWS temperature is above 16°C (adj.) for a period of 150(adj) seconds.
- 6) The following table indicates normal staging based on system load:

Table 10-1 Chiller staging vs load

Chiller Stage	Turn on system load (kW adj)	Turn off system load (kW adj)	Delay (adj)	Notes
Base load chiller 1	0 - 1000kW	Always 1 chiller operational as a min	300 seconds	Thermal energy storage tanks provide thermal storage in case of power failure thus '+1' standby

Base load chillers 1 and 2	0 - 2000kW	Always 2 chillers operational as a min	300 seconds	None
Chiller 4	Max cool, chiller block failure	N/A	300 seconds	Should supplier specific equipment be more efficient at lower load, 3rd chiller can be used as hot standby

- 7) Cooling energy supplied per chiller shall be monitored directly by the chiller and communicated to the CPC and from the CPC to the future BMS. The AC shall also confirm the cooling energy via flow meter and water temperature calculations.
- 8) In the event that the duty CPC does not operate the standby CPC takes over and a fault signal shall be received at the future BMS.
- 9) In the event of the second CPC failing, a fault signal shall be received at the future BMS and all operational chillers shall revert to their ULC controllers to maintain supply temperature.

11 Chiller Start-Up and Shutdown

- 1) Each chiller shall be controlled by its integral controls and the CPC via hardwired interface.
- 2) Chiller shall be initiated by:
 - a) Normal mode Start-Up
 - b) Low Load
 - c) Generator mode Start-Up
 - d) Loss of communication from Data Hall CPC
- 3) The Chilled Water Blocks are to run in hot standby mode ie. N+1 chillers are always active
- 4) The active (N+1) Chilled Water Blocks are to control to supply water temperature.

- 5) The CPC shall be equipped with cut-in and cut-out program to start an additional Chilled Water Block(s) or stop an operating Chilled Water Block Based on the cooling requirements which are calculated by headers differential temperature, chilled water flow rate or chiller rated load amps.
- 6) Each chilled water block is assigned a sequence number in order to perform rotation. Block operation shall be rotated every 7 days (adj.) to ensure balanced operation times for all chillers.

12 Normal Mode Start-Up

- 1) The chiller demand shall be generated by the CPC described in the “Chiller Sequencing Control”. Chiller loss of disable signal shall be a hardwired interface communication from the CPC to each chiller onboard controller.
- 2) Upon receiving the loss of disable signal, the chiller onboard controller shall:
 - a) Start the CHW pump and prove it is running via a differential pressure switch across the pump. The pump shall be initially ramped up to 40-60% (adj to chiller minimum flow) after which it will be controlled by the CPC to deliver the required CHW flow required by the chiller to maintain the supply flow temperature at a 12 deg C dt water side and system ΔP .
- 3) The CPC shall allow each chiller to operate for [5] minutes to reach the design capacity and an extra [5] minutes for system stability before the next chiller sequencing command.

13 Normal Mode Shutdown

- 1) On receipt of chiller disable demand from the CPC, the onboard controller shall:
 - a) Disable the compressors of the relevant chiller
 - b) Disable the CHW pump after [5] minutes when chiller run status has been proven “not running” via hardwired interface

14 Partial/Low Load Cooling Mode

- 1) During this mode the load on the Chilled Water System is too low to run the chillers and low load is activated to ensure that the chillers don't cycle on and off more than once every 30 minutes. The bypass valve is opened (see table below).

- 2) For a Day 1 load of say 250kW it is proposed that only one chiller be active. This equates to 25% load on a single chiller block. Should this chiller fail the buffer tanks will have enough storage capacity to enable the standby chiller to start up. Also, the secondary pumps are to be on UPS power so should one chiller block fail, the next block's pumps should be immediately active to circulate chilled water to the system.

15 Generator Mode Start-up

- 1) Generator Mode shall only occur in the event of complete power loss.
- 2) On complete power loss, the building's standby generators shall be signalled to start and shall generate sufficient power to support the whole Data Centre operation. The thermal storage tanks are provided in the circuit to provide CHW back-up during that duration when chillers are not available to operate at full capacity.
- 3) Following the "Power Failure Shutdown" Sequence as described in the previous section, the CPC shall perform the following:
 - a) Chiller control panels shall have a separate UPS backed power feed to ensure quick start up of chiller following the loss of power. As the power supply is never lost to the control panel is should not need to self-reset or enter self-diagnose mode. The CPC shall monitor the chiller control panel status and shall be ready to energise chillers when chiller status is reported as "online".
 - b) Pump ULC's to maintain flow based on differential pressure setpoint.
- 4) The CPC shall send loss of disable signals to all online chillers upon the following scenarios:
 - a) Upon receiving a signal confirming that the generators are online and supporting load.
 - b) Chillers online status reported from the chiller control panel detected
 - c) Upon receiving the loss of disable signal, the onboard controller shall confirm the run status via hardwired interface.
- 5) If a fault is detected during the chiller start-up sequence, the chiller shall report fault signal to the CPC and the CPC shall disable the fault chiller in the chiller control sequence.
- 6) With a constant 24°C return temperature, the chiller must be capable of providing the chilled water flow temperature of 16°C within a set period of time from start-up to ensure the chilled

water reservoir in the thermal energy storage tanks are recharged to the required supply temperature. *Simply put, once the chillers have all confirmed full operational loading capacity, the pumps are to speed up to max flow to recharge the TES tanks. Once all temperature sensors in the TES tanks are <21C, differential pressure control resumes for the pumps.*

16 Generator Mode Shutdown

The generator shutdown shall be delayed a minimum of 25 (adj) minutes to enable the thermal energy storage vessels to re-charge, CHW system shall shut down in the same sequence as Normal Mode. The commissioning engineers shall establish during the commissioning period the practical re-charge time for the thermal energy system and shall reschedule the generator hold off time after power restoration to match this.

17 Chiller Sequencing

17.1 Start-up Sequencing

- 1) The lead chiller shall be determined by 7-day duty rotation, chiller fault status and chiller run hours.
- 2) Each chiller that receives a loss of disable signal shall register the number of starts and prohibit the chiller from being enabled / started in the given time period in accordance with the manufacturer's datasheet. This will be monitored via each chiller's internal controller.
- 3) Each chiller shall include a "maintenance" key switch. Upon key switch position being closed, the associated chiller shall be removed from the chiller staging sequence. An alarm shall be shown on the future BMS. A lockout method must be in place such that should one chiller be locked out for maintenance it should not be possible to lockout any other chillers.
- 4) In the event when the next chiller in sequence is called, the CPC shall allow the starting chiller to operate for [5] minutes to reach the design duty and an extra [5] minutes for system stability before the next chiller sequencing command.

17.2 Chiller Line Up Failure

- 1) A chiller line up consists of the following:
 - a) Air Cooled Chiller
 - b) Chilled Water pump

c) Associated sensors, flow meters, switches

d) Isolation valves

2) In the event that a chiller line up fails the next sequenced chiller is to start up. A critical alarm is to be sent to attend to the offline chiller urgently. Should a second chiller also fail the highest priority alarm is to be sent indicating remaining cooling capacity time in the thermal energy storage tanks before cooling will not be able to be maintained. Once the chiller has been restored the alarms are to be cleared and normal operations are to be resumed.

3) The following table indicates possible equipment failure in a chiller line up and fall back reactions

Table 17-1 Chiller block fall back reactions

Equipment Reference	Failure Description	Affected Sensors	Sensor State	Fall Back System Reaction
CHWP (typical)	Chilled water pump failure	DPS Chiller Flow Switch	Low/No Pressure No flow	Chiller onboard controller inhibits startup of chiller. Combined sensor state signals should indicate to the future BMS that there is a pump fault or, isolation/motorized valve is in closed position. Next sequenced chiller to startup.
Chiller Line Up (typical)	Water leak after chiller	DPS2 PMS flow rate	Low/No Pressure >> commissioned value (>0.5l/s adj)	Any of these two alarms are to signal the future BMS that there is a water leak after the chiller. No change to chiller line-up

18 Secondary Pump Start-up and Staging

1) The CPC shall manage the pump staging control.

2) The number of secondary pumps that shall be enabled shall be determined by the instantaneous cooling demand as determined by the CPC via differential pressure feedback from the field sensors. The CPC is to use a delay (adj) before staging the next pump, whether it be adding or subtracting. This will be to ensure staging in and out is not subject to rapid change.

3) The CPC shall enable or disable pumps as below:

a) One (1) small pump is to be operational when initial cooling demand requirement is received

- b) Enable the 2nd small pump, when pump VSD speed > [90(adj)] % of the operating pump capacity for [5] minutes
- c) Enable the 3rd large pump and switch off one of the small pumps when combined pumps VSD speed > [90(adj)] % of the operating pump capacity for [5] minutes
- d) Enable the 4th large pump and switch off the two small pumps, when combined pumps VSD speed > [90(adj)] % of the operating pump capacity for [5] minutes
- e) Disable the 4th pump, when combined pumps VSD speed < [40(adj)] % of the operating pump capacity for [5] minutes
- f) Disable the 3rd pump, when combined pumps VSD speed < [40(adj)] % of the operating pump capacity for [5] minutes
- g) Disable the 2nd pump, when combined pumps VSD speed < [40(adj)] % of the operating pump capacity for [5] minutes

4) The following table indicates normal staging based on system load:

Table 18-1 Pump staging vs load

Pump Stage	Turn on system load (kW adj)	Turn off system load (kW adj)	Delay (adj)	Notes
Base load Pump 1+2 (small pumps)	0 – 1000kW	Always 1 pump (large or small to suite) operational as a min	300 seconds	Thermal energy storage tanks provide thermal storage in case of power failure thus '+1' standby
Base load Pumps 3 & 4 large pumps	1000 - 2000kW	Ensure redundancy and optimize efficiency	300 seconds	See sequence of operations schematic
Chiller 4	Standby pump	N/A	N/A	N/A

5) When starting a next pump the active pump speed is to be locked, the next pump to be brought up to the same speed and then the pump VSD speeds to be interlocked to delta P control from CPC

19 Pump Sequencing

19.1 Startup Sequencing

- 1) The lead pump shall be determined by 7-day duty rotation, pump fault status and pump run hours.
- 2) Sequencing will be in sequence.
- 3) In the event that a pump is taken out of service the next pump must be put in sequence by the CPC.

20 Chilled Water System Setpoints

Table 20-1 Chiller supply temperature and differential pressure setpoints

Name	Descriptor	Initial Value (adj)
CHILLER/1	Air Cooled Chiller Supply Temperature Setpoint	20°C
CHILLER/2	Air Cooled Chiller Supply Temperature Setpoint	20°C
CHILLER//3	Air Cooled Chiller Supply Temperature Setpoint	20°C
Secondary pump differential setpoint	Differential pressure setpoints to CPC for control of the secondary pumps	100kPa (adj) all pumps interlocked by CPC. Upon loss of communication with CPC pumps to ramp to 80%
FAU	Fresh air units setpoints	20°C @ 45% RH (adj) Humidification start @30% RH and Dehumidification start at 57%RH

21 Misc. Systems/Monitoring

21.1 Automatic Chemical Treatment System (ACTS)

- 1) The Automatic Chemical Treatment System is used to filter a nominal % (5-15%) of the full flow of the water flowing through the chilled water system. The total system volume will thus be filtered at least 2-3 times per 24hours. The primary purpose of the system is to filter out suspended particles in the recirculating water as well as treat it.

- 2) The system is to be installed to manufacturers recommendations as shown on the schematic drawings.
- 3) The units' common alarm status shall be monitored by the BMS via hardwired interface. On receipt of a common fault status, a "Level 2" alarm shall be raised on the BMS Head End. These common alarms shall be as a result of filter blockage, low chemical level or loss of communication.

21.2 Degasser & Make Up Water System (DMWS) and Pressure

- 1) The packaged degasser and make up water system are used to add 'make up' water to the chilled water system as well as remove gas from this water and thus minimize corrosion.
- 2) The units' common alarm status shall be monitored by the future BMS via hardwired interface. On receipt of a common fault status, a "Level 2" alarm shall be raised on the future BMS Head End.
- 3) The operational run status of the pressurization units shall be monitored by water meter and "Critical" alarm shall be raised in the event of the pressurization units running continuously for 300 seconds.

21.3 Pressure Maintenance/Stabilization (PMS) System

- 1) The PMS system is used to absorb any changes in the thermal expansion of the chilled water system as a result of water temperature change.
- 2) Two hardwired interfaces shall be provided in the packaged pressurization units integrated controller for connection to the future BMS for the purpose of raising an alarm at the BMS in the event of a fault:
 - a) Pressurization unit common fault
 - b) Pressurization unit run status

21.3.1 Low Pressure Monitoring

- 1) A low-pressure switch shall be installed for each pressurization unit, a "Critical" alarm shall be generated on the future BMS system.

21.3.2 High Pressure Monitoring

A high-pressure switch shall be installed for each pressurization unit, a “Critical” alarm shall be generated on the future BMS system.

22 Graphics

The following graphic shall be generated as a minimum Based on a common graphical interface:

- CHW system overview in schematic form (all parameters)
- Chiller 1 to 3 information page
- CHW TES vessel information page
- CHW circuit cooling supplied and electrical power consumption in graphical form
- All plant