


REPORT	
For:	Technical Specification for Supply, Delivery, Installation, Testing and Commissioning of Heating, Ventilation, and Air Conditioning (HVAC) System for the New Clothing Facility in the Port of Durban
Project Name:	New Clothing Facility in the Port of Durban
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1. Scope of Work

1.1. Scope of Work Terminologies

- 1.1.1. Design, Manufacture, supply, delivery, install, commissioning, testing and handing over in complete working order ready for immediate use and subsequent maintenance for a period of twelve (12) months of all plant equipment necessary for the installations described herein and as indicated on the accompanying drawings, of which:
- 1.1.2. The words “handing over in complete working order” in the clause above shall mean not only the major items of plant and equipment covered by the Specification but also the incidental sundry component’s necessary for the complete execution of the work and for the proper operation of the installation.
- 1.1.3. The words “subsequent maintenance for a period of twelve months” in the clause above, shall mean that such period shall commence from the date the installations are accepted and after “practical completion” has been confirmed in writing by the Employer’s Engineer.
- 1.1.4. The words “described herein” in the clause above shall mean all sections or part of this Specification and drawings”.

2. DESIGN CONDITIONS

The following design conditions were used in designing the air-conditioning requirements for this project:

2.1. External Condition

Summer ambient	: 40°C Dry Bulb Maximum
Winter ambient	: 11°C Minimum
Humidity	: Average 80%
Altitude	: 8 m above sea level

2.2. Internal Condition

Summer	: 22.5°C Dry Bulb – 55% Relative Humidity
Winter	: 22.5°C Dry Bulb – 55% Relative Humidity

2.3. Tolerances

Temperature	: $\pm 1,5$ °C
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2.4. Thermostats

Shall be set to maintain the required conditions within a tolerance of $\pm 1,5$ °C. Notwithstanding this tolerance the average temperatures shall not vary from the required conditions in any of the air conditioned areas.

Humidity 55:: \pm 5%

No positive humidity control is required (except for server room units) but the cooling equipment shall be selected to indirectly control humidity within the comfort range of 45% - 55% relative humidity.

2.5. Design Conditions

The *Contractor* shall test, commission, and adjust the air-conditioning and ventilation installations so that they will maintain the inside design conditions specified above, subject to the capacity limits hereinafter specified during hours of operation.

2.6. Noise Levels

Maximum noise levels caused by the operation of the air-conditioning or ventilation plant shall not exceed OHS Act 85 of 1993 and regulations.

The specified noise levels shall be those that read at a distance of not more than 2 metres from any air outlet, return air grille or opening.

Further the air conditioning and ventilation installations shall be designed and configured to not exceed the rating levels of ambient noise for the relevant indoor dwelling spaces, based on the South African National Standard (SANS) 10103. The *Contractor* shall ensure that the complete installation does not exceed the specified noise levels.

The Contractor shall also be responsible to ensure that where ducts and pipes pass through concrete, brick or other structural members and finishes, this is achieved without transmission of noise and vibration

2.7. VRF/VRV Outdoor Units

Contractors are required to ensure that the outdoor units are weatherproof and corrosion resistant for coastal conditions including minor items such as screw, fixers, and brackets, etc. The VRF/VRV unit shall have automatic dust removal feature.

The VRF/VRV outdoor units shall have a heat exchanger that can perform efficiently in corrosive environments including coastal environments. The heat exchanger fins shall be

factory coated with hydrophilic film, acryl, epoxy, and melamine resin for minimization of moisture build up and protection from corrosion.

The Contractor shall provide the Employer with a certificate for verification of corrosion resistance performance testing in compliance to ISO 21207.

The VRF/VRV outdoor unit shall have an active refrigerant control feature to minimize the amount of refrigerant in circulation.

The VRF/VRV outdoor unit compressors shall have an oil management feature comprising of oil level sensors and oil balancing between the compressors.

The VRF/VRV outdoor unit shall have an inverter scroll compressor which provides an improvement in part load efficiency, more compressor reliability by reducing compressor damage, and direct oil injection which regulates oil supply and increases reliability.

The VRF outdoor units shall have a Energy Efficiency Ratio (EER) of not less than 4.0.

2.8. Split Condenser Outdoor Units

Contractors are required to ensure that the outdoor units are weatherproof and corrosion resistant for coastal conditions including minor items such as screw, fixers, and brackets, etc. The split condenser outdoor units shall have automatic dust removal feature.

The condenser outdoor unit shall have a heat exchanger that can perform efficiently in corrosive environments including coastal environments. The heat exchanger fins shall be factory coated with hydrophilic film, acryl, epoxy, and melamine resin for minimization of moisture build up and protection from corrosion.

The Contractor shall provide the Employer with a certificate for verification of corrosion resistance performance testing in compliance to ISO 21207.

The split condenser outdoor unit shall have an inverter scroll compressor which provides an improvement in part load efficiency, more compressor reliability by reducing compressor damage, and direct oil injection which regulates oil supply and increases reliability.

2.9. Indoor Air Conditioning Units

The indoor units shall be able to sense both ceiling and floor temperature at the remote points to provide comfort air

The indoor units shall have human detection feature to sense human presence to switch on or off for power savings

The indoor air conditioning units shall have a purification feature that can remove 99% of microfine dust (PM1.0) and the filters must be washable and easy to maintain.

The indoor units shall have individually controllable vanes for optimal air distribution.

2.10. Wired Remote Controllers

The wired remote controllers shall feature colour LCD screens and touch button for easy interface.

The wired remote controllers shall have mode change control which includes cooling, heating, auto, dehumidification, and fan. The controllers shall display temperature, humidity, time and control temperature and fan speed. The remote controller shall have vane control and auto swing features.

The wired remote controllers shall have energy savings features which shall include energy monitoring which will monitor real-time and day/week/month/year energy usage. The energy feature shall allow energy usage target setting and operating time setting which will control the operating time of the air conditioning units and automatically switch the units on/off. An alarm shall be displayed when the energy usage target has been exceeded.

2.11. Supply and Extract Air Fans

Mechanical ventilation shall comply with SANS 10400.

The window/wall extractor fans shall have a wall/window mounting kit which includes a wall/window liner. The window/wall extractor fan motor shall have class B insulation for ambient temperatures up to 40°C and be fitted with a thermal cut out.

The ducted supply and extractor air fan shall be mounted in a round galvanized steel casing and in accordance with Eurovent 1/2. The impeller shall be balanced dynamically in accordance with DIN ISO part 1. The motor shall have thermal overload relays for protection from overheating or thermal overload.

The supply and extractor air fans shall match the required airflow and operate at high efficiency levels.

The smoke extraction fans shall be rated as per the EN12101 code.

2.12. SOUND ATTENUATORS

2.12.1. Sound attenuators shall be the product of manufacturers regularly engaged in the production of such products and of which catalogue and selection data is available.

- 2.12.2. Casings shall be constructed of galvanised mild steel sheet, flanged for connection to ductwork, complete with matching counter flanges. The metal gauge for the casing shall not be less than the thickness specified for ductwork of the same dimensions. All casing joints shall be made airtight with Hardcast Sealing and Jacketing System or have soldered joints.
- 2.12.3. Sound attenuators in the supply and return air ducts shall have sound absorbing infill materials covered with Melinex or Hostaphan or other approved material.
- 2.12.4. All sound attenuators shall be labelled on the outside of the casing with aluminium identification tags, fastened to casing with pop rivets. Identification shall state type of sound attenuator, size, airway spacing, etc. Tags shall not be painted over.
- 2.12.5. Sound levels in the air-conditioned and ventilated spaces shall be as follows, when the air supply and return systems to which they are connected are operational: -
 - 2.12.5.1. General Air-conditioned Areas: Room Criteria (RC) Neutral (N) Level 35-40
 - 2.12.5.2. At 1.5 Metres Distance from Ducted Air Intake / Exhaust Air Louvres: RC (N) Level 5055
 - 2.12.5.3. Air conditioning Units: As Per Manufactures Ratings
- 2.12.6. Air pressure drop through attenuators shall not exceed the following when delivering the air volumes:
 - 2.12.6.1. General Air-conditioning Areas:

35 Pascal (Supply Air)
- 2.12.7. Sound attenuators make, type and size indicated on the drawings are for tender purpose only and shall be reselected by the supplier of the sound attenuators based on final fan selections and contractors working drawings.

2.13. Specialist Firms

- 2.13.1. Insulation shall be carried out by specialist firms regularly engaged in this type of work.
- 2.13.2. The HVAC installation, testing and commissioning shall be done by a Contractor that has been trained and approved by the plant manufacturer
- 2.13.3. Such specialist firms shall in addition be required to show completed installations to the selected Subcontractor and Employer's Engineer, to prove that they are specialists in their field.
- 2.13.4. When starting on site, the insulation specialist shall be required to insulate certain piping, valves, fittings, ductwork etc. for approval by *the Employer's Engineer*. After approval by the Employer's Engineer the insulation specialist may proceed with the work under this Selected Subcontract.

- 2.13.5. Should the sample insulation be of an unacceptable standard, the Selected Subcontractor will engage another firm, whose standard of work is acceptable, without any extra cost to the Employer.
- 2.13.6. Where in the opinion of the Employer's Engineer, the standard of work produced by the Insulation Specialist deteriorates below acceptable or approved standards, then the Selected Subcontractor shall remove all such unacceptable work and appoint another insulation firm to complete the work under this Subcontract to a satisfactory standard, at no additional cost of the Employer.
- 2.13.7. The Selected Subcontractor shall be held responsible for the supervision of the workmen engaged in all insulation work and shall act on all instructions given by the Employer's Engineer or his authorised representative.

2.14. Adhesives

- 2.14.1. Use mastic and liquid sealants and adhesives that comply with the relevant requirements of SANS 1238 and that, in addition (to obviate fire hazards when used on site in the wet stage), have a flash point determined in accordance with ASTM D 93. To prevent fire hazards, ensure that proper ventilation is provided during the application of insulation on the inside of ducts or other enclosed spaces.

2.15. Metal Bands, Wires

- 2.15.1. Metal band insulation to piping. Bands shall be aluminium with wing seals, 13mm wide and 0,5mm thick, for piping which is not sheet metal or aluminium clad.

2.16. Equipment Insulation

- 2.16.1. Equipment Insulation
 - 2.16.1.1. Controls and indicating instruments shall, where sweating occurs due to condensation, be insulated. Pay particular attention to binder fittings.
 - 2.16.1.2. Use insulation as specified in section 2.17.2 where possible, otherwise non drip tape applied in sufficient layers. Paint non-drip tape after application.
 - 2.16.1.3. The insulation shall not be damaged, cut or compressed in any way due to the installation or pipe hangers utilized. Under no circumstances are cable ties to be utilized on the refrigerant piping.

2.17. Refrigerant Piping

- 2.17.1. The refrigerant piping shall be completely insulated. Thicknesses of insulation shall be as follows:

Nominal Pipe Size (mm)	Insulation Thickness in (mm)
6.35 – 9.53	19
12.7 up	25

2.17.2. The insulation properties shall be as follows:

Physical properties and Specification	
Type	Flexible elastomeric foam, Closed cell / EPDM
Thermal Conductivity	$\leq 0.033 \text{ W/(m.K)}$
Temperature range	-50°C - 110°C
Fire rating	Self-extinguishing, Zero spread of flame and zero Drip. FM Approved
Water vapour resistance	$\mu \geq 10000$
Fungi resistance	No fungal growth, Anti-microbial behaviour

2.18. Drain Piping

2.18.1. Insulate all drain piping from cassette units and ceiling concealed units drip trays with a minimum of 19mm thick, see section 2.17.2. for insulation properties.

- 2.18.2. Flexible hose must be used between the indoor unit and drain pipe. Drain pipe must not be connected to the waste pipe.
- 2.18.3. Drain pipe down slope must not be less than 1/50~1/100.
- 2.18.4. Air vents should be installed at intervals of 10 meters. Air vent shall be higher than the common Pipe.
- 2.18.5. Install U-trap to prevent bad smell from entering indoor.

2.19. Ductwork

- 2.19.1. Ducting and plenums shall be manufactured, installed and commissioned to the following standards: -
- 2.19.2. SANS (South African National Standards) 1238 – Manufacture Air-conditioning Ductwork.
- 2.19.3. SANS (South African National Standards) 10173 – Installation and Commissioning.
- 2.19.4. All ductwork on the upstream side of Operations Room air-handling units shall be constructed to the pressure classification equal to 1½ times the recommended terminal filter change-out (dirty) pressure differential. All ductwork shall be flanged, with longitudinal and transverse joints made airtight with Hard-cast Sealing and Jacketing System. Final connections shall be sheet metal.
- 2.19.5. All bolts and nuts for flanged joints shall be cadmium plated.
- 2.19.6. All ductwork otherwise shall be supported on hot-dip galvanised brackets complete with adjustable hanger rods. Duct sizes indicate clear inside dimensions. Round ducting to be of the spiral wound type unless indicated otherwise.
- 2.19.7. During construction, all duct systems **shall be protected** from ingress of dust, dirt and foreign matter particularly for systems serving operating theatres. Strict compliance with this requirement will be enforced and internally soiled ducts will not be accepted as part of acceptance tests.
- 2.19.8. Flexible ducting to have a class 1 fire rating complying with sabs 0177 part 3 and to be less than 1.5m in length. ends are to be sealed and fixed with jubilee type clamps. flexible ducting shown connected to small fans is to be 1,5m long of the acoustic type for noise reduction.
- 2.19.9. Flexible round ducts shall only be used for connecting Air conditioning, diffusers and grilles to the supply, return and extract air ducts. Therefore, final bends to the air conditioning units and various diffusers shall be by means of flex ducting and not galvanized sheet metal ducting. Bends shall be of the maximum possible radius without flattening or distorting the duct.

2.20. Duct Insulation

- 2.20.1. All air-conditioning supply and return air ducting inside ceilings shall be externally insulated with 25 mm insulation with a density of 18kg/cubic metre, K-value 0.038w/m.k covered with aluminium foil reinforced Vapour barrier. Insulation shall comply with the latest SANS 428.
- 2.20.2. All air conditioning supply and return air ducting not inside ceilings shall be internally insulated.
- 2.20.3. The insulation shall be mechanically fastened by means of Clipfas nylon pins and washers, glued to ducting with adhesive suitable for bonding between glass wool blanketing and galvanized sheet metal and shall, in addition, be mechanically secured at maximum intervals of 400 [mm] with nylon strapping, or by means of spot-welded pins with securing washers/heads of diameter not less than 30 [mm]. and sealed along all longitudinal and transverse overlapping joints with approved adhesive to provide a vapour seal. Overlapping joints shall be approximately 120mm wide. Insulation thickness shall be carried over flanges or other upstands to prevent sweating due to condensation.
- 2.20.4. The insulation shall also be strapped with plastic straps at regular intervals spaced not more than 400 mm apart. Where necessary, especially at bends, transformation pieces, branches, etc., use adhesive, tape and straps to ensure that insulation is vapour sealed. Tears in duct insulation shall be taped over with aluminium type duct tape.
- 2.20.5. Insulation thicknesses shall be carried over duct flanges and sound attenuators.
- 2.20.6. Duct wrap insulation shall be non-combustible and conform to SABS 0177 Part 5 with a fire index that conforms to SABS 0177 Part 3 Class A. Ductwrap shall have a density of 40kg/m³ with SABS Class 1 Fire rating.
- 2.20.7. All air ducts carrying heated or cooled air, except where specifically excluded in the Supplementary Specification shall be thermally insulated.
- 2.20.8. Flexible ducts conveying conditioned air shall be of the insulated type.

2.21. FIRE STOPPING

- 2.21.1. The Contractor shall employ suitable fire stopping methods wherever deemed necessary in terms of these specifications, drawings, Works Information, statutory codes and regulations/standards, the Employer's specifications or any other applicable standards and documents related to the works.
- 2.21.2. All products used for fire stopping shall be SABS approved and/or be in accordance with other recognized and accepted standards. Typical fire stopping products that may be considered by the Contractor include intumescent sealants, special coatings, foams and the like. Particular attention shall be given to instances where electrical and

electronic equipment enters or leaves buildings, traverses through walls or similar types of installations.

- 2.21.3. The Contractor shall be responsible for the design and installation of the control system that will be responsible for activating the smoke extraction fans and for switching off all the other HVAC equipment in case of a fire occurrence. The control system must include wiring and the control panel. The smoke extraction fans must activate automatically as soon as smoke is detected.
- 2.21.4. The purpose of fire stopping is to ensure that, should any fires occur, the fire and smoke will be localized and contained and not propagate via any electrical and/or electronic infrastructure. The Contractor shall fully comply with these requirements.

2.22. Air Filters

- 2.22.1. Air filters for air-handling plants shall be as follows with average dust spot efficiencies of:-
 - 2.22.1.1. Primary filtration: 25% based on ASHRAE, G4 classification minimum.
 - 2.22.1.2. Primary filtration shall be installed upstream of the supply air fan.
- 2.22.2. Primary and secondary filters shall be of self-supported pocket filters designed and equipped to permit safe and easy removal for cleaning and maintenance. The filters must be washable.
- 2.22.3. During construction, openings in ductwork and air terminals shall be sealed to prevent intrusion of dust, dirt, and hazardous materials, aiding growth of infectious agents.
- 2.22.4. Air filters shall be the product of suppliers regularly engaged in the manufacture of air filtration equipment and who publish filter data from which selections can be made.
- 2.22.5. Each filter shall be suitable for the space available and shall be installed without damage to the building, building equipment or the filter. Filters shall be constructed and installed so as to prevent the passage of unfiltered air. Felt, rubber, or neoprene gaskets shall be provided between filter frames and unit casings, etc.
- 2.22.6. Steel filter parts shall be protected against corrosion by baked on enamel, epoxy resin, zinc coated, cadmium plating, or two coats of oil paint, or two coats of lacquer or coated with alkyd paint after phosphate cleaning.
- 2.22.7. Filter elements and media shall be protected against dirt during construction and shall not be operated until system is thoroughly cleaned. No fan system shall be operated without filters. Filters must be put in regular operating conditions before the fans to which they are connected are operated for any purpose, such as temporary ventilation or adjusting. After all adjustments, etc., are completed and before the filters are accepted for regular operation, they shall be cleaned and provided with additional new media to put them in 'new' condition.

- 2.22.8. Each filter bank or terminal filter shall be provided with an identification plate, mounted in a location where it will be visible after installation. The plates shall show serial number, model number, and all other data necessary for ordering renewal media.
- 2.22.9. Unless otherwise specified filter pressure differential gauges shall be fitted across all filter banks and where such banks comprise two or more sets of filters in series, gauges shall be fitted across each individual set of filters. Tertiary filter terminals shall be provided with pressure differential tapping's for measurement of filter resistances and shall also include pressure differential gauges. Each differential pressure gauge shall be suitable for the type of filter pressure range. The tubing to each switch shall include connector tees for connecting to a portable Magnehelic gauge. Dirty filter condition shall be indicated on the associated switchboard by a red pilot light.
- 2.22.9.1. The gauges shall be connected to static pressure taps for approved design so that they will correctly indicate the resistance of filters to air flow. Connections shall be made with copper tubing and shall be provided with a 3-way cocks. Gauges shall be carefully levelled and adjusted.
- 2.22.9.2. Side withdrawal filter banks shall be contained by extruded aluminium glide tracks with woven pile 'fingers' surrounding a plastic air barrier to prevent air bypassing along the tracks.
- 2.22.10. Front withdrawal filter banks shall be fitted to built up frames supplied by the manufacturers of the media and being designed specifically for the media used. Adequate precautions must be taken to prevent bypassing of the filter media or frames.
- 2.22.11. The Contractor shall ensure that the position of filters is suitable for easy removal and cleaning.

2.23. Electrical Wiring

- 2.23.1. The entire installation shall be wired in accordance with the latest version of SANS 10142-1.
- 2.23.2. After completion of the installation and prior to the acceptance thereof the following documentation must be submitted to the Employer's Engineer:
- a) All original certificates as required by SANS10142-1.
 - b) A copy of the wiring diagrams marked up with wire colours, core numbers, alterations, corrected motor loads, etc.
 - c) A cable schedule showing cable sizes, types, cable numbers, etc.
 - d) A schedule of all components and switchgear use.

2.23.3. Electrical Compliance Certificates are required by the latest revision of SANS 10142-1 are to be produced before power is applied to the specified switchboards and installation.

2.23.4. DO NOT alter wiring diagrams, switchgear selections, cable sizes, cable types, equipment positions etc., without permission.

2.24. Air Terminals, Dampers & Louvre's

2.24.1. Refer to detailed drawings and schedules on which air terminals, dampers, louvers, etc., are indicated giving type, capacity, size and make, and shall be of the following type or other approved:

2.24.1.1. Supply Air Diffusers

2.24.1.1.1. Shall be as specified in the schedule (or similar approved) with plenum unless indicated differently on the drawing complete with concealed fixing to duct spigots. The diffusers shall be externally insulated to prevent condensation forming on external flanges, etc.

2.24.1.2. Louvres

2.24.1.2.1. Shall be as specified in the schedule (or similar approved) with stainless steel wire mesh screen and masonry sub-frame as indicated on the drawings

2.24.1.3. Dampers and Fire Dampers

2.24.1.3.1. Combination fire/smoke control dampers complying with SANS 193 and NFPA 90A are required in the positions indicated on the drawings. The dampers shall be UL or SABS marked with proven low leakage in the closed position and shall meet the following further requirements:

2.24.1.3.2. Dampers shall be actuated by fusible link, electrical solenoid or pneumatic means, as specified on the drawing.

2.24.1.3.3. Fire dampers shall be flanged both sides and access panels shall be provided in the ducting at each fire damper on the upstream side.

2.24.1.3.4. Each fire damper shall be clearly marked as per Clause 4 of SANS 193.

2.24.1.3.5. Fire dampers shall have at least the resistance rating of the wall

2.24.1.3.6. The open or closed status of the damper shall be clearly indicated outside the casing for inspection purposes.

2.24.1.3.7. Dampers shall be sized so that the nominal free air area when in the open position is not less than the connected duct free air area.

2.24.1.3.8. Dampers shall be installed to form part of a continuous barrier to the passage of fire when in a closed position.

- 2.24.1.3.9. Sheet metal sleeves shall be provided for housing the fire dampers where a fire damper is mounted in a wall.
- 2.24.1.3.10. Where a fire damper cannot be fitted immediately adjacent to the fire wall, the section of ducting between the damper and wall shall be at least the same metal thickness and fire rating as the damper casing.
- 2.24.1.3.11. Dampers shall be self-supporting, to provide for the case of duct destruction due to heat.
- 2.24.1.3.12. Care shall be exercised that the frame is set so that the closing device is accessible.
- 2.24.1.3.13. Suitable hand openings shall be provided, with tightly fitted covers to make dampers accessible for inspection and maintenance.
- 2.24.1.3.14. Retaining angles shall be installed on four sides of the fire damper sleeve and on each side of the wall.
- 2.24.1.3.15. Angles shall be fastened to the sleeves only, and not to the wall.
- 2.24.1.3.16. Retaining angles shall lap the masonry by a minimum of 35 mm around the entire opening.
- 2.24.1.3.17. Dampers shall be sized at a maximum face velocity of 7m/s and shall be fitted with flanges on the duct connection side. The dampers shall be of opposable blade type to ensure air balancing can be done.
- 2.24.1.4. Door Grilles
 - 2.24.1.4.1. Shall be fitted by the Principal Contractor. The Selected Subcontractor shall however check that the door grilles indicated on the drawings are installed
- 2.24.1.5. Finishes
 - 2.24.1.5.1. Aluminium louvers or transfer grilles shall be natural anodized aluminium.
 - 2.24.1.5.2. All ductwork and flexible ducting which is visible through air terminals shall be painted matt black.

2.25. Equipment Supports

2.25.1. Steel or Timber Rafters & Purlins:

- 2.25.1.1. Any attachment to any structural steelwork or timber rafters or purlins shall be by means of clamps and/or drilling, and no cutting, welding, etc. of timber roof trusses and structural steelwork will be allowed. If extra purlins or structures are required, due to manufacturer requirement of equipment being installed, they shall be added to the structure to accommodate said equipment.

2.25.1.2. Any bolts and nuts, washers, clamps, threaded rods, etc., used for fixing to structural steelwork, rafters and purlins shall be electro-zinc painted to BS 1706 of 1990.

2.25.1.3. Plant layout drawings, indicating point loads, at rafters and purlins, shall be submitted to the Employer's Structural Engineer for approval so that rafter and purlins are approved by the Employer's Structural Engineer prior to installation of ductwork.

2.25.2. Slabs

2.25.2.1. Any mechanical fixings to any concrete shall in no way damage such concrete.

2.25.2.2. All mechanical fixings shall be SANS approved.

2.26. Painting

The paint colour scheme shall comply fully with the SABS requirements.

Thoroughly descale, clean and degrease.

Paint all exposed metalwork and equipment which is not a specified manufactured product as follows:

2.26.1.1. Black Metalwork:

- a) One coat of PA10 primer.
- b) One universal undercoat.
- c) Two coats of high floss enamel to ensure complete corrosion protection

2.26.1.2. Galvanised Metalwork:

- a) Degrease and prepare surfaces with a wash specifically designed for pre-treatment of galvanised iron.
- b) One coat of calcium plumbate.
- c) One universal undercoat.
- d) Two coats of high gloss enamel to ensure complete corrosion protections.

2.26.1.3. Factory Painted Equipment:

- a) Damaged and scratched paint surfaces shall be touched up with identical colour paint.
- b) All packaged unit supporting steelwork shall be painted.
- c) Paint shall be of the highest quality and shall be applied strictly in accordance with the manufacturer's specification.

2.27. Testing, Commissioning & Balancing

- 2.27.1. Testing, commissioning and air balancing shall be carried out by a Contractor, who has been trained and approved by the Manufacturer of the equipment, employing competent technicians familiar with the testing, adjusting, and balancing of air conditioning plants. Such a Contractor shall forward all test results to the Employer's Engineer for approval.
- 2.27.2. The Contractor shall notify the Employer of all tests to be done and shall ensure that the Employer's Engineer is present to witness all testing including the pressure testing of pipework and the vacuum level before the vacuum is broken.
- 2.27.3. Commissioning of the VRF unit/s shall be carried out by the manufacturers of the units, to ensure that system performs and designed and specified duties and functions and that all temperature and control monitoring/adjustment are in place and also functioning correctly.
- 2.27.4. The contractor shall allow in the price for a minimum of 5 refrigerant pipes to be cut and checked for any contamination within the pipes. The Employer's Engineer shall be present when the pipes are cut and shall verify that the installation is being done correctly. If any contamination is picked up the pipework will need to be removed, cleaned and replaced to the satisfaction of the Employer's Engineer.
- 2.27.5. Testing, adjusting, and balancing of the systems shall generally be in accordance with Chapter 34 of 1995 ASHRAE HANDBOOK (Testing, Adjusting, and Balancing).

2.28. Operating & Maintenance Manuals

- 2.28.1. Four Sets of Operating and Maintenance Manuals shall be prepared in the form as suggested in Chapter 59 of 1987 ASHRAE HANDBOOK (HVAC System and Applications). 4.24.2 All O&M Manuals and As-built drawings shall be supplied on USB in both PDF and native format with four sets of hard copies.
- 2.28.2. Plant schematics and wiring diagrams shall be the latest revision and shall be framed behind glass and displayed adjacent to switchboards.
- 2.28.3. The operating and maintenance manuals shall include but not be limited:
 - Descriptive Information

This section shall consist of but not be limited to;

- General description,
- Design parameters,
- Building load,
- Installed capacities,
- Principal components,
- Refrigeration piping distribution schematics
- Air distribution schematics
- Control schematics
- Electrical board schematics
- Equipment data

This section shall consist of but not be limited to;

- Equipment designation
- Manufacturer and model
- Manufacture local representative
- Size and rating
- Speed, pressure and temperature limitations
- Operating instructions

This section shall consist of but not be limited to;

- Starting and stopping procedures
- Time switch functions
- Seasonal adjustments
- Sequence under loading and unloading
- Normal operation and tripped conditions
- Logs and records to be kept
- Inspection and maintenance

This section shall consist of but not be limited to;

- Inspection Schedules and Checklist.
- Lubrication Schedules.
- Air Filter Maintenance Schedules.
- Routine Replacements, Adjustments and Calibrating.
- Routine Cleaning, Painting and Protection.

- Inspection and Maintenance Logs and Records to be kept.
- Reference documents

This section shall consist of but not be limited to;

- Tender Specification & Drawing List
- As built Record Drawings
- Test Reports
- Commissioning Reports
- Equipment manufacturer data

This section shall consist of but not be limited to;

- Descriptive literature
 - Catalogue Cuts, Brochures or Shop Drawings
 - Dimensioned Drawings
 - Materials of Construction
 - Parts Designations
- Operating characteristics
 - Performance Tables and Charts
 - Performance Curves
 - Pressure, Temperature, and Speed Limitations
 - Safety Devices
- Operating Instructions
 - Pre-start Checklist
 - Start-up Procedures
 - Inspection during Operation
 - Adjustment and Regulation
 - Testing
 - Detection of Malfunction
 - Precautions
- Inspection instructions procedures
 - Normal and Abnormal Operating Temperature, Pressure and Speed Limits.
 - Schedule and Manner of Operation
 - Detection Signals
- Maintenance instructions procedures
 - Schedule of Routine Maintenance.
 - Procedures.

- Troubleshooting Chart
 - Parts list
 - Service contracts

2.29. Maintenance

- 2.29.1. Allow for the maintenance of the complete installation for a period of TWELVE (12) MONTHS after 'practical' completion certificate has been issued by the Engineer. Visit the installation once a month on the basis of a proper preventive programme approved by the Engineer.
- 2.29.2. Report to an official nominated by the Client on arrival and again on leaving their premises on the occasion of each visit. Such person, who has been nominated by the Client, shall sign a Service Report giving details of corrected temperature and humidity readings taken, etc.
- 2.29.3. At each service visit, maintenance personnel shall, inter alia, perform the following duties in addition to any other which may be necessary.
 - 2.29.3.1. Check all fans and variable speed drives, lubricate moving part and tighten where applicable, belts, as required, and check all lock-out stops. Check air conditioning units, drip trays, drainage systems for cleanliness and correct functioning. Check air conditioning units for condensation.
 - 2.29.3.2. Check all air filters, etc, replacing filter media or filter panels as required. Check differential pressure gauges and switches, etc.
 - 2.29.3.3. Check all switchboards. Tighten connections, check switchgear for burnt contacts, check overload settings, phase failure relays, etc. Relays etc. Replace defective voltmeters, ammeters, transformers, pilot lights, hour meters, timers, time switches, etc.
 - 2.29.3.4. Check all control systems and safety devices, air flow switches, manometers, etc. for correct functioning and replace defective items or any other items as necessary.
 - 2.29.3.5. Check VRF units for correct functioning. Check refrigerant system for leaks, refrigerant dryness, sufficient oil level, and all safety controls and settings, etc. and correct and top-up as required.
- 2.29.4. Make good any defects as required in items of the guarantee given for the plant in terms of the specification.
- 2.29.5. Attend to any complaints made with respect to the installed plant by the authorized person mentioned in the foregoing. No other person shall have any right to instruct the Selected Subcontractor or make any complaint.
- 2.29.6. Instruct the Client's maintenance personnel on the attention required to any item requiring more frequent attention during the service visits.

2.29.7. A major service shall be executed in the sixth and twelfth month of the maintenance period shall be to the satisfaction of the Employer's Engineer. This major service shall include all annual servicing functions as recommended by the manufacturers of material and equipment supplied and/or installed under this contract.

2.30. Guarantee

2.30.1. The contractor shall guarantee the materials, apparatus and workmanship delivered and installed by him. The guarantee shall be valid for a period of twelve months starting on the date when the practical completion certificate is issued. The complete installation shall be guaranteed against defects as a result of patent and latent defects of the apparatus, as well as against faulty materials and workmanship. Fair wear and tear is excluded from the guarantee.

2.30.1.1.1. The guarantee shall provide for all parts, spares and appurtenances which become defective during the guarantee period, to be replaced free of charge to the Client. All costs of labour, out-of-town allowances, materials and transportation required to replace such part of a defective installation shall be borne by the Selected Subcontractor and shall be included in his guarantee. The Selected Subcontractor shall cede to the Client the remainder of any equipment guarantee which he has received from his suppliers and which may extend beyond the period of twelve months mentioned herein.

2.31. Extended Guarantee

2.31.1. Where certain equipment have supplier's standard guarantee clauses of which do not correspond with the guarantee Clause 4.27, the *Contractor* shall allow in the tender price for the extension of guarantees and additional charges thereof, in order to comply with guarantee clause.