SPECIFICATION- AIR CONDITIONING AND VENTILATION INSTALLATION

For SABC STUDIO 6 REINSTATEMENT

Date Approved: 17/11/2021

Revision: 0

INDEX

PART 1

RETURNABLES

*** THIS PAGE IS TO BE COMPLETED AND RETURNED**

1 RETURNABLES

1.1 Tender Sum

Tenderers price strictly in accordance with the air conditioning and ventilation specification **G3915** for **SABC STUDIO 6 REINSTATEMENT.**

The entire installation must conform to the requirements of this specification and must be complete in every aspect. The Tenderers to complete the pricing under the BOQ provided.

(Transferred to N-S Subcontract Agreement page)

Thus, done and signed at _____on _____ day of _____ 2021

_____ _____

Name of Signatory Capacity

_____

Company Details

WE ACKNOWLEDGE COMPLIANCE TO GPCE TENDER DOCUMENT & TECHNICAL SPECIFICATION

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1.2 Tenderers P&G's

Tenderers must include the following items as line items within their P&G's section of their bills of quantity.

Special Prelimnary&General Conditions Pertaining to this Subcontract		**FIXED**
Shop Drawing	Fixed	In BOQ
Engineering Services	Fixed	In BOQ
12 Months Maintenance (as per spec)	Item	By tenderer
Test and Inspections	Fixed	In BOQ

1.3 Cost Breakdown

A detailed cost breakdown to be supplied by each tenderer at time of tender. This detailed cost breakdown supplied by the HVAC Contractor is to be used as the basis for controlling costs and substantiating claims for payment to the air conditioning sub-contractor.

Re-measurement of the works and agreement on quantities will take place throughout the course of the project. The sub-contractor will be responsible for re-measurement, with checking and approval by the Consulting Engineer.

The sub-contractor needs to submit cost for additions and omissions to the Consulting Engineer within 21 days for approval.

Percentage completion is to be reflected on the breakdown, which is to accompany all Progress Claims. No payments will be made for claims which are not accompanied by the updated measurement of work done.

1.4 Rates

The following rates are to be provided at tender stage and returned with the submission at tender closing. These rates are to be as per the allowances used to compile the submission. These rates shall be used to assess variations during the course of the project.

Should these rates be different from those supplied in the tender submission, the lower of the two will apply for variation assessment.

Preliminary & General _____% Mark-up to cover overheads and profit _____%

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1.5 Schedule of Equipment

Tenderers must offer the equipment specified below as part of their main offer.

Should tenderers wish to offer an alternative suppliers' equipment not listed below this may be done under separate cover. However, equipment compliance to our specification, unit handling and equipment size must be compatible with the design as indicated on the drawings and is the responsibility of the contractor to ensure this is adhered to at Tender stage.

Equipment	Approved Suppliers	Name of Supplier Tendered
Air Handling Units	Trox	
Air Handling Unit Valve Assembly	Belimo	
Sound Attenuators	Trox	
Automatic Controls	Belimo	
Fans	AMS	
Diffusers	Rickard	
Grilles	EMAir	
Weather Louvres	EMAir	

Alternative Equipment	Alternative Suppliers	Name of Alt Supplier
Air Handling Units	Skyshot, Apache, Systemair, Heating Centre, Thermopak.	
Air Handling Unit Valve Assembly	Flowcon, Danfoss	
Sound Attenuators	AMS, Systemair.	
Automatic Controls	Siemens, Carel	
Fans	Systemair	
Diffusers	Systemair	
Grilles	Systemair	
Weather Louvres	Systemair	

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1.6 Sub-Contract Work – Where Applicable

Tenderers to list any work or service which they intend to sublet and name the firm to whom they propose subletting the work.

Service	Name of Firm
Ductwork Fabrication	
Ductwork Installation	
DB's and Controls	
Chilled Water Piping Installation	

PART 2

TENDER CONDITIONS & PROJECT DESCRIPTION

2 TENDER CONDITIONS & PROJECT DESCRIPTION

2.1 Inspection of Documents

It is hereby deemed that the tenderer shall have carried out a full and detailed inspection of all drawings, tender documents (Parts 1,2,3,4) and site conditions prior to the submission of the tender for this project. By such an inspection the tenderer shall be deemed to be fully informed of all matters which may influence his tender. No claim of any nature whatsoever will be considered after the submission of tenders, due to failure on the part of the tenderer to fulfil this obligation.

Cognisance must be taken of all the information when pricing. Should the tenderer consider that inadequate information has been provided he shall apply in writing to Graeme Page Consulting Engineers for complete information, as no claim in this respect will be considered after receipt of tenders.

2.2 Contract

The successful tenderer for the Heating, Ventilation and Air Conditioning installation will be appointed as a selected sub-contractor to the main contractor.

The preliminaries applicable to the Main Contract Agreement are included in Part 3 of this tender document.

The Terms & Conditions of Contract shall be in general accordance with JBCC Series 2000 Edition 6.1 published March 2014 N-S Subcontract Agreement Contract Data SE.

The penalties for late completion shall be as stated in the preliminaries applicable to the Main Contract Agreement in Part 3 of this tender document.

2.2.1 Contract Period

The construction on site has already commenced and practical completion for the project will be as provided by the PQS documentation.

Tenderers are to ensure that they can comply with the programme requirements of the Main Contract. High level program is included by the PQS.

2.3 Submission Details

Tenders shall be submitted on the Form of Tender accompanied by all the documents issued herewith duly complete.

2.3.1 Key Milestone Dates

Email Issue of Tender Documents: **TBC**

Tender Submission: **TBC @ 12h00**

The tenders can be submitted in two ways:

- Hard Copy – SABC Tender Box
- Email – N/A

All tenders must be valid for 60 (sixty) days from date of tender submission.

The lowest tender will not necessarily be accepted. Any Tender which does not comply with the requirements stated in these documents may be considered invalid. Tenderers may include with their Tenders any descriptive matter which, if referred to in the Tender, will form part of the Tender. In case of any discrepancy, however, the issued Tender and Contract documents and information completed therein by the Tenderer, will be considered as the valid and binding Tender.

2.4 Pricing of Tenders

Prices are required to be included in the tender for each offer and the right is hereby reserved to accept all or part of the items listed and priced for. The prices shall be presented and be compiled in the tender pricing schedule included in Part 1.

2.4.1 Foreign Exchange Risks

Preference will be given to tenders for which forward cover against foreign exchange variations will be provided by the tenderer. The tenderer shall state in the Price Adjustment Schedule whether he will provide this cover.

If no mention is made, it is accepted that the contractor allowed in the tender price for forward cover against foreign exchange variations. If the contract price or part thereof is subject to adjustment for variations in rates of foreign exchange, the rate applied shall be that ruling at the date for the contractual despatch ex-factory.

2.4.2 Escalation

The fully completed tender price and rates shall be fixed and firm for the duration of the contract and shall not be subject to escalation.

2.4.3 Value Added Tax

Tenderers shall allow for Value Added Tax in the tender prices as indicated in the Form of Tender and if applicable, the Schedule of Quantities. VAT is currently applicable and shall apply. Should the percentage tax be adjusted during the currency of the contract, the increase or decrease will apply only to such materials as have been purchased at the date of the change.

2.5 Alternative Offers

If the Tenderer wishes to submit other offers in place of any of the provisions of the Requirements for Tendering, Conditions of Contract, Specification or Schedules, he shall set out details of his proposals in a separate covering letter.

2.6 Schedule Of Sub-Contracts

The Tenderer shall state in the Schedule of Proposed Sub-Contractors the name of any Sub-Contractors he proposes to employ to assist him to complete the Works and the proposed extent of the Sub-Contractor's responsibilities.

All sub-contractors who are proposed to be used during the contract must be nominated in order for the Engineer or Client's representative to sanction such choices.

2.7 Copyright

No part of any document enclosed in this enquiry may be copied, photographed or repeated in any manner or by any processes without the written consent of the Engineer. Copyright is reserved on all designs, specifications, patents and patentable designs, systems and processes contained in the documents and drawings. The person, firm, body or contractor to whom these documents and drawings are issued or made available, shall be held responsible, jointly or severally, in their personal and corporate capacities for any contravention of this requirement for tendering and/or copyright clause contained in the documents.

2.8 Description of Project

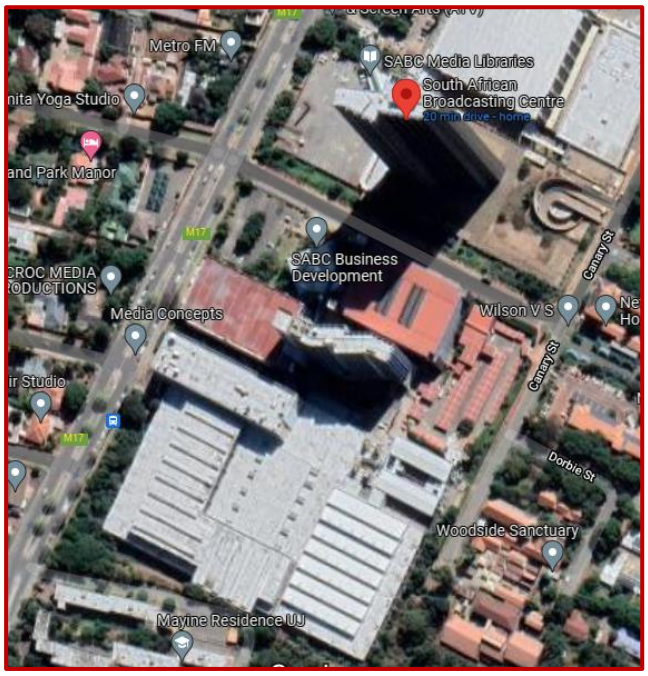
This tender is for the SABC STUDIO 6 REINSTATEMENT.

The sub-contract includes the supply, delivery, installation, commissioning, guarantee and 12 month "free" maintenance of the new mechanical air conditioning and ventilation systems designed for SABC STUDIO 6 REINSTATEMENT. The one year guarantee and maintenance period will commence once practical completion has been reached.

The Client is SABC.

2.9 Site Description & Constraints

General Details



Site Location: Studio 6, Henley TV Facilities,
South African Broadcasting Centre,
Cnr Henley Ave & Artillery Rd,
Johannesburg
2092

Electricity will be available on site. The contractor will be responsible for providing a suitable extension cable from the point of supply to the point of use. Extension cables shall be safe and free from defects.

The contractor will provide test certificates or logs on all lifting equipment if requested by the main contractor, the consultant or personnel authorized by the main contractor or client.

The contractor will provide the designated crane driver's certificate prior to establishment on site. The certificate must be current and acceptable, in terms of the Occupational Health and Safety Act.

Site Constraints

It is the responsibility of the Tenderer to visit the site during the tender phase and to familiarise himself with conditions related to it.

At this visit the Contractor is also to familiarise themselves with any equipment rigging conditions. The tenderer is responsible for rigging of his equipment into position.

No claim for additional payment related to ignorance of site conditions will be accepted. By submitting a tender it is accepted that the Tenderer is fully aware of all site conditions as well as the access to it, and has allowed for this in his tender price.

2.10 Reference Documentation

All equipment specifications can be read from the equipment schedules on the drawings. If the equipment schedules on the drawings are incomplete or incorrect the author of the tender document needs to be contacted for more information.

The drawings are for tender purposes only and shall not be used for ordering and purchasing. Construction Drawings will be issued post Contractor Appointment.

DRAWING #	DRAWING DESCRIPTION	REV
G3915-1001	HVAC Installation Second Floor Layout	**A**
G3915-1002	HVAC Installation Third Floor Layout	**A**
G3915-1003	HVAC Installation Roof Layout	**A**

2.11 Site Design Conditions and Inside Conditions Required

- Site Conditions:

Altitude	1700m above Sea Level
Outside Design Conditions	Summer 32.0°C db and 20,0°C wb
	Winter 0°C db
Electrical Supply	400 volt, 3 phase 50 Hertz plus neutral and earth or
	230 volt, 1 phase 50 Hertz

- Inside Conditions Required:

Temperature	Summer	22,5°C db
	Winter	20,0°C db

- Tolerance:

Differential of Controls	within ±1.5ºC
Relative Humidity	40% < RH < 60%

- Relative humidity will be actively controlled to ensure the studio's relative humidity remains between 40% to 60%.

- Maximum allowable noise levels:

Studio	NC20
Control Rooms	NC20

2.12 Detailed Description of Installation

The air handling units serving Studio 6 and the associated support areas are to be replaced with new air handling units that connect directly to the existing chilled water system, by way of new chilled water pipes and control valves.

2.12.1 TV Production Studio

This area shall be served by a separate plant, comprising of a chilled water air handling unit supplying conditioned air to the studio through a system of internally insulated sheet metal ducting, and distributed to the studio through dedicated drum louvres.

Re-circulated air shall be returned through dedicated drum louvres positioned near the supply air drum louvres and shall be ducted back to the plant area through internally insulated sheet metal ducting. .

The required quantity of fresh air shall be introduced through dedicated fresh air fans positioned at the return air ducts before they connect to the unit.

Active humidity control will be provided to ensure that the studio's relative humidity remains between 40% to 60%.

Heating in Winter shall be provided by means of electric resistance type heaters mounted in the units.

The plants shall be automatically controlled to provide the required temperature conditions in Summer and Winter, and shall be switched on and off automatically at the BMS.

A manual override control, which shall allow each plant to operate for a maximum of two hours when actuated, shall be positioned at a remote-control point in the control room.

Sound attenuators will be installed in the duct runs for both supply and return air, to achieve a noise criteria level of NC20 to NC25.

The drawback area located on the ground floor of the studio will be passively conditioned by the main studio air handling unit, but will not have dedicated ducting to the spaces.

2.12.2 Control Suite

Studio 6 contains three (3) control rooms located on the second floor of the studio in the control suite. This control suite, as well as the dimmer room and lantern store on the floor above, will be conditioned by a single chilled water air handling unit.

Conditioned air from the dedicated chilled water air handling unit shall be supplied through systems of internally insulated sheet metal ducting and distributed to the areas through ceiling diffusers.

Re-circulated air from the control suite shall pass into the return air ducting at the back of the suite, and the air shall be ducted back to the air handling unit.

The required quantity of fresh air shall be introduced through dedicated fresh air fans positioned at the return air ducts before they connect to the unit.

Active humidity control will be provided to ensure that the studio's relative humidity remains between 40% to 60%.

The required heating in Winter shall be provided by means of electric resistance type heaters mounted in the air handling unit.

The plants shall be automatically controlled to provide the required temperature conditions in Summer and Winter and shall be switched on and off automatically at the plant control panel at each unit. A manual override control, which shall allow each plant to operate for a maximum of two hours when actuated, shall be positioned at a control panel in the control suite.

Sound attenuators will be installed in the duct runs for both supply and return air, to achieve a noise criteria level of NC20 to NC25. Cross talk attenuators shall be installed between individual control rooms.

2.12.3 Equipment Room

A dedicated closed control chilled water floor standing top discharge unit shall supply conditioned air to the equipment room. This unit will control closely the temperature in the equipment room, as well as the relative humidity therein.

Conditioned air from the dedicated chilled water air handling unit shall be supplied through systems of internally insulated sheet metal ducting and distributed to the areas through ceiling diffusers.

Re-circulated air from the equipment room shall pass into the return air ducting, and the air shall be ducted back to the air handling unit under pressure by a dedicated return air fan.

Active humidity control will be provided to ensure that the studio's relative humidity remains between 40% to 60%.

2.12.4 Chilled Water Air Handling Units

The existing chilled water air handling units at Studio 6 are to be completely decommissioned and isolated from the main chilled water piping, by way of freezing the existing chilled water branches and installing a shut off valve. These units then need to be disassembled and removed from site. The new air handling units need to be installed on the same plinths, with new chilled water piping reticulated from the isolating valves to the air handling unit, and the new control valves installed. The new chilled water units need to be modular and capable of fitting through a standard double door, of dimensions 1800mm x 2100mm, and are to be assembled in situ. The AHU is to be complete in all aspects.

All chilled water AHUs to interface with existing Johnson Controls BMS, the AHU controls are to be Bacnet IP compatible with the following Software Points (SP) available for each AHU:

1. Run / Stop status
2. Run / Stop control
3. Common Fault / Normal status
4. Dirty Filter Fault
5. Room Temperature Sensors
6. Temperature Set point
7. Supply Air Temperature
8. Return Air Temperature
9. Cooling or Heating Mode.
10. Relative Humidity Set point
11. Relative Humidity
12. Humidifier Run/Stop

Room temperature sensors need to be installed in the main studio space, as well as the control suite.

2.13 Technical Submissions

The tenderer shall for the items below timeously submit full submittals to allow technical and aesthetic approvals prior to ordering.

- Chilled water schematics.
- Ventilation Equipment – Fans.
- Terminal Devices – Diffusers, grilles, weather louvres.
- Electrical wiring diagrams and control panels.
- Sound Attenuators.
- Chilled water equipment – AHU, valves.

2.14 Programme

The entire air conditioning and ventilation installation must be commissioned, tested and taken over by the Engineer no later than two weeks prior to the final practical completion date of the project.

The Sub-contractor will be notified of the success of his tender. Thereupon the Sub-contractor shall immediately put the work in hand, notwithstanding the fact that no official Sub-contract will by this time have been entered into. During the period prior to the signing of an official sub-contract, but during which the work must in terms of the above be proceeded with, the work will be administered by the Engineer as if, in fact, such document had already been in force.

The Sub-contractor shall be required within two weeks after acceptance of his Tender, to submit to the Engineer for his approval, a Programme showing the order in which the Works will be executed. Such Programme shall show the times for the preparation of all drawings, ordering and delivery times promised by the suppliers for each major item of the Plant, manufacturing and delivery times for all manufactured items, installation and the programmed dates for testing and commissioning the Plant.

The dust blow-out date of all ducting installations prior to the installation of ceiling boards and tiles shall also be indicated on the programme.

The Programme shall be prepared in consultation with the Main Contractor and the execution of the Works shall be programmed so as to keep pace with the Building Programme. The Sub-contractor is required to visit the site and discuss the programme with the Main Contractor. It shall be assumed that by submitting a tender, the Sub-contractor has complied with this clause. The Sub-contractor shall submit TWO copies of his Programme to the Engineer once approved by the principal contractor. The Sub-contractor shall supply copies to the Principal Contractor. After submission to and approval by the Engineer of such Programme, the Sub-contractor shall adhere to the order of procedure and method stated therein unless he obtains the written permission of the Engineer to vary such order or method. The

submission to and approval by the Engineer of such Programme shall not relieve the sub-contractor of any of his duties or responsibilities under the sub-contract.

2.15 Scope of Work

The air conditioning sub-contract shall include but not be limited to:

Supply and installation of the air conditioning and ventilation systems as specified, including testing and commissioning to final handover, acceptance and 12 months guarantee and "free" maintenance, in monthly intervals, **resulting in 12 visits for the year.**

The provision of all necessary controls, fire relays, instrumentation and wiring from control panels to air conditioning and ventilation equipment as specified herein.

The timeous provision of builder's work details.

The co-ordination with other trades and services especially with regard to structure, lighting, ceiling and piped services layouts.

Painting and weather proofing of exposed visible ducting, venturi-cowls, equipment and piping, where specified, control panels and any touching up as required. Colours to be used shall be selected by the Consulting Mechanical Engineer and to suit the Architects' requirements.

Provision of galvanised steel channel forms and holding down bolts for equipment plinths, which are required for rotating equipment. Minimum depth 150mm.

The provision of all minimum 32mm diameter condensate drain PVC, copper and galvanised piping including traps, supports etc. from equipment into the building drainage system.

The supply and installation of galvanised wire mesh type cable trays for the support of all inter connecting refrigeration pipe, condensate drain pipes and control cabling work and between indoor and outdoor units.

Protect all HVAC equipment properly on site against building and painting operations, until the final handover date of the entire installation.

The insulation and cladding of all ductwork and refrigeration piping as specified. This includes internal and external insulation / cladding of exposed ductwork and piping on the roof, mounted under concrete slabs, in ceiling or roof voids.

Provision and installation of all necessary wiring, conduit, cable trays, relays, contactors and switchgear to switch off units in a fire condition. This includes the wiring to the I/O points provided by the smoke / fire detection installation sub-contractor. Unless otherwise specified the fire signal will be provided by others in the form of a single, potential-free contact at each A/C board.

Provision and installation of galvanized hail guards on all finned coils exposed to the elements, unless specifically excluded in the specifications. Hail guards to be minimum 20 mm x 20 mm galvanized weldmesh screen with angle iron frame, unless otherwise specified.

Provision and installation of all external weather louvres and all door grilles as shown on the drawings. Provision and installation of all internal supply and return air louvres, diffusers, etc, as indicated on the tender drawings. All external openings to the building or equipment to be protected by vermin-proof screens.

Installation ("shop") drawings.

Record "as-built" drawings (3 copies + electronic copies on CD).

Three sets of Operating and Maintenance manuals. A draft copy to be approved by the Consulting Mechanical Engineer, prior to the submittal of the three sets. Commissioning test reports shall indicate the actual measured and design readings and all equipment serial numbers.

Removal from site at regular intervals of excess and waste material generated during HVAC works.

2.15.1 Electrical Work

Unless otherwise indicated or specified, all electrical work including conduit, trunking, cable trays, wiring and cabling associated with the HVAC equipment to be supplied and installed in terms of the HVAC sub-contract, shall form part of the HVAC sub-contract.

All fans, air handling units, etc., except where otherwise noted, shall be provided with local isolators which shall form part of the main electrical sub-contract (i.e. by others).

2.15.2 Scaffolding

All scaffolding is to be provided by the air conditioning sub-contractor.

2.15.3 Spare Parts

Tenderers are to allow in their tender price for the following:

- ONE set of filters for each Air Conditioning and Ventilation system installed just prior to opening/occupation
- ONE set of filters for each Air Conditioning and Ventilation system installed after 12 months' guarantee.

2.16 Work to be Carried Out by Others

The following work associated with the air conditioning installation will not be included in this sub-contract.

2.16.1 Builders Work

The provision of openings in structural concrete work, masonry brick work, roof or wall cladding, etc.

The building in of duct sleeves, burglar bars, fire damper etc, where required to provide an air tight, fire or sound proof seal. The provision of the fire dampers, duct, pipes shall, however, be the responsibility of the HVAC sub-contractor.

The final flashing and waterproofing of all pipe and duct penetrations through external walls and roofs, etc. (Temporary waterproof seals shall be carried out by the AC Sub-contractor).

The casting of level concrete plinths for mounting air conditioning equipment and the waterproofing of same.

The provision of 25mm hardwood timber frames in masonry openings as required for fixing ducts, grilles, louvres, etc.

The provision of openings in doors for door grilles and also the provision of undercut doors where specified shall be carried out by others.

The provision of openings in ceilings for diffusers and the provision of additional ceiling tees to frame such openings.

The provision of minimum 600 x 600mm access panels where noted. – (Hinged type shall be required to plaster board ceilings).
The main contractor must ensure that all HVAC equipment is properly protected against building and painting operations, at all times, until the final hand over stage of the HVAC installation.

Supply and installation of external louvres to all air intake / discharge openings, where applicable.

2.16.2 Electrical Work

Temporary proper lighting and power will be provided to all areas, by the Main Contractor.

The supply and installation of power cables to air conditioning control panels and ventilation fans shall terminate on main isolators.

The supply and installation of switched isolators adjacent to A/C Units in the ceiling void and in plant rooms, complete with wiring, where necessary.

The supply and installation of the interconnecting wiring between the smoke detection installation and the I/O points for the HVAC system.

The provision of a separate emergency/standby power supply cable to the emergency section of the air conditioning control panels and termination on main isolators.
The provision of power supplies terminating in isolators adjacent to each toilet /kitchen/ventilation fan shall be the responsibility of the electrical sub-contractor. Final connection from isolator to fan plus starter and motor protection by HVAC sub-contractor. Where required, the interfacing of fans with light switches (ceiling fans) shall also be the responsibility of the HVAC sub-contractor.

The main electrical sub-contractor shall generally carry out the following electrical work associated with this sub-contract:

- Provide power (normal and/or emergency) to the air conditioning and ventilation control panels or isolators. Power will terminate on incoming side of main panel isolators.
- Provide power to single or three phase isolators adjacent and within 1 metre to fans and smaller equipment. Isolators shall be supplied and installed by the main electrical sub-contractor.
- Where power is provided to equipment with remote condensers, the power will be supplied local to the condensers only, by the electrical contractor.

2.16.3 Plumbing Work

Provision of trapped full bore drains adjacent to all air handling units in the plant rooms as shown on the drawings.

Provision of a water point (c/w tap) in each plant room and wherever else required, over the full bore drain to be used for washing of filters. This will also apply to any filter washing facilities installed as part of the building construction.

Connection points in the drainage stacks for connection of Ø 32 condensate drain pipes (positions to be clarified).

Trapped drain points for condensate drainage from any air conditioning unit where required and indicated on the drawings. Drain pipe between AC unit and drain point by AC sub-contractor.

PART 3

CONDITIONS OF CONTRACT & GENERAL PRELIMINARIES

PART 4

GENERAL SPECIFICATIONS

4. CONTRACT ADMINISTRATION AND MANAGEMENT

4.1 Codes And Standards

The entire installation shall be in accordance with the following:

- The National Building Regulations and Building Standards Act No. 103 of 1977 as amended in 1984, and all amendments thereafter.
- The latest revision of SANS 10142: Code of Practice for the Wiring of Premises, as amended.
- The Machinery and Occupational Health and Safety Act No. 85 of 1993.
- All air conditioners will comply with the latest revision of SANS 10147, as amended.
- Any other relevant by-laws of local or other authorities.
- The latest revision of SANS 1424: Filters for use in air-conditioning and general ventilation.
- The latest revision of SANS 10140: Identification colour marking.
- Air Distribution Systems: SANS 10173: Code of Practice for the Installation, Testing & Balancing of Air Conditioning Ductwork.
- Refrigeration Systems: CIBSE: Commissioning Code: Series R: Refrigeration Systems.
- Control Systems: CIBSE: Commissioning Code: Series C: Automatic Controls.

Materials and/or equipment used for this project to be of the same manufacturer wherever possible.
The Sub-contractor must obtain approval from all authorities as required for materials and/or equipment used on the project.

The Contractor shall provide himself with copies of all the South African National Standards, British Standards and American Society of Testing Materials Specifications and any other publications, regulations and by-laws, quoted in the Specification.

Where Standard Specifications are referred to in the Specification, latest edition of such standards available at the date set for the closing of Tenders for this Sub-contract shall apply. No claim will be entertained because of lack of knowledge of such specifications or regulations.

4.2 Units

All units shall be expressed in SI (International System of Units).

4.3 Scope

This specification applies to the General and Technical Requirements for the Selection, Fabrication, Installation and Testing for the Air Conditioning and Ventilation Systems of the project.

This specification shall be used in conjunction with other relevant Project Specifications and Data Sheets. All equipment, goods, materials and services supplied shall comply with the applicable standards as set out in this document.

All workmanship shall be to a high standard of quality in accordance with the norms of the industry and appropriate to the function of the works. To this end the contractor shall employ only suitably qualified personnel and artisans to undertake the various skilled works under the supervision of a competent person.

4.4 Supervision

In addition to the requirements of the Condition of Tender and Conditions of Contract the Contractor shall supply the services of an experienced and competent Contract Supervisor to be in constant charge of work at site.

Only qualified refrigeration technicians, coded welders, qualified boilermakers and qualified electricians are to be used.

4.5 Shop Drawings

The sub-contractor shall submit to the Engineer, for approval and at his own expense, all shop drawings as required for the execution of the contract, including any additional details which may be requested by the Engineer or Client.

The tender drawings issued do not necessarily purport to show the exact position, size or details of construction of equipment.

The Consulting Engineer's drawings are not to be used for manufacturing or installation purposes without express approval from the Consulting Engineer and acceptance of the risks therein by the Tenderer.
The sub-contractor shall not, unless otherwise directed by the Engineer, in writing, commence with any work prior to the approval of the relative shop drawings. Work installed prior to the approval of shop drawings shall be liable to rejection by the Engineer and removal and/or replacement by the sub-contractor, at his cost, if it is considered by the Engineer to deviate from the specification.

Shop drawings shall indicate all the necessary information necessary for installation, these must include but not limited to:

- Electrical drawings shall comprise complete control and power wiring diagrams, as well as front and side elevations giving major dimensions of control panels as well as instrumentation and switch position layouts.
- Power requirements and locations
- All Builder's Work requirements indicating the location and extent of all horizontal/vertical brickwork/concrete openings, timber frames, piping bases, plinths.
- Actual equipment sizes
- Equipment positions including positional dimensions
- Support and fixing details to be used
- Condensate drainage and water supply points required.
- Plantrooms drawn to a scale of not smaller than 1:100
- All drawings and details shall be drawn down to a scale to enable the Builder to execute work without any misunderstanding.

Within a reasonable period after receiving such drawings, the Engineer shall signify his approval.

The Engineer will check drawings for correctness and compliance with design only. Physical sizes and correct location of equipment and components shall remain the responsibility of the Contractor.

Correction or comments made on drawings by the Engineer does not imply a change in the "Scope of Work". The Sub-contractor shall inform the Engineer immediately, in writing, prior to modifications to the original drawings, whether in his opinion such corrections and comments will result in a change to the "Scope of Work".

Drawings approved as above described shall not be departed from except as authorised by the Engineer.

4.6 Mistakes on Shop Drawings

Any expense resulting from an error or omission in or from delay in delivery of the shop drawings, shall be borne by the Sub-contractor.

The Sub-contractor shall be responsible for any discrepancies, errors, or omissions in the shop drawings and other supplied by him, whether such drawings and have been approved by the Engineer or not, provided that such discrepancies, errors, or omissions are not due to inaccurate information or particulars furnished in writing to the Sub-contractor by the Engineer.

4.7 Co-operation with Principal and Other Contractors

Where relevant, the contractor must render full co-operation to the Principal Contactor and to work Sub-Contractors. Provide any information necessary to permit work of all trades to be installed satisfactory and without interference or delay.

Where work is to be installed near work of other trades, or where there is evidence that work may interfere with work of other trades, assist in resolving co-ordination issues to make satisfactory adjustments prior to preparation of shop drawings.

The Contractors exact requirements shall be transmitted to the Main Contractor. Should these instructions be issued after completion of relevant areas, then this work will be carried out at the expense of the AC contractor.

4.8 Equipment Selection Submissions

No equipment shall be installed until equipment submissions have been approved by the Engineer.

4.9 Sample Submissions

Samples shall be physical examples to illustrate materials, equipment or workmanship and to establish standards by which the works may be judged.

The engineer may request sample grilles, diffusers and louvres to be submitted for approval prior to purchasing.

4.10 Handling of Equipment

The Mechanical Contractor shall investigate each space through which equipment must be moved or handled. Where necessary, equipment shall be transported from the manufacturer in crated sections of size suitable for moving through restricted spaces available.

Tenderers must satisfy themselves that the equipment offered by them can be accommodated in the available space and positioned in such a way that access for maintenance, repairs or removal is not obstructed.

Verification that the positioning or location of equipment, opening sleeves, penetrations, trunking, etc., does not clash with other services is the responsibility of the Contractor.

4.11 Temporary Use Equipment

No equipment intended for permanent installation shall be operated for temporary purposes without the written permission of, and in complete agreement with stipulations as set out by the Engineer.

4.12 Protection Against Damage

Suitable measures shall be taken during transport, delivery, storage on site and installation to ensure that the entire system is in an ‘as new’ condition at first start-up.

The AC contractor shall always remain responsible for protecting the equipment and retaining the as new condition. Any damage caused by the contractor or their sub-contractors shall be rectified to the satisfaction of the engineer, by and at the expense of the AC contractor.

4.13 Storage of Materials on Site

Materials permitted to be stored within the building shall be safely packed and shall not overload floor construction beyond the legal permissible floor loading.

Combustible materials shall not be stored on premises longer than the minimum period necessary for execution of work. Provide fire protective measures as directed by Engineer and/or Principal Contractor.

The contractor is responsible for the security and insurance of all their equipment on site.

All equipment delivered to site shall be well protected from weather and other trades.

4.14 Handover Inspections

The Contractor must allow for reasonable assistance to the Engineer during inspections. The installation will be inspected by the Engineer on a regular basis during the Contract to ensure compliance with the specification. A written record will be kept of all defects noted.

The contractor shall provide a competent person to accompany the Engineer or his representative during inspections. This person shall know the installation, shall be able to accept and carry out instructions and shall take notes during the inspections so that the remedial work can commence immediately and is not held up while waiting for the inspection certificate.

The Contractor must ensure that the installation is correct, complete and to specification before calling for acceptance inspections.

Test commissioning data of all tests by the Contractor must be submitted to the Engineer before applying for acceptance inspections.

The cost of any abortive inspections, where the Engineer is called to site, but finds the Contractor ill-prepared for it, may be deducted from the Contract Price by Variation Order.

The Engineer can request that any part of the complete system be retested, recorded and measured as part of the acceptance inspections, if any reasonable doubt exists about the accuracy of the tests.

4.15 Guarantee

The Contractor shall guarantee the material, apparatus and workmanship delivered by him for a period of twelve months. The guarantee must be valid for a period starting on the date when the contract is accepted by the Engineer as complete. The complete installation must be guaranteed against defects because of patent and latent defects of the design and apparatus, (save design defects made or specified by the Engineer), as well as against faulty materials and workmanship. The guarantee must provide that all parts, spares and appurtenances that become defective during guarantee period be replaced free of charge.

The Contractor shall provide to the engineer during the 12 month guarantee period, copies of all service job cards.

The contractor shall provide for a full set of replacement filters for all equipment at the end of the guarantee period.

The costs of labour and transportation required to replace such part of the defective installation shall be borne by the Contractor and shall be included in his guarantee. The Contractor shall cede to the Employer the remainder of any equipment guarantee which he has received from his suppliers which extend beyond the period of twelve months mentioned herein.

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

4.16 Operating and Maintenance Instructions

4.16.1 Manuals

A Condition of the final acceptance of the works will be the provision of five hard copies and five electronic copy of an approved comprehensive Maintenance and Operating Instruction Manual.

Each copy of the manual is to include the following:

- A general description of the system and the operation thereof.
- Details of the method of operation of the plant and controls.
- An equipment and controls list giving the following in the form of an asset register:
    - Description
    - Quantity
    - Make
    - Model Number
    - Location
- A schedule of the servicing to be done on each item of equipment and controls and the frequency.
- Description of automatic control system accompanied by control schematics (where necessary).
- Step-by-step instructions for starting / stopping each item of equipment.
- Full final commissioning data including test certificates & air flow data.
- Certificate of Conformity for Refrigeration and Air Conditioning Installation.
- Certificate of Compliance for Electrical Installation.
- “As-built” drawings, wiring diagrams, piping schematics (pdf. and dwg. format)

4.16.2 Training

The Contractor, in addition to the Operating and Maintenance Manuals, shall give detailed explanation of and full training instructions to the Owner on the operation of the complete installation as finally commissioned and handed over to the Engineer.

The Contractor shall operate the whole plant for the duration of the twelve-month free guarantee and maintenance period.

The contractor shall be present for a period of 2 weeks after the guarantee period to assist the handover of the plant to the owner and new maintenance contractor.

5 GENERAL REQUIREMENTS FOR WORKMANSHIP AND MATERIALS

5.1 Commissioning and Testing

5.1.1 General

The Contractor shall test, balance and commission the installation as required, achieving specified performance and efficient operation of the system and recording all details of measurements taken.

A responsible Commissioning Engineer employed by the Contractor shall be present to supervise the operation and adjustment of the equipment during the entire commissioning stage.

The Contractor shall carry out all the above before requesting acceptance and witnessing of performance by the Engineer. Commissioning data shall be fully tabulated in conjunction with the design data and submitted to the Engineer prior to the inspection being carried out by the Engineer.

All acceptance tests, whether in the manufacturer's works or on site, must be carried out in the presence of the Engineer.

Commissioning of equipment and systems shall not be undertaken if damage to the equipment, systems or the building could result due to incomplete and incorrect installation work. Testing and balancing shall not begin until the system has been completed and is in full working order.

Commissioning procedures as stipulated by the suppliers of equipment shall be strictly adhered to.

The commissioning of equipment such as refrigeration machines, boilers, air compressors, etc., shall be undertaken by the suppliers under the supervision of the Contractor.

Calibrated instrumentation required to measure flows, pressures, temperatures, etc., shall be provided by the Contractor. Specific attention is drawn to the fact that calibration certificates will be required for Watt meters, ammeters, voltmeters, frequency meters, pressure gauges, flow meters, orifices plates, temperature gauges and dynamometers.

The entire control system shall be adjusted and commissioned by the control system specialist Contractors, where applicable.

All safety protection systems shall be fully commissioned and set points properly checked out and adjusted, before equipment shall be allowed to run for commissioning purposes.

Should the Engineer or Client wish to verify the calibration of any instruments, the Contractor shall make the necessary arrangements for the instrument to be re-calibrated by a recognised authority.

Complete test reports shall be submitted to the Engineer, prior to the first delivery of the project. Reports shall cover all tests carried out on individual sections, including such works tests as may have been conducted. All reports shall be neatly typed.

List of all commissioning tests required:

- A general description of the system and the operation thereof.
- Condensate drain fall measurement results
- Full and comprehensive commissioning report by the supplier for chillers and rooftop package units.

Rooftop & AHU commissioning data to include all technical information on components (unit number, model numbers, location, serial numbers, design ratings etc) and the following measured information.

Cooling/Heating Operation to incl:	**Running Amps/Voltage for:**	**Compressors**
Ambient Temperature	Compressors	LP
Room Temperature	Condenser Fans	Suction Temperature
Evap on/off	Supply Air Fans	Superheat
Cond on/off		Subcooling
	Airflow	HP
Fire Signal Integration Test	Supply Air Volume	Condensing Temperature
Phase Failure Test	Return Air Volume	
	Fresh Air Volume	

Chiller commissioning data to include all technical information on components (unit number, model numbers, location, serial numbers, design ratings etc) and the following measured information.

Cooling/Heating Operation to incl:	**Running Amps/Voltage for:**	**Compressors**
Ambient Temperature	Compressors	LP
Room Temperature	Condenser Fans	Suction Temperature
Evap on/off	Pumps	Superheat
Cond on/off		Subcooling
	Medium	HP
Fire Signal Integration Test	Water flow	Condensing Temperature
Phase Failure Test	Water in/out temperatures	
	Set point	
	Operating Schedule	

5.1.2 Pre-Start Procedure – Water Systems

Make use of temporary connection or flushing bypass (if included) to ensure the flushing water shall not flow through any fan coil unit, coil, metered orifice or control valve.

5.1.3 Duct Pressure Testing

At the discretion of the Engineer and at no additional cost low, medium and high-pressure air ducts shall be tested in accordance with SANS 10173

The duct pressure test shall be at least 2 times the operating pressure or 150Pa whichever is greater.

The test shall be completed with all spigots installed and blanked off, before external insulation is applied.

Leakage shall not exceed 8% under operating conditions.

The Contractor shall provide the required test fan and approved instrumentation and the tests shall be witnessed by the Engineer.

5.1.4 Air Balancing

Air duct systems shall be adjusted and balanced so that air quantities at outlets are as specified, uniform over the face of each outlet.

Air quantities specified for fans include for duct leakage of 8%. The sum of air quantities of all outlets would normally be acceptable at a tolerance of ±5% of that specified for the fans.

The individual outlet air quantities would normally be acceptable at a tolerance of ±10%, if the total air supplied to that space is within a tolerance of ±5%.

Airflow quantities shall be measured and cross-checked by an agreed combination of the following:

- Air Velocity Reading Over Filter Banks or Dampers
- Air Velocity Reading Over Coil
- Pressure Differential Across Fan
- Main Supply Air Duct Pitot Tube Traverse
- Air Quantities Measured with an Adaptor Fitted Over the Inlets or Outlets

Airflow quantities shall not be reduced by artificially increasing the system's resistance by more than 5% of the total system resistance.

5.1.5 Test Certificates

The Contractor shall ensure that copies of all relevant test certificates, inspection reports, materials analysis certificates and similar data as may be required under various sections of this specification, or by Government Licensing and Inspection Authorities or Local Authorities, shall be provided before handing over the plant. Acceptance of the plant will be delayed if such certificates are not available. Attention is drawn to pressure vessel and boiler construction and materials test certificates.

5.2 Noise and Vibration Control

The design, manufacture and installation of all the mechanical and electrical equipment shall be such as to ensure compliance with the relevant sections of SANS 10103 "The Measurement and Rating of Environmental Noise with Respect to Annoyance and Speech Communications", as amended.

The noise and vibration generated by equipment shall be isolated from the structure by means of anti-vibration mountings, spring hangers or flexible pipe connections. The sub-contractor shall be responsible for the prevention of direct transmission of vibration from moving equipment to the structure.

The sub-contractor shall make the necessary corrections in an approved manner without additional charge for noise more than the specified limits and vibration considered excessive by the Engineer and for the transmission of noise and vibration due to faulty equipment or workmanship.

All vibration isolators shall be selected and supplied by the same manufacturer and shall be approved by the Engineer before installation.

Vibration isolators shall have a guaranteed static deflection as specified and the isolators shall be installed in accordance with the manufacturer's recommendations.

Should the installation, in the opinion of the Engineer, be excessively noisy (i.e. exceed the specified noise levels) acoustic tests shall be carried out by a nominated Acoustic Consultant.

Should the results of the initial acoustic test prove to be unsatisfactory, the Sub-contractor shall carry out modification to the equipment so that further tests can be made until the plant complies with the Specification. The cost of all such further tests and the necessary modifications to the plant shall be met by the Contractor.

5.3 Service Access

Where equipment such as fans, dampers, etc. are installed above ceiling, the Contractor shall ensure that access will be possible for maintenance purposes after installation.

Any concerns noted by the Contractor are to be immediately presented to the Engineer without delay. Any remedial works due to late notification will be for the Contractors account.

5.4 Painting

Any paint or solvent based coating used during the installation shall have a VOC content of less than 200g/l in the ‘ready to use’ product.

Before any painting is applied, the surfaces shall be prepared according to SANS 10064, Code for Preparation of Steel Surfaces for Painting. All surfaces shall be moisture free, clean and properly prepared.

During painting, the Contractor shall ensure that all the necessary fire prevention and fire-fighting precautions have been taken.

Name plates, labels and notices on equipment shall not be painted.

Items which do not require painting such as diffusers and grilles, shall only be installed after the paintwork on the plant, ceiling or walls have been completed.

Painted surfaces on proprietary manufactured items shall be adequately protected. Equipment on which the paintwork has been damaged during installation shall be repainted before first delivery of the plant will be considered.

Unlagged black piping, flat iron, angle iron for supports, brackets, frames, duct stiffeners, shall be painted on all sides with a zinc phosphate primer to SANS 1319, followed by one coat universal undercoat and one finishing coat of enamel paint to SANS 630 Grade 1.

All galvanised surfaces requiring painting other than those covered in the next point shall be thoroughly degreased. In case a detergent is used, the surface shall be well rinsed and dried. It shall then be painted with one coat wash primer (self-etch primer). When dry, the surface shall be painted with one undercoat to SANS 681 type II and one coat universal undercoat and one coat high gloss enamel paint to SANS 630 Grade 1 as top coat.

5.5 Colour Bands

The installation shall be painted in accordance with SANS colour coding where applicable. Colour code bands and arrow indicators shall be as per SANS 10140, and the basic colour shall cover the full length and circumference of pipes and ducts.

Bands shall be provided at all valve locations, points where piping enters/exit walls, floors or ceilings or every 10m of straight runs. Entry and exit points to each vessel, tank or piece of equipment shall be identified by bands.
Bands shall be at least 200mm wide on piping. Pre-printed lettering shall indicate service and direction of flow and be at least 20mm high. Lettering to be white.

Piping of less than 32mm need not be banded.

Application	**Colour Description**
Chilled Water Supply	Midnight Blue
Chilled Water Return	Light Blue
Condenser Water Supply	Light Orange
Condenser Water Return	Dark Orange
Condensate Drains	Black

5.6 Equipment Labels

All outdoor units, fans, air handling units, rooftop package units are to be labelled with engraved Bakelite type labels.

These labels are to be white with black text (min text height 10mm).

If the larger equipment is available with suitable factory fitted name plates these labels may be omitted for these items.

All internal controls are to be labelled with a pre-printed sticker. These labels are to be white with black text (min text height 5mm).

Information to be contained on the label: Unit Reference (as per the as built dwgs) and area served.

- Eg: AC 1.1 Reception

5.7 Fixing Materials

5.7.1 General

Tenderers shall allow for a complete installation, including the provision of mobile cranes, air compressors, lifting tackle, measuring equipment, precision levels, and all other special or regular tools and equipment that may be needed to complete the entire installation in accordance with the specification, and to the satisfaction, of the Client.

It is the responsibility of the Contractor to position and securely fix conduits, ducts, cables and cable channels, switchboards, fittings and all other equipment or accessories as required for the installation. The Contractor shall provide and fix all supports, clamps, brackets, hangers and other fixing materials. Clamps and brackets used to fix or support equipment such as cable trays, ducts, etc. shall be of a purpose-made type suitable for the specific application.

5.7.2 Structural Steel

Supports, brackets, hangers, etc. may only be welded to structural steel members where prior permission of the Structural Engineer and/or Client has been obtained. Where welding has taken place, the Contractor shall make good the corrosion protection coatings by approved local treatment of the welded areas.

Fixing methods to purlins etc to be submitted.

5.7.3 Wall Plugs

Where the fixing holes in brick or concrete walls are smaller than 10mm diameter and where the mass of the equipment is less than 10kg, wall plugs may be used to fix conduits, cables and other equipment. Fibre or plastic plugs shall be used. Wooden plugs are not acceptable. Aluminium plugs may be used in face bricks. Plugs installed in joints between bricks are not acceptable. A masonry drill of the correct size shall be used to drill holes for plugs. Round-headed screws of the correct diameter to match the specific plug shall be used throughout.

5.7.4 Anchor Bolts

Where the fixing holes are 10mm and larger or where the mass of the equipment is greater than 10kg, equipment shall be fixed by means of expanding anchor bolts or by means of bolts cast into the concrete or built into walls.

It is the Contractor's responsibility to obtain permission from the Structural Engineer and/or the Client prior to the use of this type of fixing.

5.7.5 Shot-Fired Fixing

Materials such as metal cable ducts or channels may be fixed against walls and concrete slabs by means of shot-fired fixings if this means of fixing is acceptable to the Structural Engineer and/or the Principal Contractor responsible for the structure.

It shall be the Contractor's responsibility to ascertain whether this method of fixing will carry the weight of the material including conductors, cables and other items of equipment to be installed later. Should it be found that the method of fixing is inadequate and supports tend to loosen, the Contractor will be required to fix the material by an alternative method to the satisfaction of the Engineer.

Where the shot-fired method is used, warning signs shall be placed at all entrances leading to the area where this work is in progress. The Contractor shall take all reasonable precautions to prevent accidents and shall always adhere to the requirements of the Manpower and Occupational Safety Act.

Nails and explosive charges recommended by the manufacturer shall be used throughout.

5.8 Welding

Welding shall be carried out in accordance with the current edition of SANS 10044 and any other applicable SANS standard.

All welded filler or butt joints shall be free from porosity, cavities and entrapped slag. Joints shall be ground smooth, if required for aesthetic reasons only, without effecting weld strength.

The joints in the weld run, where welding has been recommended, shall be as smooth as possible and shall show no pronounced hump or crater in the weld surface.

The profile of the weld shall be uniform, of approximately equal leg length and free from overlap at the toe of the weld. Unless otherwise specified the surface shall be either flat or slightly convex in the case of fillet welds and with reinforcement of not more than 3mm in the case of butt welds. The weld face shall be uniform in appearance throughout its length.

Filler metal electrodes shall be of an approved type for the material being used and shall be kept in a dry condition. All electrodes shall conform to SANS 455.

Only welders in possession of a valid approved competence certificate shall be employed.

All welds must show proper fusion.

Where welding is contemplated in pipework systems, Tenderers shall allow for X-ray testing the testing by an approved body of the welded joints in the system. The quantity to be as per the information provided in the P&G breakdown.

5.9 Galvanising

The following items shall always be galvanised:

- Fabricated Mild Steel Sections Exposed to the Weather
- Steel Grilles & Louvres Exposed to the Weather

Where hot dip galvanising is called for, items to be galvanised shall be entirely pre-fabricated and then dismantled in sections for galvanising. No cutting of threads or welding will be accepted after galvanising. All hot dip galvanising shall be carried out in accordance with the latest SANS standard where applicable, including preparation for galvanising.

Mild steel plate and sections shall be of good commercial quality, or higher grades, best suited for galvanising. The materials shall be free from slag or coarse laminations, fine fissures and rolled-in impurities.

Castings shall be sound, dense and clean and free from distortion, porosity, carbon and slag enclosures, blowholes and other injurious conditions.

Welding flux shall be chipped away, and all welds wire brushed before galvanising.

The surface to be galvanised shall be free from paint, oil, grease and similar impurities.

All exposed surfaces including welds shall be thoroughly sand blasted prior to galvanising.

The Engineer reserves the right to inspect all steel components before galvanising and shall have the right to reject or ask for remedial treatment of any material which is considered to be unsuitable. This applies particularly to welds.

The galvanising coating shall be smooth, adherent, continuous and free from black spots or flux stains.

Globular extra-heavy deposits of zinc, which interfere with the intended use of the material, will not be acceptable. Excessively protuberant lumps and nodules shall be removed by hot wiping or by the skilful application of mechanical means, however there shall remain enough minimum thickness of unbroken zinc coating. Flaws on small parts and working surfaces shall be repaired only by stripping and re-dipping.

Repairs to galvanised coatings will not be accepted. Items damaged will need to be re-galvanised.

Coating thickness shall be as per SANS standards unless otherwise specified in the supplementary specification.

The SANS requirement for uniformity shall apply.

Galvanised surfaces specified with paint finishing shall not be passivated.

5.10 Waterproofing

The final flashing and waterproofing of all pipe and duct penetrations through external walls and roofs by Main Contractor. (Temporary waterproof seals shall be carried out by the AC Sub-contractor).

5.11 Ducting and Sheet Metal Work

5.11.1 General

The material, construction and dimensions of all steel and aluminium ductwork (together with fittings and dampers) for use in air conditioning and ventilation systems that operate at low, medium and high pressures shall be in accordance with the requirements of South African National Standards SANS.

Where spigots are cut into internally lined ducting, the internal lining must be brought outside and glued securely before fitting the spigot.

All duct dimensions quoted are sheet metal sizes.

Cognisance of structural limitations to be taken when producing working drawings.

Duct layouts to be co-ordinated with ceiling, lighting and piped building services layouts.

Flexible canvas collars must align and have no strain after installed. The minimum clearance between two sections that are linked is 30mm.

All flexible collars exposed to UV light shall be provided with a sheet metal cover.

Airflow arrow shall be installed.

5.11.2 Insulation

Insulation materials shall prevent rotting, mould, fungal growth and be non-hygroscopic. Shall be free from asbestos and shall not contain CFC's and have and ODP of 0. The thermal resistance shall not degenerate of the quoted life span of the product.

Sheetmetal ducting insulation may be:

- Glass fibre duct wrap (Min Density 16kg/m^3) and k value = 0.038W/m.K
- Closed cell foam (Min Density 16kg/m^3) and k value = 0.038W/m.K

At coastal areas with high humidity (eg: Durban) where ducting is externally insulated, high density insulating material is required between the ducting and the duct support bracket.

5.11.3 Flexible Ducting

Flexible ducting shall be manufactured from aluminium unless otherwise specified and shall be approved by the Engineer.

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

Where second fix position results in a longer flexible duct, circular ducting must be installed from the duct to the second fix position to ensure a maximum flexible length of 1.5m.

Connections between duct spigots and diffusers spigots shall be by means of flexible ducting and secured with aluminium tape and external jubilee clamps.

Flexible ducting shall be constructed of non-combustible materials.

5.11.4 Discrepancies

If manufacturing details of any specified ducting are not covered by the relevant SANS specifications, then the relevant SMACNA standards will be applicable provided that the thickness of sheet metal will not be less than that specified under South African National Standards (SANS).

5.12 Air Dampers

5.12.1 Balancing Dampers

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

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

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

5.12.2 Control Dampers

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

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

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

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

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

Damper blades shall have "V" crease in middle to receive damper rod.
All control dampers shall be supplied by an approved manufacturer and approved by the Engineer.
The leakage rate with the damper in the fully closed position shall not be more then 150l/s/m^2 at a differential pressure of 100Pa.

5.12.3 Fire Dampers

Where ductwork or the passage of air passes through fire walls, fire dampers are to be installed. Fire damper are also required where ductwork or the passage of air passes through floor slabs that are classified as fire barriers.

The dampers are to be thermally activated at 74°C and externally re-settable.
They are to be SABS Approved and comply to SANS 193 – Fire Dampers.

5.13 Condensate Drains

Each unit shall be provided with a suitably sized, trapped and vented drain pipe which shall discharge into a common drainage network.

All condensate drainage shall be installed with a minimum 1:100 fall.

All condensate drainage shall be tested by the contractor and confirmed in writing to the Engineer as follows – underside measurements to be taken at the equipment and at 3m intervals along the length of the line.

All condensate piping within ceiling voids shall be of the Blue PVC drainage piping type (i.e. high pressure type). All condensate drainage in plantrooms shall be galvanised piping from unit to closet drain point and shall be adequately supported.

Drainage Insulation:

CONDENSATE DRAINAGE WITHIN CEILING VOID	
Location	**Insulation**
High Humidity (e.g. Durban)	Entire Length
Moderate Humidity (e.g. Cape Town)	First 2m from source
Low Humidity (e.g. Johannesburg)	None

PVC Piping Support Spacing within Ceiling Voids:

Nominal Diameter	**Support Spacing**
15mm	0.85m
20mm	0.95m
25mm	1.05m
32mm	1.2m
40mm	1.35m
50mm	1.5m

5.14 Vibration Isolation Mountings

5.14.1 Neoprene Mountings

Neoprene mountings shall have a minimum rated static deflection of 10mm. All metal parts shall be moulded into the neoprene to prevent corrosion and to provide friction, so that the mounting need not be bolted to the floor.

5.14.2 Unrestained Spring Mountings

This Specification covers three alternatives, 2.14.2.1 is preferred (or 2.14.2.3 when equipment is mounted on a deep concrete base), being more economical and efficient than 2.14.2.2 However, 2.14.2.3 shall be used when additional lateral support is required, to ensure stability during starting and stopping.

5.14.2.1 Open Spring Mountings

Spring mountings shall be open and free standing, and laterally stable without any housing. The springs must be isolated from the floor by neoprene friction pads or cups. Mountings shall have levelling bolts that can be rigidly bolted to the equipment. Spring diameters shall not be less than 80% of the compressed height of the springs at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. When the load per mounting exceeds single spring capacity, springs may be clustered in units of two or more.

5.14.2.2 Housed Spring Mountings

The housing shall consist of cast iron top and bottom elements, separated by neoprene sponge inserts to provide lateral support. The mounting shall incorporate a height adjusting bolt and a friction pad bonded to the bottom element, which must have provision for bolting down to the floor. Spring diameters shall not be less than 80% of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. When the load per mounting exceeds single spring capacity, springs may be clustered in units of two or more.

5.14.2.3 Open Spring Mountings with Concrete Bases

When equipment is installed on a concrete base (without steel framework) the height of the base shall be at least 250mm and the base shall be cast on a plastic sheet to facilitate separation from the floor. Cast iron or fabricated steel housings shall be cast into the base, so that spring mountings as described in Specification i) can be neatly recessed into the base. The housing shall have an internal height equal to the height of the mounting and shall have a means of locating the adjusting bolt of the mounting in the centre of the housing, so that the mounting can be used to elevate the concrete base.

5.14.3 Restrained Spring Mountings

Equipment which has an operating mass different from the installed mass, such as cooling towers, chillers and boilers and equipment exposed to the wind, shall be mounted on spring mountings as described for unrestrained spring mountings, but installed in a housing that includes restraining bolts to prevent extension when the mass is reduced. The housing shall also serve as blocking during erection so that the installed and operating heights shall be the same. A minimum clearance of 5mm shall be maintained around the restraining bolts and of 12mm between the housing and the spring, so as not to interfere with the spring performance. The housing shall be hot dipped galvanized.

5.14.4 Vibration Isolation Hangers

This Specification covers three spring hanger alternatives:

5.14.4.1 This is a basic spring hanger incorporating a low-profile spring that ensures that the hanger rod does not touch the hanger cage. Vibration isolation hangers shall consist of a steel spring housed in a steel cage. The spring shall fit into a neoprene cup which is located in the cage, to prevent contact between the cage and lower hanger rod. The cup shall contain a steel washer to evenly distribute the load on the neoprene. Spring diameters shall not be less than 80% of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. The spring height and diameter, and the neoprene cup containing the spring, shall be so dimensioned as to allow the lower hanger rod to swing through a 30º arc before coming into contact with the cup. When the load exceeds single spring capacity, springs may be clustered in units of two or more.

5.14.4.2 This adds a neoprene element to 2.14.4.1 for better efficiency, particularly in eliminating high frequency noise, and is to be used when superior performance is required. Hangers shall be as specified in 2.14.4.1 above but shall incorporate a neoprene element with a minimum rated static deflection of 8mm. The element shall locate in the top of the cage in order to prevent contact between the cage and the upper hanger rod.

5.14.4.3 This adds a fixed elevation device to 2.14.4.1 and 2.14.4.2, to facilitate installation. It also ensures that excessive load is not put onto equipment flanges, and is to be used for the three hangers nearest the inlet and outlet of each item of equipment. Hangers shall be as specified in 2.14.4.1 or 2.14.4.2 above but shall have provision for the spring to be precompressed to the rated deflection so as to keep the piping or equipment at a fixed elevation during installation. The hangers shall be provided with a method of releasing any residual pre-compression after the installation is complete and the hanger is subjected to its full load. Deflection shall be indicated by means of a scale. Precompressed hangers shall be used at the three support points nearest the inlet and outlet of each item of equipment.

5.15 Sound Attennuators

Sound attenuating units and sound absorption lining in ductwork shall be provided as required to control the system sound level within the limits as specified in SANS 10103.

Sound attenuators shall be supplied by an approved manufacturer. Published data of attenuator performance must be available. Acoustic data measured to ISO 7235

Detailed calculation sheets substantiating the selection of attenuators to achieve the sound levels specified in SANS 10103 of this document shall be submitted for approval by the Engineer prior to ordering.

The sound attenuator's casing shall be made from galvanized sheet steel at least 1,6mm thick. All joints shall be made airtight for pressures up to 1kPa.

Connection between attenuator and ductwork shall be by means of matching angle iron flanges.
When required, splitters shall be made with a galvanized steel frame and an acoustical fill of mineral wool covered with galvanized perforated sheet.

The leading edge of the splitter is required to have an aero profile such as to reduce additional noise and pressure drop.

5.16 Grilles and Diffusers

All grilles and diffusers shall be capable of delivering the air quantity stated without noise or unnecessary draughts. The grilles shall be pleasing in appearance. All mitres, welds, shall be neat.

The fixing of grilles shall preferably be concealed or, alternatively, by means of neat countersunk Phillips type screws. A felt or plastic foam gasket shall be installed behind grille flanges to ensure air-tightness and prevent dust streaks.

All supply air grilles, diffusers, return air grilles, transfer grilles, door grilles and weather louvres shall be of aluminium or steel construction and the colour finish shall be to the Architect’s specification.

All required galvanised fixing brackets and hangers to support diffusion equipment shall be included in this sub-contract.

Door grilles shall be supplied and installed by the air conditioning sub-contractor by means of counter sunk screws. The main contractor shall provide all opening into doors with sub frames to semi solid doors, in a position indicated on the drawings. The under cutting of doors shall be carried out by the main contractor.

5.17 Electrical Work (for Mechanical Installations)

5.17.1 General

All electrical equipment shall be suitable for the declared voltage of the Supply Authority.

Electrical energy will be brought to the Contractor's main switchboard by the Electrical Contractor. The supply and installation of the Control Boards, Sub-boards, Electrical Equipment and complete wiring therefrom shall form part of this Contract.

The Contractor shall provide and install any necessary conduits, cables or ducting and perform all wiring and connections necessary for the complete installation.

Copies of these diagrams and those for manufactured equipment are to be included in the panel itself (appropriately secured and protected inside the door) and in the Operating and Maintenance Instruction Manuals.

The system shall be clearly labelled at the MCC or DB and number on the circuits shall be labelled in accordance with the numbers on the drawings.

Earth straps must be fitted across each flexible connection, canvas collar and fixed to the steel section to ensure continuity.

The earth strap shall comprise of a coiled section of wire secured with lugs and screws on each side. The wire is to be green/yellow in colour.

The MCC or DB as indicated on the drawings shall provide the distribution of power from a central point to the individual items of equipment in the sub-systems and in addition providing the necessary equipment protection and control interface facilities required by the specified control system. Facilities for pad locking the sub system on the “off” position shall be provided.

MCC’s are to be vermin proof and capable of operating in ambient temperatures of 40deg.

5.17.2 Electricity Supply

All equipment shall be capable of operating continuously under variations in the supply system of ±10% in the voltage and ±10% in the frequency.

5.17.3 Compliance with Regulations, Standards and Specifications

The complete electrical installation shall satisfy the local Supply Authority and shall further comply with the Code of Practice for the Wiring of Premises as issued by the South African Bureau of Standards, the Local Supply Authority By-laws and the requirements of the Machinery and Occupation Health & Safety Act, Act 85 of 1993. The latter shall take precedence in the case of conflicting requirements.

Except where otherwise provided for in this specification, all equipment offered shall comply with the requirements of the relevant South African National Standards SANS standard specification, if published and shall bear the mark, otherwise with the relevant British Standards in force at the time of tendering, the specifications mentioned herein or shall otherwise be "approved".

Where equipment offered complies with the recognised standards of the country of manufacture and not specifically with the standards required by this specification, such equipment will be considered at the discretion of the Engineer. In this case, Tenderers shall state fully, all respects in which the equipment offered departs from the standards laid down in this specification.

5.17.4 Protection of Electrical Equipment

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

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

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

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

5.17.5 Standardisation of Material and Equipment

Wherever possible the equipment offered shall be of one make with the facility to interchange corresponding parts/components.

Materials and equipment used in this contract must, where possible. The Contractor shall submit samples of any materials or equipment, if required, for approval before installation. Such samples will be held for comparison purposes with equipment and materials installed and will be released on satisfactory completion of the contract.

5.17.6 Conduit

All conduit located within plantrooms or basement areas shall be galvanised steel type complete with flexible galvanised connections and fittings as required. Internal conduits may be PVC.

Connections to motors shall terminate in a short length of flexible conduit. Adaptaflex type SP, Kopex or equal and approved for dry conditions, Adaptaflex type SPL for conditions exposed to dust, watery suds or oils.

Conduits shall be screwed into outlets of conduit boxes where possible but where fixed to boxes they shall be secured by means of sockets passing through properly sized clearance holes.

All conduit ends shall be cut square to enable the conduits to be butted at all conduit sockets and joints and conduit threads shall not show at the joints or terminations except where running joints are made. All lubricants used to ease screwing shall be wiped off and oil shall not be used. The inside of conduits, the ends of conduits, and all fittings used in the connection therewith shall be smooth and free from burrs and all other defects. All exposed screw threads and parts where the galvanized or paint finish has been damaged shall be thoroughly cleaned and painted with a zinc-rich paint for galvanized or a black bitumastic paint for black enamel conduits.

Conduits shall comply with South African National Standards SANS.
All conduits shall be heavy gauge, screwed, welded seamless, or solid drawn. No conduit with less than 20mm external diameter shall be used.

All junction boxes used in conjunction with steel conduit shall be of heavy steel or cast-iron construction, to South African National Standards SANS. Boxes for external use or in damp situations shall either be provided with gaskets or with machined faces and watertight covers. The use of inspection elbows, solid bends and tees will not be permitted except where shown on the drawings. All fittings used with galvanized conduit shall be galvanized. All screws shall be cadmium plated. All surface conduits shall be supported by cast distance saddles. Conduits shall be supported on both vertical and horizontal runs at 1500mm centres.

5.17.7 Cabling

Single core cables used in the wiring of building shall be 600/1000 Volt grade PVC insulated to South African National Standards SANS. The cables shall be from recent stocks and must be delivered on the site with seals unbroken and bearing the SABS mark.

Cables shall be sized according to the duty they are to perform in accordance with the relevant standards.
Where multiple circuits or single core cables are run in parallel runs, the use of proprietary metallic wiring trunkings with PVC cables drawn in will be permitted. Such wiring trunks shall be totally enclosed, electrically continuous, bonded, provided with removable cover plates and fabricated from 43mm galvanized steel and provided with returned edges.

Earth continuity conductors shall be installed in all conduits and provided for all cables.

Terminals shall be enclosed in purpose-made terminal boxes. The terminal boxes shall be generously sized, metallic or approved non-metallic (e.g. dough moulding compound and shall be provided with DIN mounting rail terminal blocks sized to requirements, terminal screws which do not act directly on the conductors, removable cover plates and adequate cable or conduit entries.

Multicore armoured cables shall be PVC SWA PVC to South African National Standards SANS or MICC to BS 6207 Part 1 and shall be fitted with maker's approved glands, and ends shall be properly made off.
Cable glands for PVC cables shall comply with the requirements of South African National Standards SANS and shall bear the mark.

5.17.8 Cable Trays

In most circumstances, it will be permitted to run cable on a cable tray in which case the tray shall be manufactured of galvanized steel of not less than 1,6mm gauge.

Cable trays shall be complete with bends, tees, etc. and be continuous.

Cable trays shall be perforated galvanized steel or wire cable basket.
Trays shall be securely supported from ceilings or brackets and by means of screwed galvanized rods 10mm diameter and cross supporting angle or Unistrut section, at intervals of 1500mm.

5.18 Testing of Electrical Installation

Conduct such tests and adjustment of equipment as specified elsewhere, and as necessary to verify performance requirements, and as required by all Authorities having jurisdiction. Submit data taken during such tests to the Engineer. The Engineer reserves the right to be present during these tests and shall be notified 48 hours in advance.

Attend on the Engineer and give all assistance required and provide such tools, materials, implements and instruments as are necessary for the tests. The Engineer reserves the right to call for such additional tests as he may consider necessary.

Upon completion of work the electrical installation shall be tested for earthing and short circuits in accordance with the Code of Practice. If tests indicate inadequate insulation resistance, corrections shall be made as directed by the Engineer.

Insulation resistance values shall be not less than those specified in the Code of Practice.

Operational tests of electrical equipment shall be performed as directed by the Engineer and as specified elsewhere.

Notify and decide with the officials of the Supply Authority for carrying out all municipal tests. Provide attendance, tools, staging and all other facilities to the Supply Authority as may be required for these tests. Should retesting be required by the Supply Authority pay all fees incurred by such test. The Engineer reserves the right to be present at the tests and should be notified 48 hours in advance.

5.19 Electric Motors

All electric motors shall be constructed in accordance with the following requirements where applicable:

- SABS Standards applicable to Rotating Electrical Machines

The mounting and coupling arrangement for the motors shall suit the plant layout, but adequate provision shall be made for ease of replacement of motors.

Motors shall be minimum Class F insulation.
Motor terminal boxes shall be adjustable to allow for cable entry from any one of three directions at 90º i.e. entrance from below or either side (not above) and for all forms of cable connections. It shall be possible to remove the motor.

Terminal boxes shall be drilled and tapped to take two cable glands to South African National Standards SANS. Both holes shall be fitted with blank brass plugs.

The colour code for motors, guards, baseplates, pumps, etc., shall be standard manufacturer's ex-works paint finish unless specified otherwise.

All motors shall be continuous maximum rated, three-phase or single-phase squirrel cage induction type, wound for duty on an earthed 380/400 or 220/230 Volt 50Hz system.
All motors shall be rated for direct-on-line starting unless otherwise indicated. Speeds shall be suitable for the equipment to be driven. Motors shall be rated at not more than 1,3 times the designed mechanical load.

Rating plates shall be provided on all motors and shall be of stainless steel or a non-corrosive alloy.

All electric motors shall include the following protection:

- Single phase motors - thermal overload protection

- Three phase motors - combined thermal overload and phase failure protection

5.19.1 Requirements for Various Environments

Indoor Dry

- Enclosure to IP54 Degree of Protection
- Cable Entry from Bottom or Sides

Outdoor

- Enclosure to IP56 Degree of Protection
- Cable Entry from Below
- Frames Shall be Aluminium

Indoor Wet

- Enclosure to IP55 Degree of Protection
- Windings to be Treated with Extra Impregnation & Baking
- Cable Entry from Below
- Frames Shall be Aluminium

Caustic

- The entire housing, terminal box, fan cover, end shields and mounting foot or plate shall not be of aluminium construction.
- Enclosure to IP66 Degree of Protection
- Dust Explosion Proof
- Enclosures and terminal boxes shall be suitable for CLASS 1 DIVISION 2 are in accordance with South African National Standards SANS.
- Enclosure group, in addition to the above, will be to IP54.

5.20 Variable Speed Drives (VSD)

The VSD is required to operate at full load conditions of driven motor with variations of ±10% of the supply voltage and 2% of the supply frequency.

The VSD is required to operate continuously at full load conditions at a temperature of 38°C.

The VSD shall enable full output voltage to be reached without waveform distortion. De-rating of the specified motor kW is not permitted.

It must be taken as a given that the drives will be included on a commercial building with high tech computers and sensitive electronic equipment. The VSD is required to operate without interference to this equipment. The VSD shall comply with EMC/EMI standards for immunity IEC 802-805.

Earthing for the enclosure to be taken directly to earth.

The VSD shall provide comprehensive information on the controller and motor condition.

The following are minimum requirements:

- Reference % of control signal
- Frequency [Hz]
- Current [Amp]
- Torque [%]
- Power [kW]
- Output Voltage [V]
- Motor Rotation [rpm]

The VSD shall provide protection from:

- Over current
- Over voltage
- Under voltage
- Overload
- Overheating

And include facilities for:

- Current limiting setting
- Auto restart following trip or power supply interruption

For VSD’s installed in internal mechanical plant area’s a minimum enclosure protection of IP54 is required.

For VSD’s installed in exposed mechanical plant area’s a minimum enclosure protection of IP65 is required.

The VSD is to be mounted in a ventilated area allowing the dissipation of heat.

6 GENERAL REQUIREMENTS FOR MECHANICAL PLANT

6.1 Fans

6.1.1 General

Fans shall be statically and dynamically balanced and shall be free of any objectionable vibrations.

Fans shall be selected to operate as close as possible to the point of maximum efficiency.

Lubrication points for fan bearings shall be readily accessible and shall where necessary be extended to the outside of the fan casing.

Fan openings shall be provided with protective wire guards in accordance with the Manpower and Occupational Safety Act, 1983.

All belt drives shall be designed for a minimum of 25% overload with no less than two matched belts being used. Belts shall be selected and installed in accordance with BS 3790 - 1981.

Belt guards shall be provided and arranged to permit oiling, use of tachometers and other testing and maintenance operations with the guard in place. The guard shall have a front screen of expanded metal.
Fan bearings shall be selected for a minimum of 20 000 hours average life.

Fan shafts and bearings are to be properly protected from rust and corrosion by means of suitable wrapping and protective grease coatings prior to commissioning.

Where no pressure requirements are indicated Tenderers shall estimate the fan static pressure requirements for the system layout and equipment as offered by them and tender accordingly.

Flexible connections shall be fitted between fan inlet/discharge and ducting or equipment as appropriate. Flanges are required with flexible connections.

Fans shall be fitted with manufacturer's nameplates permanently fixed to the casing in a prominent position clearly indicating manufacturer, model number, maximum operating speed, maximum power absorbed, size and serial number for larger fans.

Indicating arrows for both direction of rotation and direction of airflow shall be provided on fan casings.

Safety:

- Single phase motors - thermal overload protection
- Three phase motors - combined thermal overload and phase failure protection

6.1.2 Centrifugal Fans

Centrifugal Fans shall be of the double width, double inlet, multi-blade, backward curved blade type with single thickness, shaped blade, designed to give the fan a continuously rising, non-overloading pressure characteristic.

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

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

Fans shall be driven by an electric motor through a V-belt drive. The motor shall be standard metric frame size with speed not exceeding 1450 rpm, motor nameplate power shall exceed brake power by a minimum of 20% and the motor shall be suitable for the starting method as further specified herein.
Motors shall be rated for continuous operation.

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

Fans with wheel diameters above 1 000mm shall be provided with access doors fitted to the fan casing.

Shaft bearings shall be of the self-aligning, ball type selected for quiet operation and a minimum average life of 20 000 hrs.

All belt drives shall be designed for a minimum of 25% overload with no less than two matched belts being used.

All pulleys shall be of the taper lock type and shall be accurately keyed to the shafts and shall be aligned before the system is put into operation.

Belt guards shall be provided and arranged to permit oiling, use of tachometers and other testing and maintenance operations with the guard in place. The guard shall be totally enclosed back and front. The front screen shall be of expanded metal.

6.1.3 Axial Fans

Unless otherwise specified, axial flow fans shall be in-line, direct driven type, with motor mounted inside the fan housing. The fan rotor assembly shall be attached directly to the motor shaft.

Fan housings and flanges shall be manufactured from mild steel material either spun construction or with end flanges continuously welded to casings.

Fan rotor shall be cast aluminium construction, blades shall have an aerofoil section, having a varying degree of twist and width from the hub to the tip of the blade to ensure equal air distribution along the length of the blade. Blade pitch shall be manually adjustable.

The fan motor shall be totally enclosed rated for continuous operation and shall be squirrel cage induction type suitable for vertical and horizontal operation with grease lubricated bearings.

Fans shall be of the long casing type, unless otherwise indicated.

Fans installed under free intake conditions shall be fitted with an inlet cone supplied by the fan manufacturer.

6.1.4 Propeller Fans

Propeller fans shall be ring or diaphragm mounted.

Fan rotors shall be statically and dynamically balanced before leaving the factory and shall have at least four pressed steel blades.

Fans shall have rubber in shear type vibration eliminators mounted on their feet.

Fan motors shall be totally enclosed, rated for continuous operation and shall be squirrel cage type with sealed bearings.

Fans shall be provided with a suitable wire mesh guard.

6.2 Air Filtration Equipment

6.2.1 General

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

ASHRAE Standard 52-76 "Method Testing Air Cleaning Devices" and SANS 1424 – 1987 apply
Prior approval of the filters to be used is to be obtained before purchasing.

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

Provide access doors in ductwork or casing walls for convenient servicing and removal of filters.

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

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

Filters shall be adequately protected against dirt during construction. This may be achieved by covering all filters with flat filter media. This is left to the discretion of the contractor.

6.2.2 Washable Media Panel Filters

Each filter tank shall consist of a factory-made, robust, sectional steel supporting frame which shall accommodate the filter cells.
Media shall be kept in position by means of matching inner and outer retaining frames to form a filter cell, or alternatively the filter cell structure shall be sufficiently rigid to ensure air tight fitment within the support frame.

Filter cells shall be easily removable from the upstream side of the filter when of the clip-on type, or from the side of the filter assembly when of the slide type.

Filter media is to have a mean arrestance (ASHRAE) of at least 92% (equivalent to the class G4).

Filter panels shall be installed with pleats running vertically to prevent panel collapse.

6.3 Split Air Conditioning Units

6.3.1 General

The split air-conditioning air-cooled units shall be suitable commercial applications. Domestic type units shall not be accepted. The system shall include an outdoor condensing unit section and an indoor evaporator unit section with interconnecting refrigerant pipework and fittings. All plant shall be to the engineer's approval and shall be complete in all respects.

All split units shall have auto restart.

6.3.2 Outdoor Unit

A weatherproof galvanized steel cabinet, epoxy powder coated, shall house the compressor, condenser and shall be mounted on anti-vibration mountings. The internal components shall be easily accessible for inspection and maintenance by removing service panels. For coastal or high corrosive environment applications entire outdoor unit to be supplied with suitable corrosion protection as specified elsewhere in Part 4.

The compressor shall be of the hermetically sealed type, internally sprung and mounted on rubber vibration isolators.

The condenser coils shall have aluminium fins mechanically bonded to seamless copper tubes, unless otherwise specified.

All condensing units to be selected based on an operating temperature of at least 5 degrees above maximum ambient conditions indicated.

Hail guards are to be included for all exposed coils. These must be welded mesh with maximum hole size of 25mm and size powder coated to match the unit colour. Plastic hails guards shall not be accepted.

All Unistrut outdoor unit mounting brackets are to be powder coated white or galvanized.

6.3.3 Indoor Unit

The evaporator unit shall be made of sheet metal and shall be thermally and acoustically insulated throughout on all panel inner surfaces. Exposed edges of insulation material to be neatly finished and riveted with galvanized sheet metal nosing strips. Readily removable panels shall provide easy access to all the internal components.

The evaporator coils shall be manufactured from seamless copper tube with aluminium bonded fins, unless otherwise specified

The evaporator coils shall be manufactured, forward curved centrifugal type and shall be dynamically balanced. The fan motor must be mounted on rubber bushes and quiet operation must be ensured.

A drain pan shall be provided beneath the coil, graded to fall towards the drain outlet.

6.3.4 Refrigerant Piping

Refrigerant piping shall be run in hard drawn copper on straight sections with soft drawn copper for bends.

The refrigerant piping between the indoor and outdoor units shall be insulated with suitably sized Armaflex insulation. All joints shall be properly taped and sealed to prevent formation of condensation on the refrigerant pipes.

Piping and suitable oil traps shall be sized and installed in accordance with the manufacturer's requirements. The installation shall be complete with all necessary valves and fittings and shall be free of dirt and scale.

All connections must be thoroughly checked before the closing of ceilings and brick shafts and prior to start-up, to ensure that there are not leaks.

All refrigerant piping shall be supported in cable trays as detailed in this specification. Piping is to be secured to the cable tray by means of a black Velcro strap such that the insulation is not compressed.

All refrigerant piping installed external to the building shall have a galvanised trunking cover installed.

6.3.5 Electrics

A switched power supply, terminating in an isolator adjacent to the outdoor unit, shall be provided by others. The sub-contractor shall supply all power and control wiring from the isolator to the indoor unit and outdoor unit.

6.3.6 Controls and Safeties

Control and safeties shall include but not be limited to the following:

- Internal overload protection on all motors
- High- and low-pressure cut-out (automatic reset)
- Automatic defrost
- Thermostat controller (digital) – on/off, min 3 speed, 24-hour timer, temperature control, fan only
- Low ambient temperature protection

6.4 Air Cooled Packaged Unit

The maximum dimensions and component arrangement shall comply with the general arrangement drawings.

Each unit shall be contained in one enclosure housing compressor(s), air cooled condenser, direct expansion cooling coil, supply air fan, condenser fans, air filters, integral electric control panel. Heat pump units to include refrigerant reversing valve.

The air-cooled package unit shall comprise the following components:

- Hot dipped galvanised base
- Air cooled condenser coils
- Condenser fans and motors with variable speed drive
- Minimum of 2 refrigeration compressors
- Refrigeration pipe work and controls
- Refrigerant gas charge
- Direct expansion cooling coils
- Centrifugal supply air fan or EC plug fans
- Washable air filters
- Mixing plenum with dampers
- Electrical distribution board
- Internal electrical wiring
- Variable speed drive for supply fan motor
- Electronic Thermal Expansion Valve

The unit shall be weatherproof and shall require no additional protection from the elements. All necessary drainage trays shall be provided, and the base shall have drainage holes.

The unit shall be constructed of not less than 1,2mm double skin galvanised sheets suitably braced so as to prevent deformation and noise. The outer skin shall be epoxy powder coated or have a Chromadek finish. For coastal or high corrosive environment applications the unit to be supplied with suitable corrosion protection as specified elsewhere in Part 4.

The unit shall have a minimum of 50mm closed cell insulation between the two skins.

The evaporator fan section shall be fully insulated to prevent condensation and eliminate heat pick-up.

The unit design shall ensure even air distribution across the face of the coils and eliminate air passage around the coil. Face velocities shall not exceed 2.5 m/s.

(if included) The electric heaters shall be complete with:

- Auto reset thermal cut out device set at 65deg
- Airflow interlock by means of either supply air pressure sensor or and airflow switch.

A minimum of 2 refrigeration compressors mounted on anti-vibration mountings. The compressors shall include:

- Mounted on vibration isolators.
- Suction and discharge stop valves.
- Pressurized lubrication with an oil filter.
- Crankcase oil heater.
- The compressors shall be protected by low limit thermostats positioned in the mixing plenum. These thermostats shall be set to prevent the compressors from operating at temperatures below 10°C.
- Motor windings to be provided with motor overload protection to all three phases.
- High pressure and low-pressure switches.
- Liquid line sight glass.
- Filter drier.
- Charging valve.
- An anti-cycling timer which will prevent the compressor motor(s) from being subjected to starting current more than once every five minutes.
- The compressor must be protected against liquid slugging.

6.4.1 Supply Air Fan

Should the supply air fan be of the backward curved type as per details provided in paragraph 3.1.2 Centrifugal Fans.

A variable speed drive shall be provided for the fan motor, to enable soft starting thereof.

The specified estimated external static pressure for the supply air fan is for tender purposes only. The final static pressure shall be determined by the subcontractor.

The supply air fan if required to be operational during a mains power failure and will be supplied with emergency power. The DB is therefore to be designed and provided such that it can receive and operate with normal and emergency power supply. This requirement only pertains to the supply air fan.

The direct expansion coil shall consist of at least two separate refrigerant circuits and shall comprise copper tubes with aluminium fins. The coils shall be mounted in a heavy gauge galvanised steel casing fitted with a 1.2mm stainless steel condensate pan with no joints. The condensate pans shall be liberally sized to prevent moisture carry-over into the air stream, whilst also ensuring positive drainage of condensate. Condensate pans shall be insulated with a closed cell insulation to prevent moisture forming on the outside. Air filters shall be 50mm thick of the washable pleated panel type, housed in adequate holding frames, and fitted with gaskets to ensure a positive airtight seal as per paragraph 3.2.2 Washable Media Panel Filters.

The mixing plenum shall be fitted with a fresh air damper and weather louvre.

Condenser coils shall consist of copper tubes with mechanically bonded aluminium fins, all housed in a robust galvanized steel frame and protected with a suitable galvanised wire mesh screen.

Condenser fans shall be of the slow-running propeller type. The units shall be provided by a minimum of two fans, which shall be arranged for vertical discharge. Condenser air intake and discharge arrangements shall be such that no short-circuited discharge air can be drawn back into the air intake.

The condensing coils are to be selected based on an operating temperature of at least 5 degrees above maximum ambient conditions indicated.

The fan and motor bearings shall be of the permanently lubricated sealed type. The fan casing and impellor shall be of steel manufacture.

Refrigerant piping shall be routed and supported such that is not subjected to any stresses from vibrating compressors. Refrigerant circuits shall incorporate replaceable core type filter driers, sight glasses, and electronic thermostatic expansion valves and vapour proof insulation on the suction lines.

Automatic safety controls within the unit shall include a dual pressure switch with manual reset on the high-pressure side, and an oil pressure switch with manual reset. Units shall incorporate timing devices to delay starting of compressors in order that refrigerant compressors may first balance between starting and stopping of compressors.

An electric distribution board (DB) shall form part of the unit. The DB shall house all the necessary switchgear and controls and shall incorporate the necessary protection against overload and short circuit. The DB shall be fitted with a suitably sized main isolator backed up by fuses with a minimum capacity to suit the system fault level. Phase failure relays shall be incorporated to protect against low voltage or phase failure. The switchgear shall be fully interlocked so that cooling and heating cannot operate simultaneously, or so that compressors cannot operate unless the supply air fans are running. A run-down timer shall be incorporated so that the supply air fans shall continue to run for 5 minutes after the unit is switched off. The

DB shall be fully labelled with engraved labels having 6mm high lettering. All wiring shall comply with the relevant regulations.

Wiring within the switch panel and the unit shall comply with wiring regulations as relevant and shall be neatly grouped in horizontal and vertical runs in P.V.C. trunking. All wiring shall be colour-coded in the colours red, yellow and blue for the relevant phases and black for neutral, the busbars being similarly marked. Busbars shall be copper of adequate cross-sectional area, suitably spaced and mounted on stand-off type porcelain insulators. All exposed current carrying parts must be fully insulated in P.V.C. tape of the colours mentioned above. Every wire inside and outside the switch panel shall be fitted with ferrules and labelled with identical numbers at both ends. All outgoing leads shall be connected to a clearly marked terminal strip.

All plants shall have an auto restart facility for starting after a power failure.

The air-conditioning system shall be controlled via the systems internal controls and the room averaging temperature sensors.

Heat pump (Reverse-cycle), units where specified shall include an automatic reversing valve controlled by a common cooling/heating thermostat. Commencement of the heating cycle shall be automatic without manual changeover to heating mode. Heat pumps shall be equipped with auto-defrost cycle.

Electric heaters where specified shall be of factory-bent incoloy type, rated for still air and fitted into the unit in such a manner as to ensure full air flow over each element. The heater elements shall be fitted into a withdrawable fabricated galvanised channel frame. The side on which the terminals are located shall be fitted with a terminal base of enough size to contain all necessary electrical wiring, the terminal box being fitted with a removable weather proofed cover so fastened that no screw shall project into the actual terminal box. The electrical wiring within the terminal box shall be affected in insulated wiring capable of withstanding the temperatures encountered without breakdown of the insulation.

The unit shall automatically switch off on receiving a signal from the smoke detection system. Manual reset shall be provided. The control circuit shall include a 7-day timer with 24-hour back up.

A remote-control panel (if specified) shall be installed in the Managers Office. The panel shall be flush mounted. The door of the panel shall be fitted with a clear Perspex viewing window.

6.4.2 Drain Pan

Drain pans shall be stainless steel.

Drains pans shall be provided with drain connections on both ends. The pans are to be externally insulated with a minimum of 15mm closed cell insulation neoprene and shall be treated internally in an approved manner to prevent corrosion.

Drain pans in various unit configurations shall be as follows:

- Draw through units: A one piece drain pan to be provided under the complete fan and coil section on horizontal units and under the complete coil section on vertical units.
- Blow through units: A one piece drain pan provided under the complete coil and discharge plenum section.
- All drainage connections to rooftop package, and air handling units to come complete with threaded point to allow firm connection. Clamped connections will not be allowed.

6.5 Montreal Protocol

Equipment utilising chlorofluorocarbons (CFC's), hydrochlorofluorocarbons (HCFC's) or hydrofluorocarbons (HFC's) to be supplied and installed shall be within the constraints and schedules of the Montreal Protocol and the Copenhagen Agreement and such amendments thereto as may be made by the international community.

6.6 Factory Assembled Chilled Water Air Handling Unit (AHU)

The maximum dimensions and component arrangement shall comply with the general arrangement drawings.

6.6.1 General

Units shall include mixing box, filter section with cleanable filters, cooling coil section with condensate pans, hot water heating coil or electric heating coils (where specified), fan section with electric motor drive and internal electrical wiring.

When assembled the casing shall be leak proof.

6.6.2 Sandwich Panels

Sandwich panels for internal plantroom units shall be constructed of not less than 1.2mm thick mild steel panels suitable braced and framed so as to prevent drumming while at the same time being arranged in easily removable panels to facilitate access to any portion of the internal components. Sandwich panels shall be attached to a sub-frame of galvanised steel sections, which framework shall also hold all internal equipment in position. The casing panels shall be internally lined with "sonic liner" or equivalent non-combustible materials (when tested in accordance with SANS 1238), such insulation being adequately

secured to the internal surfaces with non-combustible adhesive and mechanical fasteners. The insulation shall not tear, detach or sag due to air movement when the unit is in normal operation.

Sandwich panels for external plantroom units shall be constructed from prefabricated panels of laminated foam core. The inner and outer skin must be a minimum of 0.6mm thick white galvanised pre-coated steel with a chromadek finish. Units installed in external plantrooms shall be weatherproof. The unit shall be complete with a factory fitted sloping roof to avoid water collection on top of the unit.
Panels shall be insulated to achieve the following:

- Internal Plantroom R=1.0 m^2K/W
- External Plantroom R = 1.3 m2k/W

Suitable sized access doors shall be installed as required for maintenance, repair and inspection. The hinges and door handles shall be of a robust construction and lockable.

6.6.3 Drain Pan

Drain pans shall be stainless steel.

Drains pans shall be provided with drain connections on both ends. The pans are to be externally insulated with a minimum of 15mm closed cell insulation neoprene and shall be treated internally in an approved manner to prevent corrosion.

Drain pans in various unit configurations shall be as follows:

- Draw through units: A one piece drain pan to be provided under the complete fan and coil section on horizontal units and under the complete coil section on vertical units.
- Blow through units: A one piece drain pan provided under the complete coil and discharge plenum section.
- All drainage connections to rooftop package, and air handling units to come complete with threaded point to allow firm connection. Clamped connections will not be allowed.

6.6.4 Cooling and Heating Coils

Coils shall be a product of the unit manufacturer and shall be mounted in the unit to be accessible for service and to be removable without dismantling the entire unit.

The unit design shall ensure even air distribution across the face of the coils and eliminate air passage around the coil. Face velocities shall not exceed 2.5 m/s.
All coils shall be suitably protected during shipment and installation so that the fins and casing flanges are not damaged. If fins are damaged they may be combed to restore them to the original shape and/or spacing.

If however, in the opinion of the Engineer the coils have loose or damaged fins at the time of final inspection they will be rejected and shall be replaced with new coils.

Coils shall have aluminium fins mechanically bonded to seamless copper tubes. For sprayed coils fins shall be of copper. The fins shall be spaced not closer than 12 per 25mm.

The pressure parts of coils shall be constructed and tested to a pressure of not less than 1 700 kPa. Water coiling coils shall be of the serpentine type and headers shall be welded steel, cast iron, brass or copper. Headers shall be provided with vent and drain connections.

Each coil section shall be securely mounted in a die formed zinc coated sheet steel casing with a minimum thickness of 1,60mm. Casing to be arranged for bolting to other sections, ductwork, unit casings, etc. Coil sections shall be supported on angle frame or other strong rigid construction. Supporting frame shall be hot dip galvanised. The coils shall be rigidly braced to ensure that there is no bending or flexing. Coil fins must be treated for coastal application to avoid corrosion.

6.6.4.1 Electric Heating

The electric heaters shall be complete with:

- Auto reset thermal cut out device set at 65deg
- Airflow interlock by means of either supply air pressure sensor or and airflow switch.

6.6.5 Fan

Fans shall be of the centrifugal type, double width, double inlet, forward or backward curved blades OR of the EC plug fan type.

The fan shall comply with the requirements set out in, *General Requirements for Mechanical Plant – Fans – Centrifugal Fans*, within this document.

6.6.6 Filters

The fan shall comply with the requirements set out in, *General Requirements for Mechanical Plant – Air Filtration Equipment – Washable Filter Media*, within this document.

6.6.7 Controls and Safeties

Internal electrical wiring shall comply fully with wiring regulations as relevant and be adequately secured. All controls and safeties shall be installed in an integral distribution board

Control and safeties shall include but not be limited to the following:

- Internal overload protection on all motors

- Dirty filter trip switch with external indication gauges
- BMS output compatibility in BACNET format (if required)
- No air flow trip switch

6.7 Cooling Towers

The fan shall operate in the stable part of the curve.

Provide pilot operated valve for filling and bleed connections to offset drift and evaporation loss. The operating level of the water shall be automatically controlled.

Eliminators shall be removable in easily handled sections.

Provide access doors to reach all interior parts of the cooling towers.

The cooling tower shall be completely weatherproofed, and corrosion protected.

There shall be no spillage on the floor, piped to the nearest gully.

The piping system shall be adequately supported so that no strain is imposed on the cooling tower.

6.8 Plate Heat Exchangers

The heat exchanger shall be installed in accordance with the manufacturer's instructions. The installer shall ensure that the connecting piping is adequately supported so that no strain is imposed on the heat exchanger.

The heat exchanger shall consist of a frame in which the pack of heat exchange plates are held.

The plates shall be stainless steel with nitrile rubber gaskets.

Stainless steel drip trays shall be provided to prevent water leakage onto the floor.

Plates shall be arranged for counter flow.

6.9 Chillers (Air Cooled)

6.9.1 General

Products must carry the relevant local and international certifications, proof of such must be provided.

The Chillers shall be of a standard, factory assembled, packaged type, pre-wired, pre-charged, complete with controls and protection devices and shall include the features as specified herein.
Must have a minimum net EER rating of 3.00 (EN 14511 2013) and a minimum net ESEER rating of 4.00 (EN 14511 2013).

Must be installed & signed off in accordance with manufacturer's instructions.

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

The chiller plant manager must be capable of the following:

- Time of day scheduling: to provide 24hr start stop control for each day of the week.
- Duty cycle: to cycle equipment according to user defined on/off patterns
- Demand limiting
- Chiller sequencing
- Monitoring of chiller plant run-time and starts
- Provide maintenance scheduling facilities
- Soft loading: to start the minimum number of chillers for morning pull down load
- Control of auxiliaries: chilled water and condenser water pumps.

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

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

May utilize R134a or R410a refrigerants or equal and approved

Condenser coils may be either copper tube and fin or micro channel construction.

Must be provided with factory fitted corrosion protection coating equivalent to bluchem on all coils exposed to the ambient conditions (condenser coils).

Cooling capacity specified shall be selected using the following fouling factor:

- Evaporators 0,044 x 10-3 m^2 ºC/W

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

The cooling / heating capacity as specified in the detailed specification shall be delivered in accordance with the relevant ARI specification.

Minimum capacity control steps for each chiller shall be:

- 100% - 66% - 17% - 0 - Units less than 600 kW nominal cooling capacity.
- 100% - 75% - 50% - 25% - 0% - Units greater than 625 kW nominal cooling capacity.

Evaporator shell, refrigeration piping and associated chilled water piping are to be insulated to ensure efficient operation in defined operating conditions.

Hermetic motor, suction gas cooled shall be equipped with motor winding thermostat for overheat protection. Lifting eye bolts or fixing points for eyebolts shall be provided for each compressor and other parts with a mass greater than 25kg.

All components, particularly compressors and evaporators are to be mounted in such a way that they are accessible for maintenance without major dismantling of other equipment, piping etc.
A crank case oil heater is required where oil meets refrigerant. These heaters are to remain energised when the compressor stops.

6.9.2 Control and Protection Devices

Chillers shall be supplied with self-contained, machine mounted, factory wired control panel housing motor starters, control switches, safety cut outs and micro-processor capacity controls.

The following protection devices shall be fully automatic and shall shut down the chiller in event of:

- Low chilled water temperature
- Low evaporator temperature and pressure
- No or reduced chilled water flow
- No or reduced condenser water flow
- High refrigerant discharge pressure (manual reset)
- Low refrigerant suction pressure
- High motor winding temperature
- High oil temperature
- Low oil temperature
- Low oil pressure (manual reset)
- Voltage fluctuations, phase reversal, phase failure and severe phase imbalance and power loss
- Pilot lights or LCD display shall be provided to indicate the operation of the above devices.

In addition, the following instrumentation and control devices shall be provided:

- Suction pressure gauge for each compressor
- Discharge pressure gauge for each compressor
- Oil pressure gauge for each compressor
- Crankcase heater control
- Overcurrent relay
- Pump down relay
- Anti-recycle compressor protection relays.
- Chiller controls shall include an anti-cycling timer to limit the number of starts to three per hour.

The controls supplied shall be such as to maintain a constant chilled water supply temperature as specified. Condensing pressure temperature control by means of fan cycling or fan speed control shall be provided.

6.9.3 Chilled Water and Treatment Filtration

6.9.3.1 General

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

- Inhibit corrosion
- Inhibit formation of scale
- Protect system against algae growth
- Protect system against sludge formation

Chemicals shall comply with the Local Health Authority regulations and shall be compatible with all materials forming part of the piping system.

Chemicals shall be readily available from a recognised supplier.

Chemicals shall be selected so as not to interact with or neutralise each other.

Concentration of chemicals in pipe systems shall be in accordance with suppliers' recommendations.

Service visits by the supplier of the water treatment systems with water analysis tests and recognised corrosion tests shall be conducted at monthly intervals during the twelve (12) maintenance period. Reports on the above shall be sent to the Engineer.

The Contractor shall provide enough chemicals for twelve months operation.

6.9.3.2 Closed System

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

An easily accessible dosing pot adequately sized and rated for the working pressure of the system shall be provided for each system, to introduce chemicals on the suction side of the pump.

Pipework with isolating valves shall connect the dosing pot to the system in such a manner as to ensure circulation through the pot. The pot must also be fitted with a feed funnel, feed isolating valve, air vent cock, flow and return isolating valves and drain valves.

6.9.4 Chilled Water Pumps

6.9.4.1 General

Minimum pump efficiency 75%.

The pumps shall have duties as specified, but it should be noted that the system resistance ordered is provisionally stated. The Air Conditioning Contractor is therefore required to re-calculate the system resistance taking into consideration the actual pressure drops through equipment that is finally ordered and satisfy himself that the resistance figures for the pumps are adequate.

Casings shall be cast iron (or cast steel) selected to withstand 1,5 times operating pressures with a minimum of 1000kPa (dynamic plus static pressure.

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

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

Shafts shall be chrome or stainless steel of enough diameter to withstand all stresses imposed and with a critical speed well above the maximum running speed.

Pumps are to be fitted with mechanical seals unless otherwise specified.

Water pumps shall be supplied as complete sets by their suppliers, incorporating pumps, bronze impellers, motors, drives, bedplates, stainless steel drip trays, etc, factory assembled and

despatched to the project complete in all respects.

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

The pump set shall be installed on steel base, vibration isolated on a concrete plinth levelled. The contractor shall allow for the cutting of the impeller, as required at commissioning stage, a spare mechanical seal and gasket set for each pump.

The installer shall ensure that the connecting piping is adequately supported so that no strain is imposed on the pump set.

6.9.4.2 Safety

Single phase motors – thermal overload protection
Three phase motors - combined thermal overload and phase failure protection

6.9.4.3 Centrifugal Pumps

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

Coupling between motor and pump shall be by means of a flexible coupling "Fennerflex" or equal and approved. The coupling shall be provided with a removable galvanized sheet steel coupling guard, minimum 1mm thick which shall be securely bolted to the bedplate of the pump.

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

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

The pump supplier is to sign-off the installation and confirm pump installation and alignment.

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

6.9.4.4 Bedplates

All bedplates shall be of fabricated mild steel with surfaces on which the pump, motor, gearbox, fan etc. is mounted.

All bedplates shall be stress relieved after welding but before machining. Each bedplate shall be provided with approximately eight horizontal jacking screws with locknuts for each unit mounted thereon to assist in aligning the pumps and motors, etc.

All bedplates shall be thoroughly cleaned, prepared and painted with one coat of Anodite red oxide primer to finishing coats being applied.

It will not be necessary to dowel equipment in place, provided the jacking screws specified above are fixed and locked.

Where equipment is delivered completely assembled on a bedplate, these items of equipment shall be removed from the bedplate prior to installation. The bedplates shall first be installed, levelled, lined up and packed to ensure that there is no twist or distortion therein. The machines shall then be installed on their bedplates and the final alignment carefully checked and adjusted until it is to the entire satisfaction of the Client.

Minor corrections to the alignment of machines may be carried out using thin shims between the machinery feet and the machined surface of the bedplate. This applies particularly to electric motors. A maximum level error of 20 seconds of arc, or as decided by the Client, will be allowed.

6.10 Chilled Water Pipework and Insulation

6.10.1 General

Water piping systems shall follow the routes indicated on the relevant drawings. Piping shall be arranged to maintain enough headroom, keep access ways unobstructed and not interfere with maintenance and adjustment of valves an equipment. The system shall be complete in all details and provide for all central valves and accessories necessary for satisfactory operation.

The relevant drawings issued are schematic and do not purport to show the exact positions of pipes. All final dimensions must be checked on site.

Where pipe sizes are not indicated on the drawings, pipes shall be sized for a maximum water velocity of 2.5m/s.

6.10.2 Pipework and Fittings

All chilled / hot water piping from sizes DN15 to DN50 shall be SABS 62 Medium piping with screwed ends to SANS 1109-1 / ISO 7-1.

All chilled / hot water piping from sizes DN50 to DN150 shall be SABS 62 Medium piping with bevelled ends to ASME B16.25.

All chilled / hot water piping from sizes DN200 to DN600 shall be SABS 719 Gr B 6mm wall piping with bevelled ends to ASME B16.25.

All chilled / hot water piping from sizes DN650 to DN800 shall be SABS 719 Gr B 8mm wall piping with bevelled ends to ASME B16.25.

All chilled / hot water piping from DN65 and above shall be welded and welded flanges, Class 150 SABS 62/719 to be used throughout. All welding shall be done by a coded welder as certified by an approved authority in terms of SANS 10044. Flange joints shall include Klingerite gaskets or equivalent.

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

Low points in piping shall be provided with drain valves with hose unions. These valves so located that the entire piping system can be completely drained.

High points in piping shall be provided with automatic air vent valves with integral check valves. Each air vent shall be preceded by a shutoff valve to allow maintenance of the air vents.

Maximum spacing supports:

- Steel Piping

Nominal Diameter	Spacing
15mm	1.8m
20mm	2.4m
25mm	2.4m
32mm	2.7m
40mm	3m
50mm	3m
65mm	3m
80mm	3.6m
100mm	3.9m
125mm	3.9m
150mm	4.5m
200mm	5.8m
>250mm	6m

Plug open ends of piping, drains, fittings and equipment connections during installation to keep system free of rubble, dirt and other foreign matter.

All piping systems shall be flushed out properly to ensure cleansing, prior to the operation of the plant.

Piping systems shall be tested by means of a hydraulic pump to twice the operating pressure of the system or, where it is not permissible due to the maximum allowable piping working pressure, the piping shall be tested to a minimum of 1500kPa to verify that no water leaks are present.

All valves installed shall be of a high standard of manufacturer and well-known brand.

Types of valves shall be of the same manufacturer. Screwed valves to be used up to and including 50mm. 65mm and over shall be flanged valves. Screwed valves shall have screwed ends to SANS 1109-1 / ISO 7-1. Flanged valves shall have Class 150 SABS 62/719 flanges.

Strainers shall be of the “Y” pattern bronze screwed with stainless steel screen equal to TOA fig. “Y” or cast-iron body flanged, bolted cover with blow down plug and stainless-steel screen to be fitted with extraction handle for easy removal.

Screen perforations as follows:

- Up to and including 50mm 1.2mm dia
- 65mm to 150mm 2.0mm dia
- 200mm and over 3.5mm dia.

Gate Valves shall be SANS 776:2005 Class B screwed, or equal, or cast-iron body flanged with bronze rising spindle, and trim, outside screw and yoke, solid wedge disc, to BS 5150 J Fig. KF 502 or equal.

Globe Valves shall be bronze body screwed, internal screwed bonnet, rising spindle bronze to bronze tapered seats to Conti Fig. 70400 or equal, or cast-iron body flanged with bronze rising spindle, and trim, outside screw and yoke to BS 5152 J Fig. KF 501 or equal.
Check Valves shall be bronze screwed, swing check type, bronze seats to Conti Fig. 77104 or equal, or cast-iron body flanged solid, cast iron flap with bronze trim and bolted cover to BS 5153 J Fig. KF 601 or equal.

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

6.10.3 Flexible Hose Connection

The hose is to be a seamless steel reinforced UV resistant flexible hose with a protective and abrasion resistant covering suitable for continuous use with a rated life span of 15 years.

The hose shall be suitable for air conditioning applications.

The connections shall be factory installed and permanently fixed to the flexible hoses.

The hose shall be SABS approved.

6.10.4 Piping Insulation Material and Thickness

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

All chilled water piping shall be insulated with either:

- Pre-formed glass-wool sectional lagging (Min Density 80kg/m3)
- Pre-formed poly-isocyanurate (PIC) rigid closed cell foam insulation (Min Density 32kg/m3)
- Pre-formed closed cell elastomeric insulation (Min Density 48kg/m3)

The insulation should have a minimum fire rating Class 1 as per SANS 10177.

INLAND		**COASTAL**	
Pipe Diameter (mm)	Insulation Thickness (mm)	Pipe Diameter (mm)	Insulation Thickness (mm)
15	20	15	25
20	20	20	25
25	20	25	30
32	25	32	30
40	25	40	30
50	25	50	40
65	40	65	40
80	40	80	40
100	50	100	50
125	50	125	50
150	50	150	50
200	50	200	50
250	50	250	50
300	50	300	50
>350” header	100	>350” header	100
Storage Tanks	150	Storage Tanks	150

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

Internal pipe fittings shall be insulated with non-drip cork tape.

6.10.5 Vapour Barrier

The insulation of pipework operating at below ambient dew point temperature shall be provided with a vapour seal.

The vapour seal shall be continuous at pipe supports.

All vapour joints to have an overlap of 50mm.

6.10.6 Cladding

In plantrooms or as indicated on the drawings the piping will have a 0.5mm galvanised metal cladding. External cladding to be arranged to shed water and be water tight.

Coastal applications require cladding to be Aluminium.

Where pipe supports are located PIC high-density pipework, supports are to be incorporated which are to be suitably vapour sealed in conjunction with the associated insulation.

6.11 Buffer Tank

The storage vessel shall be a standard product from a recognised supplier.
Storage vessel shall consist of a steel shell rated for 1.5times the working pressure in the chilled water system, but not less than 690kPa.

Storage vessel shall be installed in accordance with the manufacturer's instructions. Pipe weight shall not rest on the storage vessel.

Storage vessel shall be insulated, vapour proofed and metal clad.

6.12 Corrosion Protection

The equipment is to be supplied with suitable corrosion protection applicable to the environment it is to be installed such that the usable life of the equipment is not reduced.

The coating used must be specifically designed for the coating equipment in its entirety, i.e. enclosure, coils, electronic boards, etc. that are situated in corrosive areas.
Coating should be a metal impregnated water-based product that is resistant to most common chemical vapours.

A Certificate of Coating must be issued clearly indicating the unit serial number and warranty period.
The coating should be water based, solvent free and low VOC (Volatile Organic Compounds).
Coating must be non-flammable.

Coating applicator must provide a declaration of RoHS compliance (Restriction of Hazardous Substances). The coating dry film thickness should be 15 – 30 microns without any material bridging between fins, and no more than 40 microns to prevent pressure drop across the coils.

Impact on pressure drop and heat transfer must be less than 1%.
The coating material must have certified documents about ASTM testing of the following key specifications:

- salt spray as per ASTM B117 of > 5000 hrs (corrosion durability)
- cross hatch as per ASTM 3359-93 of 5B (adhesion)
- uv resistance as per ASTM D4587 of 500 hours

7 GREENSTAR REQUIREMENTS (IF APPLICABLE)

7.1 Environmental Management

The Contractor and workforce shall be conversant with and adhere to the site-specific Environmental Management Plan and the Main Contractor's ISO14001 Environmental Management Systems.

7.2 Indoor Air Quality Plan

An Indoor Air Quality Management Plan shall be developed and implemented by the main contractor and adhered to by all subcontractors.

The IAQ Management Plan requires that ducting, HVAC equipment, electrical systems and exposed cable trays are protected from dust during construction and interior fitout.

Sub-contractors are to identify methods to protect equipment from dirt and dust during the construction process. This may include covering equipment, identify mechanisms to reduce dust in the atmosphere from cutting, grinding and drilling.

Reference: Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) http://www.smacna.org/

7.3 Waste Management

The project aims to reduce waste disposed of in landfill by a minimum of 70% of demolition waste must be reused and/or recycled. The contractor is to adhere to the Waste Management Plan put in place by the Main Contractor.

Any waste removed from site by the contractor must be declared to the main contractor, and provide documentation provided stating

- What types of waste are collected for recycling or for reuse
- The mass of the waste reused, recycled, disposed of to landfill
- How recycling and reuse occurs

For Informal recycling, the waste material must be weighed beforehand and a record of the informal recycle collectors must be kept including their acknowledgement of receipt of such materials and quantities.

7.4 Ventilation Rates

The minimum fresh air rate for each separately served area is 12.5 litres /person /second. This is based on a design occupancy rate of 1 person per 10 m^2.

The ventilation system shall be commissioned and through supporting evidence, demonstrate that it operates as intended by the design. Commissioning documentation shall indicate the minimum outside air rates as supplied by each AHU.

7.5 Carbon Dioxide Monitoring and Control

Carbon Dioxide response monitoring is provided to ensure the delivery of optimum quantities of outside air. A minimum of one CO2 sensor is provided at all return points on each floor. The sensors shall be linked to an automated system that can provide continuous monitoring of air quality in the space and allow an upward adjustment of fresh air rate to counter carbon dioxide build up within the usable area.

- Located purely within risers does not qualify;
- Location within return ducts only or within return ducts and return risers is acceptable.

The reference set points to be:

- 600 parts-per-million.

The HVAC system shall be commissioned and through supporting evidence demonstrate that it operates as intended by the design.

7.6 Internal Noise Levels

Constant noise levels within the building resulting from building services do not exceed

- 40dB(A)eq. / 34NC for general office space (cellular offices and meeting rooms); and
- 45dB(A)eq. / 40NC for open plan office space areas.

7.7 Tenant Exhaust Riser

Dedicated tenant exhaust risers will be installed that will provide no less than 0.2litres/second/m2 for 100% of the Usable Area and has a capacity of 0.35litres/second/m2 for 100% of the Usable Area on any individual floor, and the exhaust system is not recycled to other enclosures of different use.

Alternatively, the project provides exhaust louvres for tenant extract in each tenanted area of a size equivalent to 1.25cm2/m2 of Usable Area, with an exhaust point at least 7m away from any openable window or air intake.

The contractor is required to provide As Built drawings of the exhaust riser containing the information required to clearly demonstrate compliance with the credit criteria.

7.8 Water Sub-Metering

Water meters installed in the building are required to be linked to the Building Management System (BMS), where present or automated monitoring system.

The automated monitoring system shall be designed to collect, record and monitor water consumption data from all water meters.

The automated monitoring system shall be designed to trend typical water consumption and alert the building operations management where anomalies in water consumption occur. This function will support early detection of water leaks.

All monitoring, metering and control systems (including the BMS) shall be commissioned and through supporting evidence, demonstrate that that the system operates as intended by the design.

7.9 Energy Sub-Metering

Provide sub-meters for substantive uses:
For all energy uses within the building of 100 kVA or greater;
Typical office building loads of 100 kVA or greater include:

- Car parks
- Chillers
- Air handling fans
- Lifts

Whenever lifts, individual or collectively, carry an energy use greater than 100 kVA, they must be sub-metered. If individual lifts carry an energy use under 100 kVA, they can be sub-metered individually or as a group. If individually they carry an energy use greater than 100kVA, they must be sub-metered separately unless they are monitored by an intelligent control system.

- Common area lighting
- Common area power
- Any additional item that carries an energy use greater than 100 kVA.

Sub-meters must measure kWh and need not measure kVA. Supplementary equipment can also be installed on the same measured circuit as the substantive energy use item, however it must not contribute more than 10 kVA.

Provide sub-meters for both lighting and power
Separately for lighting and separately for power for each floor for 95% of the total Useable Area (UA) only;

7.10 Automated Montoring System

All sub-meters must be linked to the building management system (BMS), if present, or automated monitoring system.

The monitoring system shall be designed to collect, record and monitoring energy consumption data from all energy sub-meters;

The monitoring system must have the facility to alert the building operations management of any change in energy consumption trends.

The meters and points to the automated monitoring system shall be commissioned and through supporting evidence, demonstrate that that the system operates as intended by the design.

7.11 Refrigerant ODP

All HVAC refrigerants in the project to have with an ozone depleting potential (ODP) of zero.

The HVAC system shall be commissioned and through supporting evidence, demonstrate that the system operates as intended by the design.

7.12 Insulation

All thermal insulation used in HVAC installations shall be free of ozone depleting (ODP) substances in both manufacture and composition.

The contractor shall provide a technical datasheet of the insulation being installed to the Main Contractor and Sustainability Consultant.

7.13 Legionella

The building system designed to eliminate the risk of Legionnaires' disease by avoiding the use of cooling towers or other evaporative cooling systems serving the building.

The HVAC system shall be commissioned and through supporting evidence, demonstrate that the system operates as intended by the design.

7.14 Commissioning Clauses

Mechanical HVAC systems and associated services shall be commissioned in exact accordance with American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) The HVAC&R Technical Requirements for the Commissioning Process Guideline 1.1-2007 (supersedes ASHRAE Guideline 1-1996).

Perform comprehensive pre-commissioning, commissioning, and quality management on all other mechanical services in exact accordance with Chartered Institution of Building Services Engineers (CIBSE, UK) Commissioning Codes A (Air Distribution systems), C (Automated Controls), M (Management), R (Refrigeration) and W (Water Distribution Systems). The systems that must undergo complete commissioning in terms of CIBSE / ASHRAE include at a minimum cooling plant, heating plant, air distribution, water distribution, and HVAC controls.

7.15 Commissioning Report

Include commissioning dates, records of all functional/commissioning testing undertaken, a list of future seasonal testing, and a written list of outstanding commissioning issues;
Include the outcomes and changes made to the building as a result of the commissioning process, accounting for all the recommendations.
Reference appended extracts of commissioning records for major plant and equipment as deemed appropriate by the relevant project team members involved in the commissioning process and as referenced in the Commissioning Report;

Demonstrate that the services were commissioned in compliance with CIBSE Commissioning Codes for the mechanical services.

- Provide particular and definitive commissioning specifications from the design engineer of each service/discipline setting out clearly what is expected of the commissioning specialist (independent or otherwise). This should include commissioning tolerances on all commissioning parameters and a clear description of how it is intended that the system should operate and the design parameters. The design should also produce cause-and-effect sheets showing how the design is intended to operate. Also, commissioning specification details of safety controls and interlocks to protect the equipment and personnel during the commissioning process;
- Provide requirements for witnessing including full details of tolerances applicable to all parameters;
- Provide commissioning program including specific period of time for client witnessing;
- Provide appropriate health and safety risk assessment and method statements for the tasks to be completed;
- Provide commissioning method statement for each system
- Provide pre-commissioning checklists for each system;
- Provide commissioning checklists;
- Provide commissioning certification for each system countersigned by the Project Engineer, Commissioning Specialists (independent or otherwise) and the accepting authority (where relevant) and including the record sheets provided in each CIBSE code.

7.16 Knowledge Transfer

At building handover, the Contractor shall provide training of building management staff, and transfer knowledge of all services to the building owner and representatives as follows:

- Design Intent Reports,
- As Built drawings,
- Operations & Maintenance Manuals,
- Commissioning records and reports, and

- Document proof of training of building management staff.

7.17 Documented Design Intent

The Project Engineer will provide a report to include a simplified diagram of the system, a description of its intended function, operation and conditions, as well as the initiatives intended to enhance energy efficiency and minimise greenhouse gas emissions

7.18 Operations and Maintenance Manuals

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.

7.19 Training of Building Management Staff

The Contractor shall provide proof that building management staff has all the information and understanding needed to operate and maintain the commissioned features and systems of the building which is to include, at a minimum:

- Information provided in the Design Intent Report issued by the Project Engineer (including energy and environmental features);
- Review of controls set up, programming, alarms and troubleshooting;
- Review of Operations & Maintenance Manuals;
- Building operation (start up, normal operation, unoccupied operation, seasonal changeover, shutdown);
- Measures that can be taken to optimise energy efficiency;
- Occupational Health & Safety issues;
- Maintenance requirements and sourcing replacements;
- Obtaining and addressing occupant satisfaction feedback.

7.20 Building Tuning

The Building Owner is to implement a twelve (12) month ‘building tuning period’ after practical completion, once the commissioning of the system is complete. Building Tuning must commence within two (2) years of practical completion on all mechanical systems.

Re-commissioning is intended to incorporate any modifications identified as necessary or beneficial during the building tuning period and to improve the performance of building operation. The term does not refer to the re-setting of the systems to the initial commissioning settings.

7.21 Scope of Work

The Mechanical Contractor and Mechanical Engineer shall oversee the building tuning process with the aim of:

- Ensuring that all mechanical systems including heating, ventilation, and air-conditioning systems, are monitored, tested and tuned.
- Verifying that systems are performing to their design potential during all variations in climate and occupancy;
- Optimizing time schedules to best match occupant needs and system performance;
- Align systems' operation to the attributes of the built space they serve

7.22 Milestones

Building tuning shall commence once full commissioning of the systems has been completed. The building should be at least 50% occupied to get building occupants reactions to the systems installed. The tuning process must commence no later than two years after practical completion

7.23 Timeframes

The following deliverables must be programmed into the main contractor's programme:

- Monthly monitoring and collection of building services data.
- Quarterly reports – 4 produced representing conditions for each season of the year.
- Final Building Tuning report
- Building Tuning – to be conducted after 12 months of building services data has been obtained.

7.24 Deliverables

The Heating, Ventilation and Air Conditioning Contractor shall:

- Obtain monthly monitoring data of the building systems during the 'building tuning period' from the building BMS and facilities management.

- Produce four (4) quarterly reports during the ‘building tuning period’ documenting monthly monitoring findings and recommending corrective actions to be taken. These shall be made available to the Mechanical Engineer and Building Owner.
- In consultation with the Mechanical Engineer, produce one (1) final Building Tuning Report at the end of the ‘building tuning period’ summarizing the findings in the four (4) quarterly reports and recommend corrective actions to be taken.
- Provide Building Tuning Report to the Mechanical Engineer, the Building Owner and Project Design Team.
- Re-commission relevant Mechanical systems at the end of the ‘building tuning period’:
    - Undertake a review of all systems to the scope of the initial pre-occupancy commissioning;
    - Incorporate any modifications identified as necessary or beneficial during the ‘building tuning period’ to improve the performance of building operation in accordance with design intent documentation from the Mechanical Engineer and the Building Tuning Report.

The Mechanical Engineer shall:

- Review the quarterly reports provided by the mechanical contractor. Where necessary, make comments and recommendations
- Review, comment upon and accept the final re-tuning recommendations made by the contractor.
- Oversee and sign off the final building tuning / re-commissioning process.

  The Building Tuning Co-ordinator will:
    - Be responsible for obtaining the data collection from the contractor on a monthly basis.
    - Be responsible for co-ordinating a quarterly meeting including the contractor and consultant to discuss the inputs for the quarterly report
    - Be responsible for submitting the quarterly reports to the building owner
    - Co-ordinating a final building tuning meeting with the contractor, consultant and building owner to discuss findings, possible costs and recommendations. The Building Owner will need to provide instruction to incorporate the recommendations.
    - Develop a final building tuning report that summarises the findings, costs, recommendations which is signed by the contractor, consultant and approved by the building owner.

7.25 Paints, Coatings, Primers, Adhesives and Sealants

Only low VOC paints and adhesives may be used in the project.

7.25.1 Paints

The Sub-Contractor is required to prepare a Confirmation Letter in the form of a final audit, at completion of work, confirming the primers, paints, varnishes etc. used in the building, describing the application, amount, type and supplier of each relevant product used, and providing the Datasheets of the various products which confirms the VOC of the relevant products.

Low VOC – Paints, Varnishes, Primers and Protective Coatings (maximum levels including pigments)	
Product Type / Sub Category	**Max TVOC Content (grams/litre of ready-to-use product)**
Interior semi-gloss, low sheen, flat washable	16
Interior gloss	75
Timber and binding primers	30
Interior sealer and General Primer	65
Any solvent-based coating whose purpose is not covered in table	200
Table IEQ-13.1: Maximum TVOC Values for Paints, Varnishes and Protective Coatings	

7.25.2 Adhesives and Sealants

The Sub-Contractor is required to prepare a Confirmation Letter in the form of a final audit, at completion of work, confirming the adhesives and sealants used in the building, describing the application, amount, type and supplier of each relevant product used, and providing the Datasheets of the various products which confirms the VOC of the relevant products.

Adhesives and Sealants (maximum permitted VOC levels)	
Product Type	**Max TVOC Content* (grams/litre of product)**
Multipurpose Construction Adhesive*	70

Structural Glazing Adhesive	100
Architectural Sealant*	250
* sealants used to enhance the fire and water-proofing properties are included	
Table IEQ-13.2: Maximum TVOC Values for Adhesives and Sealants	

7.26 Building User Guide

The Mechanical Engineer is responsible for giving input to the Building Users' Guide. This is a description of the building services written in a manner that is understandable to the ordinary building user, drawing attention to the environmental benefits of the design choices made.

The Building Users' Guide should include the following information:

- **Energy & Environmental Strategy**: Description of the building initiatives intended to enhance energy efficiency and minimise greenhouse gas emissions, including an overview of the potential savings, as stated for economic and environmental impact.
- **Monitoring and Targeting**: Details on energy targets and benchmarks for the building, such as W/m2, and on the metering and sub-metering strategy.
- **Building Services**: Description of basic function and operation of the following, with simplified systems diagrams and an explanation of energy saving features:
    - Ventilation systems;
    - Heating systems;
    - Cooling systems
    - BMS systems

- **Expansion / Re-fit Considerations**: Include a list of environmental recommendations for consideration, highlighting the areas covered in the Building Users' Guide. Consider examples such as lamp choices and light fittings.
- **References & Further Information**: Should include links to online information such as websites, publications and organisations relating to energy conservation, efficient building operation, and environmentally friendly design features.