OMAN WASTEWATER SERVICES COMPANY S.A.O.C

الشركة العمانية لخدمات الصرف الصحي ش.م.ع.م

SECTION 07

HEATING, VENTILATION & AIR CONDITIONING EQUIPMENT

(I). AIR HANDLING EQUIPMENT

1. GENERAL

1.1. Scope

This part specifies single zone, multizone, draw through and blow through type air handling

1.2. References

The following standards have been referred to in this part:
BS 746 Gas meter unions and adaptors
BS 2831 Methods of test for air filters used in air conditioning and general ventilation
BS 3120 Performance requirements of flame proof materials for clothing other purposes
BS 3928 Method for sodium flame test for air filters (other than air supply) to i.c engines and compression ASHRAE Standard 52-68

1.3. System Description

1. The units shall be installed to allow adequate access for the withdrawal of tubes, fan s

shafts, coils or other items for replacement or maintenance.

2. The internal surfaces of panel and frames shall be treated to prevent migration of particles into the airstream and to minimise the possibility of damage.

3. The overall dimension and weights shall be such that the units of sub-assemblies can be moved to their ultimate position on site through existing openings or, where possible, prearranged access ways.

4. All pipe inlets and outlets are to be sealed to prevent ingress of air moisture and foreign bodies.

5. Checks shall be carried out to ensure the frames are not distorted or twisted on arrival and, subsequently, after each every removal to another part of site. In addition checks shall be made of individual section of equipment.

6. All associated control systems and wiring shall be provided with adequate protection against ingress of dirt moisture.

7. Physical checks shall be made on all bases that have been provided for all equipment and on the installation of the equipment on the bases, to ensure correct level an alignment.
8. Where air handling units have to stand for long periods prior to use, the manufacturer shall be consulted as to any precautions to be taken.
9. Fresh air intakes shall be as remote as possible from concentrations of surface or roof dirt and positioned to avoid the intake of fumes and odors.

10. The fresh air inlet shall be positioned at least 1.2m above ground level.

11. The control system and wiring shall be provided with adequate protection against ingress of dust and moisture.

2. CONSTRUCTION OF AIR HANDLING UNITS

2.1. General

1. The unit casings shall be of double skinned sectional construction with all panels fitted on a welded penta post frame.

2. The panels should be braced to avoid vibration and drumming.

3. Panels shall be bolted to the sub-frame, except panels that are required for removal for securing. Service panels shall be hinged and latched.

4. All casing panel shall be insulated with at least 50mm thick for outdoor units and 37mm thick for indoor units 48 kg / m3 / K.

5. Panels shall be either pre-plastisized, paint finish or aluminum.

6. Frame shall be insulated such that condensation does occur due to the formation of cold bridges under adverse ambient conditions.

7. The interior of the air handling units shall be free from dangerous obstruction and projection to facilitate cleaning and thus maintain a supply of clean air.

8. Surfaces of the units table to be affected by any free water produced shall be protected by anti-corrosion paint.

9. The sealing of all panels and frames shall be made air tight by means of permanently plastic or rubber pressure sealant, and made weather proof for outdoor installation.

10. Air handing units for outside installation shall have sunshade cover and weatherproof canopy.

11. All air handling unit sections shall be produced with heavy duty lifting lugs.

12. The drain pan shall be constructed no less then 1.6mm steel sheet and galvanized after fabrication, stainless steel or heavy gage aluminium. It shall be rigidly supported by galvanized heavy duty frame.

13. The units shall include a mixing box section when required. The mixing box section shall include factory installed dampers.

14. Dampers shall be of rigid construction and should not rattle. Shut off dampers shall provide an effective seal to minimize air leakage.

15. The drain pan shall be adequately insulated to prevent sweating under adverse conditions.

3. FAN SECTION

3.1. General

1. The fans installed in all AHU shall comply with all relevant MEW regulations.

2. The type of fan installed in each AHU shall be as detailed in the Project Documentation.

3. Variable pitch pulleys shall be installed on all AHU drive motors on belt and pulley driven fans. The pulleys shall be sized to allow for ± 5% fan speed adjustment from the design fan speed.

4. Flexible connection shall be installed on the supply, return and fresh air duct to minimize vibration transmission to the adjacent ductwork.

5. The complete fan and motor shall be installed on a rigid frame. The frame will be supported by properly sized anti-vibration spring mounts to isolate the motor and fan from the units casing.

6. Where the fan volume or Static pressure is to be variable on of the following methods of control shall be incorporated as detailed in the project Documentation.

a) Multi speed motors

b) Variable speed frequency drive

c) Variable pitch

d) Variable inlet guide valves

7. The external pressure calculations shall be submitted by the contractor along with the AHU submission on order to select the suitable motor.

8. Fan and motor drive shall be oversized by at least 20%.

9. The fan shall be configured to minimize excessive pressure drop and air turbulence.

10. The fan and motor assemblies shall be mounted on suitable bases and anti vibration mounts.

11. The motors shall be connected with flexible electrical connections.

3.2. Centrifugal Fans.

1. Centrfugal fans larger than 7.5 kW output shall be of the backward curved blade type having fan total efficiency of not less than 78%.

2. Centrifugal fans below 7.5 kW may be either forward curved or backward curved type.

3. Fan casings shall be constructed of mild steel plates with angle stiffeners and base angles to ensure freedom from drumming and shall be suitable for operation at the maximum static pressure of the system.

4. Fan casings shall be constructed so that impellers can be easily hand driven after installation.

5. A drain plug shall be fitted to the fan casing at its lowest point.

6. Impellers shall be of mild steel or other approved material of riveted or welded construction, with spiders or hubs of robust design and shall be capable of running continuously at 10% in excess of normal speed.

7. Impellers shall be keyed to a substantial mild steel shaft.

8. Fans and shafts shall be operating well below their critical speeds. Each shaft assembly shall be statically and dynamically balanced before shipment from the manufacturer.

9. Fan bearings shall be ring oiled sleeve bearings, or ball or roller type. Where silence is important, the bearing pedestal shall not be attached to fan casing, and ring oiled sleeve bearings shall be applied.

10. Unless otherwise indicated centrifugal fans shall be driven by electric motors through v-belt drives.

11. The maximum fan outlet velocity shall be 10 m/s.

3.3. Axial Fans

1. Axial flow fans shall be either signal stage type of the multistage contra rotating type with each impeller mounted on an independent motor, and having an efficiency of not less than 60%.

2. Casings shall be rigidly constructed of mild steel stiffened and braced to obviate drumming and vibration. Cast iron or fabricated steel feet shall be produced where necessary for bolting to the based of supports.

3. inlet and outlet ducts shall terminate in flanged steel rings for easy removal.

4. The length of the duct casing shall be greater than the length of the fan(s) and motor(s) in order that the complete section may be removed without disturbing adjacent duct work.

5. Electrical connections to the motor (s) shall be through and external terminal box secured to the casing.

6. The impeller shall be of steel or aluminum and the blades shall either be secured to the hub or the blades and hub shall be formed in one piece.

7. The hub shall be keyed to a substantial mild steel shaft and the whole shall be statically and dynamically balanced before shipment from the manufacturer.

8. The Fan blades shell be of an aerofoil section.

9. Shafts shall be carried in two bearings which may be ball, roller or sleeve type. Lubricators shall be extended to the outsides of the casing.

10. Where axial flow fans are driven by a motor external to the fan casing, the pulleys and V-belts shall be provided with a guard and adequate sized access doors.

11. Where axial flow fans of the bifurcated type are indicated, the motors shall be out of the air stream. Motors may be placed between the two halves of the casing in the external air or may be placed within the fan casing provided that effective ventilation is given to the motor.

12. Where hot gasses or vapors are being handled, the motor and bearings shall be suitable for operation at the temperature they may experience.
13. Axial flow fans, which do not connect to suction duct, shall be supplied with a bellmouth inlet.

4. COIL SECTION

4.1 Coils General

1. The coil casing shall be of galvanized sheet steel not less than 1.2mm and drilled to meet the adjacent sections of the AHU

2. The coils shall be fabricated from heavy gauge solid drawn copper tubing expanded into the fins to give a mechanical bond.

3. The coil fins shall be aluminum or copper with the fin spacing not less than 2mm.

4. The coils shall have a minimum of 4 rows.

5. Return bands shall be die formed.

6. Headers shall be heavy section seamless copper tubing and all joints shall be silver brazed.

7. On systems where the static pressure exceeds 750 Pa, airtight cover boxes shall be provided over the header and bends. Provisions shall be made for draining the cover boxes.

8. The resistance to air flow shall not exceed 125 pa and the face velocity shall not exceed 2.5 m / s.

9. The coil shall be constructed to maintain even leaving temperature across the total face area of the coil.

10. Cooling coils shall be fitted with eliminator plates if the face velocity exceeds 2.2m / s.

11. Cooling coil casings shall be made to form a watertight drip tray complete with drain connection. The drain shall be fitted with a water seal to prevent the insgress and digress and discharge of air to and from the system. The drainpipe shall return to the nearest sump or gully.

12. Cooling and heating coils for large air handling units shall be fitted with slide reils to facilitate easy removal by personnel.

4.2. Chilled and Hot Water Coils.

1. Coils shall be arranged in a contra flow pattern, with the flow of wither entering at the leaving air side and the leaving at the entering air side.

2. The flow and return headers and connections shall be arranged to ensure an equal flow of water through all tubes.
3. All coils shall be tested at the manufactures factory to 1½ times the working pressure or to 7 bar whichever is the greater.

4. Coil connections up to and including 65mm bore shall be screwed or flanged. Connection 80mm bore and above shall be flanged.

5. Isolating valves shall be installed on the inlet and outlet connections. The valves shall be arranged so as to facilitate the removal of the coil without disturbing adjacent pipe work.

6. Provision shall be made for effective venting of the coil and connections and for draining of the coil header and tubes.

4.3. Refrigerant Direct Expansion Air Cooling Coils.

1. The coils shall be provided with refrigerant distributors and the connections to the tubes shall be designed to ensure an equal flow of the refrigerant to each tube.

2. The suction connections shall be arranged to ensure complete drainage of any oil in the coil.

3. The coils shall be dehydrated and sealed after manufacture.

4. The coils shall be tested to 1.5 times their maximum working pressure.

5. The thermostatic expansion valve which shall incorporate an external equalizer line shall maintain the design degree of super heat at the evaporator outlet. The remote sensing bulb shall be securely fixed to the evaporator outlet piping in a position where the degree of superheat can be correctly sensed.

6. The design evaporating temperature shall not be less than -1 ºC.

7. The coil shall be sized to be compatible with the associated refrigeration equipment.

5. ELECTRICAL DUCT HEATERS

5.1. General

1. The casing shall be of galvanized sheet steel no less than 1.2 mm thick with angle framing drilled and ready to receive the counter flange on the duct work. Alternatively, the construction shall be compatible to fit within the air-handling unit where appropriate.

2. The electric heaters shall consist of a number of helically of helically coiled nickel chromium alloy heating elements of the enclosed non-corrodible type mounted in the sheet steel casing.

3. The elements shall be installed so that, they can be removed from cleaning or removal with minimum disturbance to other plant items.

4. The surface temperature of the elements shall not exceed 150 ºC.

5. The control of electric air heaters shall be inter locked with the fan motor starter and air flow switch so that the heater cannot operate unless the fan is running and air flow is detected.

6. The heater shall be installed with a high temperature limit device with hadn re-set button.

7. The control of the heater shall be by a thyristor type fully variable controller.

8. All heaters and heater sections greater than 3 kW loading shall be balanced over three phases and the complete heater bank shall be arranged for balanced operation on a 3-phases 4 –wire system.

9. The connections from each element shall be taken to readily accessible terminal box arrange for conduit entry.

10. Each heater section shall be separately fused and the neutral point of a all 3-phase star-connected section shall be brought out to a link in the terminal box.

11. The insulation of the wiring near any hot areas shall be of the appropriate quality.

12. The total resistance of the heater to air flow shall not exceed 25 Pa and the velocity through the free area shall not exceed 6m/s.

6. FILTERS

6.1. General

1. Filters shall operate to at least the efficiencies specified in this section and not les than 73% average synthetic dust weight or resistance in accordance with ASHRAE Standard 52-68.

2. Filters shall be complete with holding frames sufficiently robust to ensure that no distortion occurs in operation.

3. Filters shall be installed with edge seals which shall prevent air by passing the filters. The seal shall remain effective even thought the calls are periodically removed and refitted.

4. Filters shall be arranged so that there is easy access for cleaning and /or removal.

5. A differential pressure gauge of the dial type or incline manometer type shall be provided from each filter bank and shall be fixed in such a position outside the AHU system that it is accessible and easily read. The gauge shall be marked to show maximum differential indicating a filter change requirement.

6. Filters shall also have a differential pressure switch installed when the system is to be monitored by a BMS system. The differential switch shall be calibrated to operate indicating a fitter change requirements.

7. The air velocity through filters shall be such that the clean resistance as indicated is not exceeded and that the filter fabric or oil is not carried over into the system.

8. where a flame proof filter medium is specified the material shall comply with the following requirements when tested in accordance with the relevant standard.

a) Duration of flaming. No test sample shall continue to flame for more than 8 seconds after the igniting flame has been removed.

b) Extent of after-glow. After glow shall not spread beyond the area of material damaged by fire.

c) Length of material which chars or melts. The average length of material which chars or melts on the specimen shall not exceed 85 mm and the maximum length of the charred or melted material in any one specimen shall not exceed 115 mm.

9. Where washable type flame proof filters are offered or specified the filter medium shall comply with the requirements of Clause (b) above both before and after the washing treatment prescribed in BS 3120 Appendix A.

10. Where the filter medium is required to be flame proof the casing shall not be less than 1.6 mm thick for at least 1.8 m upstream and 1.8m down stream of the filter. The immediate frames of cases of the filter elements shall be of material complying with BS 746. Part 1. Clause 7 Class 1.

6.2. Dry Replacement Media Type Filter

1. The filter shall be of the flat panel type continued in galvanized steel front or side removal frame.

2. Each cell shall comprise a pad of glass fiber or synthetic fabric filter media, 50 mm thick and retained within a rigid frame of durable cardboard.

3. The filters shall have an efficiency of not less than 92% based on test specified in BS 2831 with test dust No. 2.

4. The maximum face velocity shall be 2.5 m/s.

5. The initial pressure drop shall not exceed 70 Pa.
6. Sufficient spare cells shall be provided to replace the enteire filter bank.

6.3 Regenerative Filters.

1. The filter medium shall be processed washable open cell foamed plastic or plastic bonded synthetic fiber.

2. The medium shall have a minimum thickness of 15 mm.

3. The element shall be supported on plastic coasted steel wire formers with a metal frame.

4. The face velocity shall not exceed 2.25 m / s.

5. The initial pressure drop shall not exceed 100 Pa.

6. Fitters of this type shall have an efficiency of not less than 90% based on the test specified in BS 2831 with test dust No.2.

6.4 Bag Filters

1. The filter shall comprise of one or more 600 x 600 mm filter bag modules fitted into a purpose made galvanized steel side or front withdrawal frame.

2. Each module shall comprise a minimum of four separate bags bonded or clipped into a galvanized steel header.

3. The bags shall have a minimum length of 600mm.

4. The medium shall be of a fine multi-layer type with high mechanical strength.

5. The maximum initial resistance shall not exceed 100 Pa.

6. Fitters of this type shall have an efficiently of not less than 99.6% based on the tests specified in BS 2831 with test dust No.2.

6.5 Automatic Fiber Roll Type Filters

1. The filter shall comprise of the complete assembly of filter frame, motor and drive and filter medium.

2. The filter shall operate automatically, with provision for manual starting and stopping of filter movements.

3. Unless otherwise indicated automatic filter movement shall be controlled by the resistance across the filter.

4. Provision shall be made for visual warning that the end of the clean filter medium is approaching.

5. The driving motor shall be automatically switched off when the end of the filter medium is reached.

6. The air velocity through the fitter medium shall not exceed 2.5 m/s.

7. Filters of this type shall have an efficiency of 95% based on the tests specified in BS 2831 with test dust No.2.

8. Where the motor and/or gearbox is mounted in the air stream the electrical insulation and/or lubricants shall be suitable for the temperature range experienced.

6.6. Grease Eliminators

1. The Grease eliminators shall be of the impingement type comprising of fluropolymer coated adjustable vertical baffles contained within a stainless steel casing.

2. The bottom of the casing shall comprise a grease collection trough from which a drain shall be provided into a removable stainless steel grease collector.

3. The baffles shall be supplied in modules with a maximum size of 500x500mm.

4. The baffles shall be installed in a frame and shall be readily removable for cleaning.

5. Grease eliminators shall be installed where specified in the project Documentation.

6.7. High Efficiency Filters

1. High efficiency filters shall consist of asbestos cellulose of glass fiber pleated Paper media in rigidly constructed case with a completely Positive Seal.

2. The efficiency of the filters shall be equal to or better than that indicated and in any case shall not be more than 0.5% penetration based on the test specified in BS 2831 with methylene blue or the sodium flame test specified in BS 3928.

3. Where fire protection is required or the air temperature may exceed 200 ºC the filtering medium shall be glass fiber paper and the casing spacers and seals shall be of a fire resistant material.

4. The air velocity at the face of the filter shall not exceed 1.25 m/s.

5. Fitters changing arrangements must be such that dust is not released into the room during the changeover operation.

6.8. Activated Carbon type Filters

1. The cell casing shall be manufactured of steel protected against corrosion.

2. The Internal arrangement shall include a corrosion proof framework of supports to ensure an equal disposition of individual panels across the all.

3. There shall be seals installed between each panel.

4. Mechanical Protection shall be provided on both the front and rear of the panels.

5. The carbon shall be of uniform thickness in the panels and shall be of sufficient density to ensure that no settling down or gaps occur in use.

6. The quantity of carbon shall be 20 kg for each rated 0.5 m^3/s.

7. The resistance to air flow shall not exceed 125 Pa.

7. HUMIDIFIER

7.1 General

Humidifiers shall be in accordance with ARI610/ASHERAE equipment.

7.2 Water Type Humidifiers

1. The water type humidifiers shall be pan or atomizer type as specified in the Project Documentation.

2. The humidifier shall consist of the following:

a) Water pan or reservoir with a water feeder valve controlled with a float box.

b) The water pan, float box tubes evaporator and all materials exposed to water shall be constructed of a non-ferrous corrosion resistant material.

c) The units shall include overflow and drain connections.

d) The water immersion heaters shall be copper sheathed.

e) The atomizer shall be of motor driven centrifugal type with directional dome and supporting brackets.

7.3 Steam Type Humidifiers.

1. The Steam type humidifier shall be of a factory assembled packaged type.

2. The humidifier shall consist of the following:

a) Packaged steam generator.

b) Steam moisture separator.

c) Water feeder.

d) Pressure gauges.

e) Thermometers.

f) Controls.

g) All materials exposed to water shall be non-ferrous.

h) The heating element shall be copper sheathed.

i) The steam distribution pipe shall be stainless steel.

8. HEAT RECOVERY UNITS.

8.1 General

1. Where specified in the Project Documentation heat recovery units shall be installed.

2. The heat recovery section shall be constructed to permit easy access.

3. The unit shall be equipped with a drain pan for moisture removal.

8.2 Static Rate Heat Exchanger

1. The static rate heat exchanger shall be of the cross flow type consisting of alternative passages.

2. The two air steams passing through the exchanger shall exchange sensible heat to achieve pre-heating or pre-cooling.

3. The heat exchanger material shall be as specified in the Project Documentation.

(II) CENTRAL REFRIGERTION & AIR CONDITINING EQUIPMENT

1. General

1.1 Scope

The part specifies the requirements of the design manufacture, construction installation testing and commissioning of central refrigeration and air conditioning equipment.

1.2 References

The following standards and organizations are referred to in this part:

ARI	Standard	210
ARI	Standard	450
ARI	Standard	480
ARI	Standard	550
ASHRAE		

1.3 Products

1. Materials and equipment furnished under these specifications shall be standard catalogue products of manufactures regularly engaged in production of such materials or equipment and shall be the manufacturer ŝ latest standard design

complying with the specification requirements and meets and capacity indicated in the project documentation. Where tow or more units of the same class of equipment are required, these units shall be produces of a single manufacturer. However, the component parts of the system need not be the products of the same manufacturer.

2. Each major component of equipment shall have the manufacturer ŝ name address, and catalogue number on a nameplate securely affixed in a conspicuous place the nameplate of a distributing agent only will not be acceptable.

2 PACKAGE CHILLERS

2.1 Air Cooled Package Chillers

1. The air-cooled packaged chillers shall be factory assembled complete with piping and wiring and shipped with refrigerant charge and oil change.

2. The only required field connections shall be the system water piping, electrical power supply and external control cables when required.

3. The units shall be provided with lifting lugs for easy site handling.

4. All components shall be mounted on a continuous structural steel base resting on vibration isolators. The isolators shall be proportional for the load at all points under the unit.

5. The chiller control and starters shall be housed in a weather proof and dust proof enclosure with lockable door. The minimum rating for the enclosure shall be IP55.

6. The system shall be designed and supplied with the refrigerant as specified in the Project documentation.

7. The power supply cables and protective devices shall be rated as recommended by the manufacturer.

8. The chiller shall be selected to meet the capacities as detailed in the Project Documentation.

9. The compressor type shall be as specified in the Project Documentation.

10. The manufacturer ŝ details should be followed wherever possible.

11. Adequate space shall be provided for operating and maintenance purpose.

2.2 Water Cooled Package Chillers.

1. The water-cooled packaged chillers shall be factory assembled complete with piping and wiring and shipped with refrigerant charge and oil change.

2. The associated condenser capacity shall be matched with the capacity of the chillers.

3. The only required field connections shall be system water piping, electrical power supply and external control cables when required.

4. The units shall be provided with lifting lugs for easy handling.

5. All components shall be mounted on a continuous structural steel base resting on vibration isolators. The isolators shall be proportional for the loads at all points under the unit.

6. The chiller control and starters shall be housed in a weatherproof and dust proof enclosure with lockable door. The minimum rating for the enclosure shall be IP55.

7. The system shall be designed and supplied with the refrigerant as specified in the Project Documentation.

8. The power supply cables and protective devices shall be rated as recommended by the manufacturer.

9. The chiller shall be selected to meet the capacities as detailed in the Project Documentation.

10. The compressor type shall be as specified in the Project Documentation.

11. The manufacturer ŝ details should be followed wherever possible.

12. Adequate space shall be provided for operating and maintenance purpose.

3. AIR HANDLING UNITS

3.1 Air Cooled Packaged Air Handling Units.

1. The air-cooled packaged air handling Units shall be factory assembled complete with piping and wiring and shipped with refrigerant charge and oil change.

2. The only required field connections shall be the system ductwork, electrical power supply and external control cables when required.

3. The units shall be provided with lifting lugs for easy site handling.

4. All components shall be mounted on a continuous structural steel base resting on vibration isolators. The isolators shall be proportional for the loads at all points under the unit.

5. The packaged Air Handling Units controls and starters shall be housed in a weatherproof and dust proof enclosure with lockable door. The minimum rating for the enclosure shall be IP55.

6. The system shall be designed and supplied with the refrigerant as specified in the Project Documentation.

7. The power supply cables and protective devices shall be rated as recommended by the manufacturer.

8. The Packaged Air Handling Units shall be selected to meet the capacities as detailed in the Project Documentation.

9. The compressor type shall be as specified in the Project Documentation.

10. The manufacturer's details should be followed wherever possible.

11. Adequate space shall be provided for operating and maintenance purpose.

3.2 Water Cooled Packaged Air Handling Units.

1. The water-cooled Packaged Air Handling Unit shall be factory assembled complete with piping and wiring and shipped with refrigerant charge.

2. The associated condenser capacity shall be matched with the packaged Air Handling Units requirements.

3. The only required field connections shall be the condenser system water piping ductwork electrical power supply and external control cables when required.

4. The units shall be provided with lifting lugs fro easy site handling.

5. All components shall be mounted on a continuous structural steel base resting on vibration isolators. The isolator shall be proportional for the loads at all points under the unit.

6. The Packaged Air Handling Units controls and starters shall be housed in a weatherproof and dust proof enclosure with lockable door. The minimum rating for the enclosure shall be IP55.

7. The system shall be designed and supplied with the refrigerant as specified in the Project Documentation.

8. The power supply cables and protective devices shall be rated as recommended by the manufacturer.

9. The Packaged Air handling Units shall be selected to meet the capacities as detailed in the Project Documentation.

10. The compressor type shall be as specified in the Project Documentation.

11. The manufacturer s details should be followed wherever possible.

12. Adequate space shall be provided for operating and maintenance purpose.

4. COMPRESSORS

4.1. General

Compressors shall be tested and rated in accordance with ISO Standard 917 of equivalent and guaranteed to operate at published capacities.

4.2 Centrifugal Compressors

Shall be serviceable, hermetically sealed requiring no shaft seals, or required stages and consisting of the following:

1. Impeller.

a) Shall be made of non-ferrous, cast aluminum alloy or approved alloy or approved equivalent material.

b) Shall be dynamically and statically balanced after fabrication and tested minimum 25% overspeed.

c) Shall be sufficiently rigid to prevent any vibration at operating speed.

d) The impeller operating speed shall be below first critical speed.

e) Two-stage impellers shall be connected to the motor by a gear train.

2. Casing.

a) All external parts shall be constructed of steel, high-strength ductile iron casting or approved equivalent material.

b) O-ring gaskets shall be used between casings

3. Lubrication System

a) Shall be of the forced-feed type and shall provide oil at the proper temperature to all parts requiring lubrication.

b) On units providing forced-feed lubrication prior to starting, a differential oil pressure cut-out interlocked with the compressor starting equipment shall allow the compressor to operate only when the required oil pressure is provided to the bearings.

c) The lubrication system shall be complete with the following:

(i) Pressure relief valves
(ii) Oil piping
(iii) Gauges
(v) Thermometers
(vi) Oil pressure switches
(vii) Oil cooler designed for use with chilled water, condenser water or directly cooled by refrigerant
(viii) Oil filter
(ix) Oil reservoir
(x) Oil heater, of a size to prevent oil from absorbing refrigerant during shut-down, thermostatically controlled. It shall not be required if the system is designed to prevent the refrigerant from contact with the oil and guaranteed not to absorb oil during prolonged shutdowns.

4. Capacity Control.

a) The compressor shall be provided with temperature or pressure-actuated capacity reduction to the pre-rotation vane or suction damper type to provide automatic capacity modulation from 100 to 10 percent capacity.

b) Hot gas by-pass automatically controlled shall be provided if required to maintain stable operation.

5. Gear Transmission

a) The gear transmission shall be of the self-aligning type, having sufficient capacity transmit the maximum compressor load under all operating conditions without objectionable noise or vibration.

b) The gears shall be double helical type, and the teeth shall be continuously flooded with filtered oil

c) The bearings shall be of the pressure lubricated type, and suitable for both gears and pinions.

6. Motors

a) The motors shall be of the hermetically sealed, refrigerant-cooled type, the winding specifically insulated for us with refrigerant.

b) The motors shall be designed for continuous operation at nameplate rating, provided with a load limit mechanism and solid-state sensors in motor winding to provide positive thermal and current overload protection.

c) The motor start shall be contained in weatherproof enclosure, completely pre-wired to the motor.

7. Lifting device

An eyebolt or approved equal device to permit lifting compressor shall be included.

4.3 Reciprocating Compressors

1. Description

a) Reciprocating compressors may be of the open or semi-hermitic serviceable type, or of the welded hermetic type, with the motor and compressor contained within the same pressure vessel and the motor shall be in contact with the refrigerant.

b) Reciprocating compressors shall be capable of operating at partial load conditions a continuous operating down to the lowest step of unloading.

c) Reciprocating compressors shall be designed for use with a fluorocarbon refrigerant.

2. Drivers and Starters

a) Open type compressor

Open type compressor may be driven by an external motor, directly through a coupling or indirect through a belt-drive or gearbox. Starting of open type compressors shall be across the line or in accordance with the manufacturer ŝ recommendations.

b) Hermetic type compressors

(i) Hermetic type compressors shall be direct driven by either a standard motor and across the line starter or a reduced voltage starter.

(ii) The motor insulation and rubber materials shall be compatible with refrigerant and oil mixtures.

3. Lubrication System

a) Reciprocating compressors shall be provided with a forced feed lubrication system by means of eccentric gear-pump, vane pump or piston pump. The lubrication pumps shall be equipped with bleed provisions on the discharge side to bent the pump and to prevent excessive pressures, and with a strainer or oil filter in the suction line.

b) Small reciprocating compressors may be lubricated by a splash. The crankcase shall be filled with oil up to the bottom of the main bearings or the middle of the crankshaft main bearings. At each revolution the crankshaft or the eccentric shall splash the oil around the inside of the compressor.

4. Features: Reciprocating compressors shall be provided with the following features:-

(a) Capacity control for unloaded start and noted capacity steps.

(b) Suction strainer.

(c) Crankcase heater.

(d) Hot gas muffler.

(e) Replaceable bearings.

(f) Suction and discharge stop valves.

(g) Oil level sight-glass.

(h) Suction and discharge refrigerant gas pressure gauges.

(i) High and low gas pressure adjustable safety control.

(j) Vibration isolators.

(k) Oil safety switch.

4.4 Rotary Compressors

1. Description.

a) Rotary compressors shall be designed and rated in accordance with ASHRAE recommendations or equivalent.

b) Rotary compressors used for household refrigerators using R-12 refrigerant or for window type air conditioners using R-22 refrigerants shall be of the rolling piston or rotating vane type.

c) Rotary compressors shall be designed to have a high volumetric efficiency and an acceptable sound level, particularly where they are intended for use in homes.

d) Rotary compressors shall have a rigidly constructed shaft to meet deflection allowances and cast iron bearing with a hardened, steel journal rotary compressors shall have tow blades, designed for maximum reliability, and constrcted to limit the deflection under lod to no more than 0.05 mm per/m of blade length. The slots shall be hardened, steel journal.

e) The journal shall be ground round and honed or polished.

f) Rotary compressor shall be equipped with a check valve at the suction inlet to close automatically when the compressor stops to prevent high pressure gas from migrating into the evaporator.

2. Lubrication System

a) Rotary compressors shall be provided with a good lubricating system to circulate an ample supply of clean oil to all working surfaces, bearings, blades, slots, and seal faces.

b) Oil grooves shall have outlets to permit free flow of the excess lubricant, and to flush particles into the sump.

3. Drivers and Starters

Rotary compressors shall be equipped with a standard split-phase motor or a permanent split-capacitor motor in accordance with the manufacturer s recommendations.

5. CONDENERS.

5.1 Air Cooled Condenser

1. Air-cooled condenser shall be rated to ARI Standard 210 or equivalent and guaranteed to operate at published capacities.

2. Air-cooled condenser shall be suitable for remote installation in a weather-protected casing, or for us with self-contained air conditioners.

3. The air-cooled condenser shall be a complete factory-fabricated and factory assembled unit consisting of the following:

a) Coils

(i) The tubes shall be seamless copper

(ii) The fins shall be Aluminum

(iii) Condenser coils for installation in salt air or corrosive atmosphere shall be constructed of copper tubes and fins with galvanized steel end sheets.

b) Fans:

(i) Propeller type or centrifugal type directly connected to the motor shaft or indirectly connected to the motor by means of a V-belt drive.

(ii) Belt drives shall be completely enclosed within the unit casing or equipped with a guard.

(iii) Fans shall be statically and dynamically balanced.

c) Housing:

(i) The frame and supports shall be constructed of galvanized angle iron.

(ii) The casing shall be constructed of hot dip galvanized steel.

(iii) Vibration isolators

d) Motors:

(i) Totally enclosed, fan-cooled for all installations where motor is exposed to the weather or in an air stream.

(ii) Open drip-proof type within an enclosure to be fully protected from the weather.

(iii) Motor starter shall be a magnetic across the line type within a watertight enclosure.

(iv) Thermal protection shall be of the manual or automatic reset type

2. Condenser Controls. One of the following methods of controlling condensing temperature shall be provided:

a) Air volume control :

(i) Thermostat or pressure switch type with a control relay shall be provided to modulate fan discharge dampers and maintain adjustable pre-set refrigerant condensing temperatures.

(ii) A solid-state variable speed motor controller may be provided in lieu of volume dampers to control the airflow over the coil.

(iii) A condenser with multiple fans may be provided with a fan cycling control to cycle on of two, or two of three fans act in response to outdoor ambient temperatures.

b) Condenser flooding. On a decrease in refrigerant discharge pressure, a head pressure sensitive valve shall start to throttle the liquid flow from the condenser outlet and thereby increase the amount of liquid in the condenser. The liquid leaving the condenser shall be reheated by hot gas to increase the temperature of the sub-cooled liquid sufficiently to maintain a balanced pressure temperature relationship relationship in the receiver.

3. Liquid Receiver.

A liquid receiver of a minimum capacity of 125% of the refrigerant charge shall be supplied and connected to the refrigerant circuit, complete with :

(a) Inlet and outlet service valves

(b) Charging connections

(c) Relief valve

An air-cooled condenser may be used for refrigerant storage in lieu of separate receiver, provided that the condenser storage capacity is 20 percent in excess of the fully charged system.

5.2 Water Cooled Condenser

1. Water cooled condenser shall be rated in accordance with ARI standard 450 or equivalent and guaranteed to operation at published capacities. Fouling factor shall be a minimum of 0.000088 in accordance with ARI Standard 550.

2. Shells and Tubes:

(a) The welded steel shells and copper tubes shall be rolled into grooved holes in tube Sheets.

(b) The tube shall be removable without affecting tube sheet or causing leakage of adjacent tubes.

(c) The tube sheets shall be made of carbon steel suitable for withstanding working pressure.

(d) Intermediate tube sheet supports shall be installed prevent tube vibration.

3. Water Boxes:

(a) The water boxes shall be made of high-grade carbon steel or material of equivalent strength and suitable for the specified pressure.

(b) Water boxes shall have the following:

(i) Separable cover with eyebolt

(ii) Vent and drain connections

(iii) Connected to shell in a manner to prevent shell exposure to water

(iv) Flanged water nozzles for main piping connections.

(v) Tappings for thermometers, control bulbs and gauges.

(vi) Piping connections shall be arranged to permit cleaning without removing the piping.

4. Baffles

(i) To prevent direct impingement of refrigerant gases upon tubes.

(ii) To uniformly distributes gas refrigerant over length of condenser.

(iii) Non- corrodible baffles sheet to segregate and collect non-condensable gases for compression purging. Purge connections non-corrodible materials.
(iv) Purge and recovery unit connection to remove non-condensable gases and water vapor.

5. Condenser controls capacity control by means of restricting water flow through condenser using one of the following to methods.

(a) Tow-way throttling valve to maintain condensing pressure in once-through applications utilizing city or well water.

(b) Three-way valve to direct water around the condenser as the condensing temperature is lowered. This system is most often used with a cooling tower.

1. Evaporative Condensers.
Draw through or blow-through type sized and installed in accordance with ASHRAE recommendations consisting of the following:

(i) Galvanized steel casing and basin with overflow and drain connection.

(ii) Frame made of angle iron.

(iii) Removable galvanized steel eliminators.

(iv) Access panels of adequate size for maintenance

(v) Make-up water float valve

(vi) Fan with adjustable pitch belt drive with belt guard and weather protection cover for motor. Fan shaft shall be epoxy coasted; zinc achromatized or approved equal finish.

(vii) Condensing coil with a liquid sub-cooler made of hot-dip galvanized steel, copper tubing or iron pipe.

(viii) Recirculation pump factory installed and piped to bronze non-clog spray nozzles.

(ix) Galvanized steel piping.

(x) Flanged collars for duct connections for indoor installations.

(xi) Water bleed system

(xii) Capacity control, can be obtained as a modulating as a modulating discharge damper to vary air flow across the coil or a multi-speed fan motor to very airflow across the coil.

5.4 dual condensing:

1. dual condensing systems shall consist of a heat rejection and an auxiliary heat recovery condenser to extract heat from refrigerant and reject some of that heat to a warm circuit.

2. heat rejection condenser. The heat rejection condenser shall be of the water cooled condenser type.

6. COOLER

6.1 General

1. Cooler shall be designed and rated in accordance with ARI Standard 480.

2. Shell and tube type and performance is based on a fouling factor to 0.000088 for non-ferrous tubes, and 0.000176 for steel tubes, consisting of the following:-

(a) Shells and Tubes.

(b) Water Boxes

Water boxes made on high-grade carbon steel or material or equivalent strength suitable for specified pressure, provided at each end for an for an odd number of passes and one end for an even.

(c) Baffles

(i) Non-ferrous

(ii) To prevent liquid refrigerant from entering compressor.

(d) Anti-freeze thermostat.

(e) Insulation with a vapor barrier

7. COOLING TOWERS

7.1 General

1. Cooling towers shall be designed, constructed and rated in accordance with ASHRAE Recommendation 21 – Equipment.
2. Field-assembled Cooling Towers. Filed assembled cooling towers shall consist of the following:

(a) Framework.

(i) Steel framework bolted, reinforced and interconnected so that stresses are transmitted directly to the tower foundation.
(ii) Bolts, nuts, washers and corners shall be made of hot-dipped galvanized steel.
(iii) Roof framing designed for additional load of fan, fan motors, gear-reducer if required, fan-casing, and other loads during erection or normal operation.

(b) Casing.

Casing shall be water and-air tight made of stainless steel, galvanized steel with a zinc coating or hot-dip galvanized after fabrication, as specified in the Project Documentation. Casing fastening to frames shall be by means of stainless steel hardware.

(c) Partitions

(i) Full height of tower.

(ii) Water and airtight.

(d) Water Distribution.

(i) Distribution system for each cell.

(ii) Header system with branches, spray arm and nozzles.

(iii) Nozzles made of non-clogging cast bronze or polyethylene type.

(e) Collection Basin.

(i) Made of hot-dipped galvanized steel or stainless steel one-piece, factory welded design.

(ii) Overflow and cleanout

(iii) Drain connector.

(f) Access.

To fan deck, gear and fan, water distribution area and basin.

(g) Fans.

(i) Propeller or centrifugal type with adjustable pulley.

(ii) Gear speed reducer, if required, with a stainless steel shaft, flexible coupling and extension pipe to permit filling, draining and sampling of the oil level out-side fan housing with an oil sight-glass.

(iii) Totally enclosed fan cooled type motor.

(iv) Removable wire screen, hot-dipped galvanized steel.

(h) Vibration Eliminators.

Vibration eliminators with an isolation efficiency of a minimum of 70 percent.

(i) Eliminators.

Removable made of asbestos, neoprene, honeycomb or approved equal materials, and supported by galvanized steel channel sections.

(j) Fill Material.

Made of polyvinyl chloride film-type or approved equal materials supported at close centers by galvanized steel structural members.

(k) Bleed-off and make-up water. The cooling tower shall be provided with a controlled bleed- off feature to minimize scale formation and to inhibit corrosion and with a makeup water connection controlled by a large-diameter seamless type copper float to maintain automatically the water level in the sump at a predetermined level.

8 PACKAGE COOLING TOWERS.

8.1 General

1. Package cooling towers shall be factory-assembled of the counter flow through design, with centrifugal or propeller fan assemblies built completely into the pan, with all moving parts factory-mounted and aligned. The packaged cooling tower shall consist of the following:

(a) Pan Section.

(i) The pan section shall consist of a steel framework and a sloped stainless steel or hot-dipped galvanized steel basin.

(ii) The pan section shall be provided with access door, stainless steel strainer with perforated openings smaller than spray nozzle orifices, waste water bleed-off line with valve, and make-up valve with a large diameter float arranged for easy adjustment.

(b) Fan assembly.

(i) The fan shall be of the propeller or centrifugal type. The housing of the fan shall have compound curve inlet rings for efficient air entry ad a discharge cover within the pan to prevent water from entering the fan.

(ii) The fan shaft shall be mounted in heavy-duty, grease-packed, self-aligning ball bearings.

(iii) V-belt drives shall be designed for not less than 150 be completely enclosed by removable screens made of stainless steel or hot-dipped galvanized steel.

(c) Surface section.

The heat transfer section shall be removable from the pan made of stainless steel or other approved material supported in galvanized steel frame, and wave formed or honeycomb in shape for optimum heat transfer.

(d) Water Distribution.

(i) Water distribution shall be evenly spread over the tower's fill area through gravity or spray hand tree, consisting of stainless steel header and removable branches with replaceable spray nozzles made of plastic or approved equal materials. The nozzles shall be held in place with snap-in rubber grommets to provide quick removal of individual nozzles or branches for cleaning or flushing.

(e) Eliminators.

Eliminators shall be removable in easily handled sections made of stainless steel or other approved material.

(f) Fan Motors.

Fan motors shall be of the encapsulated epoxy-insulated drip-proof type.

9 REFRIGERATION ACCESSORIES

1. Combination filter with a dryer in the refrigerant line, so arranged that cartridges can be replaced when the refrigerant circuit is changed.

2. Combination sight-glass and moisture indicator.

3. Solenoid valve in the refrigerant line and in the oil bleeder lines from flooded evaporators.

4. Expansion valve on refrigerant line at coil inlet with the bulb located immediately after the coil outlet.

5. Strainer in suction line on steel piping systems to protect pressure-regulating devices.

6. Strainer in refrigerant line to protect expansion valve.

7. Refrigerant charging connection in the liquid line.

8. Liquid suction interchanges in the liquid line.

9. Muffler in the hot-gas line in the downward flow risers or in the horizontal lines near the compressor.

10. Oil trap (separator) in the discharge line.

10. MISCELLANEOUS

10.1. Water Chemical Treatment

1. After preliminary design, the Contractor shall submit to the Supervising Agency a complete analysis of local water or actual water samples at the site. This information shall be accompanied by a description of each system to be treated with anticipated make-up rates and other available data.

2. Make-up rates of chemicals and water quality requirements for each system shall e in accordance with the ASHRAE recommendations and the chemical analysis.

3. Water treatment firm

The Contractor shall engage a water treatment firm which shall:

(i) Supervise installation and application of water treatment.

(ii) Supply required treatment chemicals and instructions for application and control of initial cleaning of all piping systems.

(iii) Supply testing equipment and reagent.

(iv) Instruct the Contractor on installation of chemical feeding equipment before start-up

(v) Demonstrate the proper application of treatment materials to be used operation of feeding equipment as installed and operation of testing equipment required.

(vi) Collection samples of each treated system for analysis at laboratory and submit result, with comments.

(vii) Provide proposals detailing services to be performed for an extended service period of one year from date of start-up.

4. Condenser Water System.

(a) Chemicals. Selection of treatment chemicals for the cooling tower system shall be based upon characteristics and solids content of make-up water as follows:

(i) Chemical formulation to control corrosion and scale as directed by raw water analysis or sea water analysis where applicable and equipment operation conditions, is to be introduced to system through automatic treatment equipment.

(ii) This formulation shall be a non-metallic blend of corrosion and scale inhibitors capable of producing desired treatment results without supplementary acid feed.

(iii) Biological fouling liquid formulation as dictated by water analysis and local environmental conditions to be slug-fed to system.
(iv) Cycles of concentration are to be maintained at a level consistent with raw water analysis and operating conditions.

(v) Biocides shall be added if significant amount of algae or slime are detected. After system operation. Compounds of mercury, copper or arsenic are not permitted.

(b) Equipment

(i) Diaphragm chemical proportioning pump shall be furnished to pump algae inhibitors. The pump shall include suction strainer, check valve and associated piping including corporation stop injection assembly.

(ii) Water meter shall be located in the cooling tower make-up line and shall be sized for combined peak flow of evaporation and bleed-off.

(iii) Automatic re-set timer unit and counter-unit shall be assembled as a package to modulate feed and bleed in proportion to tower make-up water.

(iv) A solenoid bleed valve and Y-strainer shall be furnished.

(c) Chilled Water System.

(i) Chemicals. Treatment shall consist of a buffered nitride-based product, maintained in circulation water systems at 700 – 1000 PPM sodium nitride.

(ii) Equipment. By-pass chemical pot feeders, consisting of cast iron and steel body, easy to fill.

10.2 Water Softeners.

1. Water softeners shall be fully automatic down flow, pressures-type water softeners having capacities as indicated in the Project Documentation.

2. Piping.

Piping shall be copper tubing with brass or wrought copper solder joint fittings, or as required in the project Documentation.

3. Tank

(i) Softener tank shall be made of riveted or welded stainless steel construction in accordance with the relevant ISO standards and/or ASME Code.

(ii) The shell shall be designed and tested at 50 percent greater pressure than the working pressure.

(iii) The tank and both sides of false bottoms shall be lined with plastic, rubber or equivalent corrosion- resistant material.

(iv) Upper head and lower side of each tank shall be provided with access openings.

4. Collector System.

(i) A suitable device shall be provided within the softener tank for collecting softened water and distributing wash water. The device shall be deflector-plate type, or false- bottom type, or other approved equal type

(ii) The under drain system shall distribute the backwash water in a manner that will not cause channeling of the gravel and exchange material.

5. Deflector-plate Type.

(i) The deflector-plate type collector shall be made of cast iron, or corrosion-resistant steel, securely fastened to the bottom of the tank and arranged for discharge around the circumstance of the plate or through radial slots in the plate. The deflector-plate type require a gravel bad.

(ii) Pipe connection for softened-water outlet or backwash inlet shall be on the underside between deflector and tank bottom.

6. False-bottom Type.

(i) The fales-bottom type collector shall consist of a false bottom with strainers attached thereto and therefore dose not require a gravel bed.

(ii) Strainers and fasteners shall be made of corrosion-resistant metal.

7. Gravel Bad.

(i) The gravel supporting bad shall be placed immediately above the under drain system of all types except the false-bottom type collector.

(ii) The gravel shall be washed and free from any foreign materials

(iii) The gravel bad shall be properly graded to prevent loss of exchange material during normal operation and back-washing.

8. Exchange Material.

(i) Exchange material shall be quartz sand, washed, processed and not less than 0.35mm in size and with uniformity coefficient not higher than 1.2.

(ii) Exchange material shall not require dosing or adding of any chemical mixture or solution to the water to be treated or to the water used for back-washing or regeneration other than common salt, NaCI.

9. Brine-storage Tank.

One brine-storage tank shall be provided for each water-softening unit, made of steel, reinforced and lined with enamel or other approved brine-resistant material, provided with automatic, float-controlled water control valve, located in an independent float chamber, inside the tank.

(III) DUCTWORK AND AIR-SIDE EQUIPMENT

1. General

1.2 Scope

This part details the requirements for the construction and installation of the ductwork and air side equipment.

1.3 References.

The following standards are referred to in this part:
BS476 Fire tests on building materials and structures.
BS1449 Steel Plate, Sheet and strip.
BS 1470 Wrought aluminum and aluminum alloys for general engineering purposes.
BS 1474 Wrought aluminum and aluminum alloys for general engineering purposes. Bars extruded round tubes and sections.
BS CP 352 Mechanical ventilation and air conditioning in buildings
NFPA 90A Installation of Air Conditioning and Ventilating Facilities.
NFPA 96 Ventilation Control and Fire Protection of Commercial Cooking Operation.
SMACNA Ductwork design and installation.
UL 555 S Smoke Dampers.

1.4. Submissions

1. Technical Submissions. After award, the Contractor shall check design calculations and shall advice the Engineer of any discrepancies found.

2. The Contractor will also prepare an air balance for supply, return, exhaust, make-up infiltration etc.

3. The Contractor will prepare full shop drawings, including sections, of distribution systems and equipment.

4. Hardware Submissions. The Contractor will submit catalogues information for all distribution equipment including, but not limited to:-

(a) Ductwork, duct sealants, gaskets and tapes.

(b) Flexible ductwork.

(c) Flexible connections.
(d) Access panels.

(e) Balancing dampers.

(f) Motorized dampers.

(g) Back draft dampers.

(h) Splitter dampers.

(i) Fire dampers.

(j) Silencers.

(k) Vibration isolators.

(l) Diffusers, grilles and registers.

(m) Louvers, sand louvers.

(n) Filters.

5. The Contractor will submit for any or all of the above as requested by the Engineer after receipt of the catalogues.

6. Samples will definitely be required of these items, which are exposed, such as diffusers, grilles, louvers. The samples must be of size, specification and finish as relevant to the project.

7. Where a country of origin is given, this refers to the head office in the case of international corporations. However, for each product not manufactured in the country separate approval must be obtained from the Engineer.

2. DUCTWORK

2.1. Ductwork Material

1. All ductwork except in laboratories, kitchens and laundry extract systems shall be manunfactured from strip mill, could reduced sheet, continuously hot dip galvanized in accordance with BS 2989 grade Z2. unless specified elsewhere in the Project Documentation.

2. All flanges and stiffeners used in the construction of galvanized mild steel ductwork shall be galvanized steel section.

3. Where flexible ductwork is used, it shall conform to ductwork of the type manufactured in accordance with BS 1470 aluminum strip corrugated and spirally wound with double lock seam.

4. The length of flexible ductwork shall not exceed 2m per section and shall be supported as recommended by the manufacturer.

5. Kitchen extract ductwork shall be air and watertight welded construction manufactured form 16g black steel sheets in accordance with BS 1449, Part 1 Grade CR4 GP. Ductwork shall be painted on the outside with two coats of heat resistant galvanic paint after manufacture.

6. Laundry extract ductwork shall be air and water tight construction manufactured from aluminum sheets in accordance with BS 1470.

7. Laboratory ductwork or systems carrying corrosive gases shall be manufactured of PVC or FRP.

2.2 Ductwork General

1. All dimensions shall be checked on site before ductwork manufacture in commenced.

2. The whole of the ductwork installation shall be carried out by an approved specialist in ductwork manufacture and installation. No ductwork shall touch the building structure or building finishes direct, but shall be isolated with insulating spacer.

3. The fabrication shall be carried out in a neat and skillful manner with all ductwork true in size and cross-section, braced and stiffened as specified and with all internal and external surfaces free from projections and sharp edges.

4. At each main branch in ductwork and at each fan discharge or suction, provide sufficient number of Pitot tube holes for balancing systems. Also, provide test holes for traverse fan discharge and at all equipment. Test holes shall be located within easy reach of catwalks or ladder.

Each test hole shall have 20mm clear opening, provided with a metal ring place with a threaded hole in the boss, and matching screwed head plugs are installed in insulated ductwork, provide an extension collar against which the insulation can be finished.

5. Reinforced holes shall be provided where thermometers, manometers, thermostats, gauges, damper rods ect., occur in ductwork. Extended collars shall be provided for the reinforced holes where these occur on insulated ductwork. Where copper tubing passes through ductwork, or provide a rubber grommet to prevent damage to copper tubing.

6. Ductwork shall be rigidly suspended or supported from building structure. Expansion type concrete inserts shall be placed so that the fastener is in shear rather than tension. Powder actuated fasteners placed by an explosive charge will not be accepted. Angle type trapeze hangers with rod supports space at 2m maximum shall be used. “C” type beam clamps will not be accepted. Provide necessary steel angle iron required for bracing of ductwork or equipment, and for supporting ductwork from building structure.

7. A layer of felts strip 12.5 mm compressed thickness shall be provided between any support member which is designed to clamp or grip the duct (e.g. circular duct band clip) or on which the duct is to rest. All supports shall be hot dip galvanized.

8. Increase in duct size shall be gradual. Where width or largest dimension of a duct is over 450 mm, duct shall be stiffened by bending in a break across corners in both directions. Ducts shall be self-supporting and complete in themselves. Single thickness partition between ducts will not be accepted. Visible internal portions of duct outlets to grilles and register shall be painted in dull black.

9. All necessary allowances and provisions shall be made in the installation of the ducts for the structural framing of the building and when changes or offsets are necessary, the required cross-sectional areas shall be maintained. All of these changes however, shall be approved, and installed as directed at the time.

10. During installation, the open ends of ducts shall be protected with blank, flanged sheet metal baffles, securely attached to prevent debris and dirt from entering.

11. Where ducts are shown connecting to masonry openings and/or along the edges of all plenums at floors, walls, etc., provide a continuous 30 x 30 x 4 mm galvanized angle iron which shall be bolted to the structure and made airtight to same by applying caulking compound on the angles before they are drawn tight. The sheet metal at these locations shall be bolted to the angle iron framing.

12. All air duct, castings, plenums etc., shall be constructed of lock forming quality prime galvanized steel sheets, which are free from blisters, slivers, pits, imperfectly coated sport etc. No second quality sheet metal allowed.

13. Where damage (or rusting) has occurred on galvanized ductwork, the affected section shall be made good by painting with two coats of zinc-rich paint and approved finishing paint, or where the damage in the Engineer's opinion cannot be made good, then a new section of ductwork shall be provided at no cost to the contract.

14. Duct shall be constructed using double or Pittsburgh lock corner seams. All seams shall be hammered down and made airtight by applying sealant before hammering down. For transverse joint, refer to the current ASHRAE guide for low pressure ductwork.

15. Support the vertical ducts installed in the various shafts at each floor level with galvanized supporting irons of approved size.

16. Install these angles across the width of the shaft, with their ends attached to angle irons securely anchored into the masonry walls of the shaft, or attached to the framing of the floor openings. The ducts shall be bolted to these supporting angle irons.

17. Ensure that all openings required through floors, walls, partitions etc, for the duct system are provided in the exact location required.

18. Each piece of ductwork shall be wiped inside and outside before installation and all open ends shall be capped and sealed to prevent entrance of dirt during construction. Ensure that ductwork systems are clean and free from dirt, duct, grime, debris etc., before initial operation of fans. Fans shall not be operated until the filters are installed and approved by the Engineer.

19. The bottom joint and 150mm of vertical joint on outside air intake ducts and mixing chamber ducts shall be soldered and made watertight. Provide drain connection and run copper drainpipe to nearest floor drain.

20. All fixing devices including nuts, bolts, washers etc., used in the construction or support of galvanized ductwork shall be sheradised, or cadmium-plated,

21. Final connections to diffusers shall be carried out using flexible ductwork or solid spigots as detailed in the Project Documentation.

22. Sealants, gaskets and tapes shall comply with DW 144 part 7 section 27 or DW 151 section 12 as appropriate.

2.3 Low Pressure Ductwork

1. This applies to ductwork with mean velocities less than 10 m/s and static pressures of 500 Pa or less.

2. Rectangular low pressure ductwork shall be fabricated from prime quality re-squared; tight coat galvanized steel sheets as specified in the relevant standard.

3. Reinforcing and joints shall be in accordance with ASHRAE Guide and Date Book, Equipment Volume, 1988 Chapter 1 or in accordance with DW 144.

4. Low pressure suction and discharge plenum chambers shall be fabricated from 1.3mm galvanized steel with galvanized angle iron framework and bracing.

5. Inn square elbows and in elbows where the radius is less than 1.5 times the width of duct, sheet metal defector vanes shall be installed the full height of the duct, being securely riveted in place. All vanes shall be double thickness vanes of two gauges heavier then the duct in which they are installed, and shall be factory made, not site fabricated. Vanes shall be tack welded to vane rail. For vane lengths over 1000 mm, tack weld vanes to 10 mm tie-rod at mid- span.

2.4. Medium Pressure Ductwork.

1. This clause applies to ductwork subject to pressures up to 1000 Pa.

2. Rectangular medium pressure ductwork shall be fabricated from prime quality, re-squared tight coasted galvanized steel sheet as specified in the DW 144.

3. Reinforcement and joints shall be as detailed in DW 144.

2.5. High Pressure Ductwork

1. This applies to ductwork subject to pressures up to 2000 Pa.

2. Rectangular medium pressure ductwork shall be fabricated from prime quality, re-squared tight coated galvanized steel sheet as specified in the relevant standard.

3. Reinforcement and joints shall be as detailed in the DW 144.

4. All high pressure ductwork shall be pressure tested in accordance with the DW 144.

2.6 Low Pressure Flexible Ductwork

1. Flexible ductwork shall be manufactured with a two-ply aluminum inner core, surrounded by 25 mm thickness of 24 kg/m³ density fiber glass, all wrapped in a reinforced aluminum outer jacket. Ductwork shall meet the standards of NFPA 90A, and be UL listed or to meet BS 476 and BS 413.

2. Flexible ducts installed in an externally insulated duct system shall be factory insulated with glass fiber insulated not less than 25 mm tick and a density not less than 24 kg/m3, re-covered with an acceptable vapor seal.

3. Flexible ducts installed in internally (acoustic) insulated duct system, shall be factory insulated with glass fiber insulation not less than 20 mm thick and a density not less than 24 kg/m³, faced on air side with PVC coated glass cloth having an open area not more than 25%, and on room side with material specified above.

4. Flexible duct installation shall be in accordance with manufacture's instruction. Joints between factory insulated flexible ducts and field insulated ductwork shall be sealed and taped under this section.

2.7. Flexible Connections

1. Flexible connectors at inlet and discharge to air handling equipment shall be per-assembled 0.7mm galvanized steel with minimum of 100 mm width (exposed) fabric. For higher pressure applications 25 mm of width of fabric shall be used fro each 25 mm of static pressure.

2. Flexible connectors attached to acoustically treated ductwork shall be insulated with 25 mm Fiberglass insulation packed between flexible connector and 16 gauge (1.5 mm) galvanized steel housing. Housing shall be fastened to duct with sheet metal screws. At equipment collar caulk between collar and flange on housing with 10mm thick

permanently flexible sealant. Care shall be taken to ensure that ducts on both sides of the connection are independently supported and that no "bridging" occurs.

3. All flexible connection will b e supplied from an approved manufacturer, with ratings of fire spread, strength etc., listed by a recognized Testing Authority.

4. The fabric shall be rated fro use up to 93 ºC working temperature with a tensile strength of not less than 690 kPa.

5. The material shall also be impervious to moisture, dimensionally stable, and shall not rot.

2.7 Access Panels

1. Duct access doors shall be minimum 450 x 300 mm. all access panels shall be constructed from double thickness galvanized steel sheets, thickness to suit the duct insulation with necessary reinforcing inside for rigidity with space filled with fiber glass insulation. Panels shall be made airtight with a continuous neoprene rubber gasket.

2. Openings in ductwork shall be provided with continuous galvanized reinforcing bars, which on insulated ductwork, shall be extended to the face of the insulation. Small panels shall be provided with at least tow brass window sash fasteners. All panels shall have brass drawer type handle.

3. Apparatus access doors shall be minimum 600 x 1500 m with angle or channel frame. Provide two 75mm strap hinges with brass pins and two handles minimum, operate from inside and outside.

4. Provide access panels where shown, required and directed and in the following locations:

(a) Bottom of all duct risers.

(b) Next to outside intakes and outlets.

(c) At each fire Damper

(d) Into apparatus casings to facilitate maintenance and cleaning of all components.

5. The duct access doors shall be fitted with CAM type to locks spaced to minimize leakage and drawer type handles.

3. BALANCING

3.1. Balancing Dampers

1. Install volume dampers in accessible locations at all branch connections and wherever necessary to adjust the flow of air to secure correct distribution. They shall be made of galvanized sheet metal, and be equipped with an approved device for fastening in any desired position. This device shall be such that the damper cannot move or rattle and position of the damper from the outside of the finished duct insulation and shall be clearly marked with words 'Open and Shut'.

2. Dampers shall be multi-leaf opposed blade with blade height not more than 1.80 mm PVC or similar blade seals shall be incorporated to the end of all blades. The blades shall be of an aerofoil design.

3. All blades shall be operated by a single operating quadrant with gears and links as necessary.

4. Spindles shall be non-corrodible, passing through non-ferrous bushings or ball bearing supports with seals.

5. The whole damper assembly shall be mounted in a galvanized frame with flanges.

6. seal material shall be rated up to 93 ºC with low water absorption and excellent chemical resistance to acids, alkalis and oils.

3.2 Flow Control Dampers

These dampers shall be installed in ductwork to maintain a constant airflow regardless of changes of pressure conditions. The damper shall be suitable for duct velocities ranging between 2 m/s to 8 m/s and shall operate from a minimum pressure of 20 Pa. These dampers shall be installed in branch ducts fitted with high efficiency particle (HEPA) filters.

3.3 Motorized Dampers

1. The Contractor shall furnish and install, control dampers as required for the proper functioning of the system.

2. All control dampers shall he opposed blade.

3. Dampers frames shall be formed channels of not less than 1.8 mm galvanized steel with mounting holes for enclosed duct mounting.

4. Dampers blades shall be of not less than 1.5 mm form galvanized steel. Blades on multi-blade dampers shall not exceed 200 mm in width and 1200 mm in length. Blades shaft bearings shall be provided at the ends of each blade. Blade side edges shall seal off against spring stainless steel seals.

5. Dampers shall be supplied in standard size, in 50 mm even increments, with transition as necessary to mating duct sections.

6. Dampers shall be suitable for operation within the temperature limit of .40 ºC to 93 ºC. Horizontal dampers shall have a rated face velocity of 2 m/s at 1500 Pa. static pressure differential.

7. Dampers used for shut off function shall be of the low leakage type.

8. Damper blades shall neoprene or PVC edging on all outside air dampers.

3.4.Backrest Dampers

1. Backrest dampers shall be low leakage with parallel blades and neoprene edge seals.

2. Damper frames shall be constructed from galvanized sheet steel with aluminum blades. Bearing shafts shall be stainless steel, in brass bearing bearings.

3. All blades shall be coupled at the blade centers and shall be in width of not more than 1000 mm, with maximum blade size of 200 mm.

4. Leakage shall not exceed 10 m^3/h per m^2 at 1000 Pa pressure differential.

5. Pressure relief dampers shall be multi-parallel blade with weighted arm closing assist. The frame shall be anodized aluminum channel sections with formed aluminum blades. Maximum blade length shall be 100 mm, and polyester foam seating strips shall be incorporated on blade edges. Bearing shall be in PVC with non-corrodible shafts.

3.5 Splitter Dampers

1. In each low pressure system take off where opposed blade duct dampers are not specified, splitter dampers shall be provided. The only justification for not providing splitters is in a system which can be demonstrated to be sized by a static regain program wand which is run in high pressure fittings. Otherwise splitter dampens shall be installed at all take offs.

2. Splitters shall consist of hollow blades in a vane rail assembly, made from galvanized steel by a recognized manufacturer.

3. A lockable quadrant adjustment level shall be located outside the insulation, and marked clearly to show vane position.

3.6 Fire Dampers

1. Provide, where required by ordinances or codes, for dampers made to BS 476 or North American Standards or NFPA 90A, and complete with angle iron frame of 3 mm thickness, 70 ºC fusible link, pivot rods, and spring catches. Fire damper housings shall be galvanized steel duct sections around the fire dampers, and shall allow 100% unrestricted duct area while in the open position. Provide approved type access doors, with airtight gaskets, for inspection and servicing of fire dampers. The fire damper blades shall be out of the air steam.

2. Provide fir dampers in all duct over 125 cm² in area, in the following locations, whether or not specifically required by ordinances and codes and as indicated the contract drawing:-

(a) Duct entering and leaving fire shafts (duct shafts).

(b) Duct passing through designated firewalls.

(c) Ducts through floors, and not encased in fire shaft

(d) Ducts leaving and entering plant area

(e) Ducts entering and leaving storage areas.

3. Where fire dampers are located remote from fire partition, duct between fire damper and partition shall be encased in double metal lathe and plaster or other fireproofing acceptable to Authorities having jurisdiction. This shall be arranged and paid for by this trade.

4. Dampers shall be operated by two stainless steel springs with the blades being held in the open position by a fusible link and stranded stainless steel strap. Blades shall be made from galvanized steel.

5. Fire dampers shall not be installed in kitchen exhaust ductwork. This shall comply in all respects with NFPA 96.

3.7 Smoke Dampers

1. Smoke dampers shall be the low leakage type, rated under UL 555 S as leakage Class **I**.

2. Frame shall be of formed channel of not less than 1.6 mm galvanized steel. Blades shall be 1.6 mm, airfoil shaped, double skin construction, opposed blade type.

3. Blade edge seals shall be silicon rubber and jamb seal shall be flexible metal compression type.

4. Bearings shall be stainless steel sleeve type pressed into frame.

5. Damper actuators shall be factory furnished suitable for either 240 volt or 24 volt application. Complete unit shall be factory tested in compliance with UL 555 S.

6. Damper and actuator shall be qualified under UL 555 S to an elevated temperature 120 ºC.

7. The damper unit shall be supplied with a two position indicator switch linked directly to the damper to provide the capability of remotely indicating damper blade positin.

4 SILENCER

4.1 General

1. Silencers shall be installed when required to achieve the specified noise levels.

2. At shop drawing stage, the contractor will undertake calculation for every unit and every area and determine the insertion loss required to meet the stated noise criterion.

3. Supply and return duct noise must be considered as well as duct breakout noise.
4. Materials of construction shall be galvanized sheet metal and mineral fiber acoustic fill which is inorganic, inert, moisture and vermin resistant. Silencers shall be so constructed as to prevent erosion and pregnability of the acoustic fill.

5. The silencers shall incorporate a removable panel which provides complete access to all internal surfaces for cleaning and also permits removal and replacement of acoustic fill.

6. Silencers shall be factory made, and shall have available certified test data concerning insertion loss. This must be available when required, in advance of ordering units. Where

a silencers is made under license, or part assembled locally, then tests must also be made after assembly and witnessed by and independent Authority.

7. The static pressure loss of any required silencer must be considered in air handling equipment original selection.

8. Silencers shall be installed in locations as indicated on the contract drawings.

9. Silencers shall be flanged to exactly match the adjacent ductwork in which they are to be installed.

5. DIFFUSERS AND REGISTERS

1. Diffusers, registers and grilles shall be arranged for flush mounting in lay-in type ceilings and over lap mounting in plaster, mineral tile and similar ceilings, with concealed fixings unless otherwise directed.

2. Grilles, register and diffuser locations shall be adjusted to suit reflected ceiling drawings, or Engineer's site instructions. All grilles, registers, diffusers, louvers shall be from one manufacturer.

3. Provide plaster frame for grilles, and diffusers installed in plaster ceilings.

4. All diffusers, grilles and registers shall be supplied completely factory powder coated. Finish color shall be to the approval of the Architect. The interior of all grilles and diffusers is to be factory painted matt black.

5. All supply grilles and diffusers will have opposed blade balancing dampers. All will have foam rubber sealing band around the edge to seal to the structure. All pivots will be round section, not of formed sheet, and not relying on a spring steel locking wire.

6. Basic grilles and diffuser materials shall be aluminum-extruded sections. Sections in the air stream shall be carefully selected to minimize turbulence.

7. All grilles and diffusers supplied on this project shall be tested and rated in accordance with ASHRAE Standard 70-72, ADC Test Code 1062-GRD and ISO 3741 or have ARI certification.

8. Linear bar grilles shall be fabricated from aluminum, with 6.4 mm wide bars on 12.5 mm centers pressed into a notched steel retaining bar. The core can be either welded into the cuter frame, or where the grille is used in a sill application, held in the outer frame by spring clips fixed to the core-retaining bar. The outer frame shall be 35 mm deep and shall have a visible flange 25.4 mm wide, milled end caps shall be welded to give a near invisible joint. The grill shall be complete with an opposed blade damper painted matt

black, and shall be fixed with universal mounting brackets. Both the damper and the fixing brackets shall be accessible through the face of the grille. Continuous grilles shall be provided with positive alignment strips, which fit into special keyways extruded into the frame of the grille to ensure clean unbroken lines.

9. Ceiling Diffusers shall be multi-core giving 4 way horizontal discharge. The three centre cores of the diffuser shall be manufactured from pressed aluminum, with the remaining cores and the outer frame fabricated from extruded aluminum welded at the corners to give near invisible joints. One, two and three way pattern cores shall be used as indicated on schedules. All cores shall be interchangeable. The core shall be removable without the use of special tools, but for safety, shall be fixed to the outer frame by a small length of chain. The diffuser shall be complete with an opposed blade damper painted matt black.

10. Wall registers shall be double deflection fabricated from aluminum, the front vanes being horizontal, the rear vanes vertical. This grille shall be complete with an opposed blade damper painted matt black and adjustable from the face of the diffuser. Both sets of vanes shall be fully adjustable without the use of special tools.

11. Egg crate return or extract grille shall be provided with 12.7 mm x 12.7 mm openings, giving a free area of 90 %. The core shall be fixed into an extruded aluminum frame, with welded corners and a 25 mm face flange. The grille is complete with an with welded corners and a 25 mm face flange. The grille is complete with an diffuser.

12. Circular ceiling diffuser shall be of aluminum construction with two concentric inner spinning. The diffuser core shall be fully adjustable for vertical or horizontal air discharge, and shall be removable without the use of special tools. An iris damper shall be provided in the neck of the diffuser that is adjustable from the diffuser face.

6. LOUVERS

6.1. Outside Louvers

1. Outside louvers shall be supplied with sleeves for the appropriate openings, and with full installation instructions.

2. Louvers shall be extruded aluminum frame with aluminum blades of not less than 2 mm thickness, and shall be firmly fixed so as not to vibrate. Unsupported blade width shall not exceed 1800 mm.

3. Behind each louver shall be an insect mesh screen 6 x 6 mm made from 2 mm diameter wire. The screen will be clamped by a 20 mm frame and will be firmly fixed to the outer edges of the louver. The screen and frame shall be hot dip galvanized after fabrication.

4. The connection to the louver shall be flexible and shall ensure no duct load is transmitted to the louver.

5. Louvers shall be provided with powder coated finish to the approval of the Architect.

6.5 Sand Louver

1. Sand louvers shall have a double deflection inlet passage to separate sand from incoming air by means of centrifugal forces.

2. Separation efficiency shall not be less than 80 % on 20 to 200 micron test dust, and 50 % on 1 to 70 micron test dust.

3. Sand louver shall be mill finished aluminum sections with casing 2 mm thick and blades 1.5 mm thick. The base of the louver shall have self-emptying sand holes.

4. Pressure drop at 2 m/s average face velocity shall not exceed 85 Pa.

5. Insect mesh shall be included.

6. Sand louvers shall be provided with powder coated finish to the approval of the Engineer.

(IV) THERMAL INSULATION

1. GENERAL

1.1 Scope of Work

This Part details the requirements for insulation for piping systems, ductwork systems, and equipment.

1.2 References

The following standards are referred to in this Part

ANSI 331.1 Pipe work Design.

ASTM E-84 Test Method for Surface Burning Characteristics of Building Materials

BS 476 Fire tests on building materials and structures.

BS 4735 Laboratory method of test for assessment of horizontal burning characteristics of specimens no larger than 150 mm x 50 mm x 13 mm (nominal) of cellular plastics and cellular rubber materials when subjected to a small frame.

DW 144 Ductwork Installation.

1.3 Submissions

1. The Contractor shall submit manufacturer's specifications and installation instructions for each type of mechanical insulation. The submittal shall include a schedule showing manufacturer's product number, thickness and recommended furnished accessories for each system requiring insulation.

2. Samples for each type of insulation shall be provided. A 300 mm long sample of each piping insulation type and a 300 x 300 mm of each duct and equipment insulation type.

3. The Contractor shall submit certification and data necessary to show compliance with the specification and other governing regulations. These shall include proof of compliance for test of products for fire rating, corrosive resistance and compressive strength.

4. Where the specification calls for additional treatments such as wrapping and waterproofing a complete sample shall be provided in addition to the above samples.

5. All samples shall be retained on site after approval to be a reference for future work.

1.4 Contractor's Responsibility

The Contractor shall provide all necessary materials, labor, equipment, tools, appliances, services hoisting scaffolding supports and supervision to provide complete mechanical insulation in accordance with the Specifications.

1.5 System Description

1. The whole of the insulation work shall be carried out by an approved specialist insulation Contractor. All allowances shall be included for arranging a specialist subcontractor accordingly and for informing the specialist subcontractor of all conditions relating to the contract and for coordinating his works with the remainder of the Works.

2. All allowances shall be included for informing the specialist subcontractor of all details of the building structure, program arrangements, and other relevant details at the time of tender and for all necessary visits to site by the subcontractor or his works.

3. In addition to complying with the relevant standards, all insulating material shall be free from asbestos.

4. Insulating materials shall be acceptable only if they are equal to or better than the grades or classes of fire resistance as follows:

(a) BS 4735, Class Q, for burning rate nil, and not producing melted droplets

(b) BS 476 Part 4, for non-combustible grade.

(c) BS 476 Part 5, Class P, for not easily ignitable

(d) BS 476 Part 7, for fire propagation index of a maximum of 12.6

(e) BS 476 Part 7,Class 1, for surface spread of flame.

(f) BS 476 Part 9, for production of emitted smoke shall not give more than 35% obstruction of the light beam.

5. All insulation finishes and coverings shall be classified as Class 1 surface spread when tested in accordance with BS 476, Part 7.

6. All adhesive, mastics, coatings, sealers and primers shall be classified as Class 1 surface spread when tested in accordance with BS 476, Part 7. They shall not in any way attack the insulation or the surface to which the insulation is being applied and shall be suitable for the working temperatures.

7. Insulating materials shall have thermal conductivity values not more than those listed as given in the following Table:

Thermal Conductivity Insulating Materials

Material	Type	Thermal Conductivity (W/m/°C)
Mineral wool	Sectional	0.04
Mineral wool	Slabs	0.04
Fiber Glass	All	0.034
Closed Cell	All	0.038
Polyurethane	Sectional	0.025
Styrofoam	Rigid	0.026

Note : all conductivity figures are rated at an average temperature of 24 ^{o}C.

8. All material delivered to site shall be new and fully dried out and so maintained throughout the progress of the works. All insulating materials shall be stored in storage sheds, and in accordance with the manufacturer's recommendations.

9. In order to ensure that the insulation applied is in all respects in accordance with Specification, sections shall, as required by the Engineer, be cut from the finished insulation. The contractor is a allow in his price for the removal and replacement two sections of each type of insulation. If however, defects are revealed, further sections shall be cut out for inspection, and all cut-out sections shall be replaced at no cost the contract. If further defects are revealed then the Engineer shall have the right, when in his opinion it is necessary, to issue instructions for any part or the whole of the insulation to be removed and replaced. The replacement with new insulation shall be to the satisfaction of the Engineer and the cutting out and replacement shall be at no coast to the Contract.

10. Particular attention shall be paid to the finished appearances of all thermal insulation which must present a neat and symmetrical appearance running true in the line with pipe layouts, etc.

11. Any rough, irregular and badly finished surfaces shall be stripped down and r insulated to the Engineer's satisfaction.

12. In certain cases the type of insulation specified will require a painted finish, in additions to identifying bands and any signs which are to be applied.

13. All systems are to have been tested and approved by the Engineer prior to installation of insulations.

14. All thermal insulations shall be non-corrosive to the metal, water repellent and fire retardant.

15. All metal surfaces shall be thoroughly cleaned and treated with approved corrosion inhibitor before applying the insulation. Can be applied directly to galvanized surfaces.

16. Lead bearing inserts shall be provided at all supports to ensure that the insulation is not compressed or damaged. The inserts shall be treated hardwood or approved plastic.

17. The vapor barrier shall be continuous and not punctured at any point.

18. The cotton canvas/fiber glass cloth shall be soaked in a compound as approved by the Engineer and shall be overlapped at least 50mm at transverse and longitudinal cloth joints.

19. Vapor seal materials shall be fire resistant, non-toxic, weather resistant, and anti fungus quality. Bitumen based products shall not be used.

20. All access doors in ductwork shall be insulated to match the ductwork that they are installed in the insulation shall b furnished to allow access without damage to the insulation.

21. Mechanical fasteners shall be used when installing slab or roll insulation. The fasteners shall be the self adhesive type and only fixed after cleaning to ensure proper adhesion.

2. PIPE INSULATION

2.1 Fiberglass Insulation

1. Pipe covering and insulation shall be manufactured by a recognized manufacturer, and shall be neatly installed to the following specifications. The general intent is to provide a sealed insulation which will not permit sweating of the pipes and which will not retain moisture to the detriment of it's insulating capability.

2. Pipes shall be thermally insulated with rigid section of fiberglass insulation with density of 65 kg/m^3, having a thermal conductivity factor of 0.03 W/m^2/K at 10 ^{o}C with self-applied aluminum craft paper. The minimum thickness shall be 50 mm unless otherwise specified in the Project Documentation.

3. The insulation, in sizes indicated shall be applied over clean, dry surfaces. Adjoining sections of insulation should be butted firmly together with the longitudinal seam of the jacket located on the bottom half of the pipe.

4. Pipes should be banded with at least three aluminum bands per section. One at the centre and one covering the edge of each circumferential strip.

5. Insulate and finish valves and fittings in the same manner and same thickness as piping in which such items are installed. Molded, factory shaped sectional pipe covering, factory or job fabricated may be used subject to satisfactory visual checking by the Engineer.

6. Direct contact between pipe and hanger shall be avoided. Hangers shall pass outside of the sheet metal protection saddle, which shall cover a section of high density insulation, of sufficient length to support the pipe without crushing the insulation. The vapor barrier shall be lapped over the saddle and securely cemented to it. Minimum thickness of metal saddle is 1.5 mm. The method shall be in accordance with DW 144.

7. Internal chilled water pipe shall be covered by 50 mm of rigid insulation plus a 200 g/m^2 woven glass cloth cover painted with two coats of approved sealant. External chilled water pipe shall be covered by 50 mm of rigid insulation plus a waterproof cover of 200 g/m^2 woven glass cloth painted with two coats of approved sealant. Where any insulated piped

service is run external to the building (including insulated pipe work run on roofs), in trenches or in plant rooms, the piped services shall be clad using an outer covering of aluminum sheet with a minimum thickness of 0.7 mm.

8. Where exposed, insulated pipe work runs through occupied or public areas, chiller yards and plant rooms the exposed pipe work shall be clad with aluminum sheet a, of 0.7 mm or thicker. or may be painted as detailed in the Project Documentation.

9. Strainers and valves of diameter 80 mm and above and fittings, which require opening for maintenance and repairs shall be provided with insulated boxes.

2.2. Polyisocyanurate (Phenolic Foam) Insulation

1. Chilled water pipe insulation shall be polyisocaynurate rigid closed cell pre-formed pipe insulation cut from blocks which have been factory produced from a chemical system complying with ASTM E-84, with a flame spread less than 25 and identified by a light green color.
2. The density shall be 35 kg/m^3 for all interior piping and 50 kg/m^3 for external pipe work.

3. All pipe insulation to be factory covered with reinforced aluminum foil/Kraft paper laminate, the whole providing a Class I rating to BS 476 Part 7.

4. Bends, to be insulated with pre-molded polyisocyanurate rigid closed cell foam meeting the same fire ratings as above but with aluminum foil applied separately on site.

5. Tees, valves, strainers etc., to be produced by the Contractor forming suitable metal boxes and pouring in-situ polyisocyanurate chemical system supplied by the pipe insulation manufacturer and in accordance with his instructions.

6. High density pipe supports, 80 kg/m^3, to be produced from the same chemical system and by the same manufacturer of the insulation and covered with aluminum foil in the factory.
7. The manufacturer's installation recommendations shall be strictly adhered to.

8. The use of fibrous insulation on chilled water pipes will not be permitted.

2.3 Pre-insulated Under Ground.

1. All underground chilled water pipe work shall be pre-insulated.

2. The system shall be non-corrosive, non metallic, structurally strong completely water proof and entirely resistance to attack by salts, water and all ground chemicals normally encountered.

3. The system manufacturer shall have fabricated systems of the composition defined here for at least two years.

4. All straight sections fittings, anchors, end seals and other accessories shall be factory prefabricated to the project dimensions. The design shall be such to minimize the number of field welds.

5. The system design shall be in conformance with the latest edition of ANSI 331.1.

6. Pipe movement due to thermal expansion shall be accommodated with expansion loops or elbows.

7. The system manufacturer shall provide an integrated leak detection/location system factory installed within the piping system. The leak detection system shall be connected to the leak detection panel.

8. The complete system shall be computer designed and analyzed by the piping system manufacturer to determine stress and anticipated thermal movement of the pipe work.

9. PVC warning tape shall be provided 300 mm above the buried throughout the length of the buried pipe.

3. CONCEALED COLD AIR DUCTS

3.1. Fiberglass Insulation

1. Unless otherwise indicated, supply and return ductwork shall be insulated with 48 kg/m^3

Unless otherwise indicated, supply and return ductwork shall be insulated with 48 kg/m^3 adhesive of high quality and a thermal conductivity of not more than 0.037 W/m/°C. The adhesive shall be applied to the entire surface of the ductwork and insulation. Butt all joints tightly and seal all breaks and joints by adhering a 75 mm aluminum foil vapor barrier tape or sheet with a fire retardant adhesive.

2. Insulate flexible connections and connections to diffusers with 25 mm thick, 24 kg/m^3 density reinforced aluminum foil faced, flame resistant, flexible fiberglass insulation. Overlap onto adjacent insulation and seal with adhesive duct tape to give good closure.

3. Finish insulation on ductwork by applying a 200 g/m^2 canvas cover adhered between two coats of approved fungicidal protective fire resistant lagging adhesive.

4. Bitumen based products shall not be used.

3.2. Polyisocyanurate (Phenolic Foam) Insulation

1. Unless otherwise indicated insulate supply and return ductwork with 25 mm of 35 kg/m^3 non- hygnoscopic foil faced polyisocyanurate (phenolic foam) slabs.
2. Flexible connections shall be insulated with 25 mm of 24 kg/m^3 reinforced flame resistant flexible fiberglass insulation.
3. The insulation shall be fixed by means of a non flammable adhesive recommended by the insulation manufacturer.
4. Finish insulation on ductwork by applying a 200 g/m^2 canvas cloth cover adhered between two coats of approved fungicidal protective fire resistant lagging adhesive.

4. EXPOSED COLD AIR DUCTS

4.1 Fiberglass Insulation

1. For ducts exposed inside conditioned spaces, insulate as described above for concealed air ducts but using aluminum foil faced fiberglass boards with density 48 kg/m^3. Then apply a 200 g/m^2 canvas cover adhered between two coats of approved fungicidal protective fire resistant lagging adhesive.
2. Where exposed cold air ductwork runs through occupied or public areas, it shall be clad with aluminum sheet, 0.9 mm or thicker as specified in the Project Documentation.
3. For ducts exposed in non-air conditioned areas and plant rooms, insulate using the method described for concealed ducts, but using insulation with a minimum thickness of 50 mm, 48 kg/m^3 density fiberglass insulation. If necessary due to market availability, this may be installed in two layers, but with each layer properly finished.
4. Finish insulation by applying a 200 g/m^2 canvas cover adhered between two coats of approved fire resistant lagging adhesive.
5. Where ducts penetrate the building shell, the duct shall be flashed and waterproofed before any insulation is applied.

4.2 Polyisocyanurate (Phenolic Foam) Insulation

1. Exposed ductwork inside air-conditioned spaces shall be insulated as described above for concealed duct work.

2. Exposed ductwork in non-air conditioned areas, insulate using the method described for concealed ducts but using insulation with 50 mm of 35 kg/m^3 polyisocyanurate (phenolic foam) insulation. This may be installed in two layers, but with each layer staggered and properly finished.

3. Finish insulation on duct work by applying a 200 g/m^2 canvas cloth cover adhered between two coats of approved funigicidal protective fire resistant lagging adhesive.

4. The finished insulation shall then be clad with aluminum sheet 0.9 mm thick.

5. Where ducts penetrate the building the duct shall be flashed and waterproofed before any insulation is applied.

4.3 External Ductwork

1. All external ductwork shall be insulated with 50 mm thick fiberglass slab.

2. The insulation shall be installed as detailed for exposed ductwork except that the insulation shall be covered with fiberglass cloth 200 g/m^2 .

4.4 Acoustic Lining

1. Acoustic lining shall be provided when specified in the Project Documentation.\

2. The lining shall be fiberglass or mineral wool slab and faced to minimize fragmentation and fiber fly. The type and thickness of the lining shall be approved by the Engineer.

3. The ductwork shall be sized to allow for the thickness of the lining.

4. The ductwork surfaces must be thoroughly cleaned and the lining fixed by an approved adhesive over the whole area to be lined.

5. Mechanical fasteners must be used at 400 mm maximum centers and not more than 75 mm from joints, corner breaks etc.

6. All edges shall be sealed or enclosed by a light metal section mechanical fastened to the duct.

7. If required by the Engineer, metal mesh may be required as a precaution against displacement or break up.

4.5 Circular Duct Insulation

1. Circular supply and return air ductwork shall be insulated with flexible fiberglass blanket of density 24 kg/m^3 and covered with reinforced aluminum foil.

2. Blanket thickness shall be 50 mm compressed to 25 mm during installation for internal ducts and 100 mm compressed to 50 mm for external ducts.

3. The method of installation shall be the same as for rectangular ducts.

4. Aluminum bands 25 mm wide shall be installed at 500 mm centers.

5. Vapor sealing shall be carried out as specified for rectangular ducts.

6. Additional protection shall be provided for exposed ducts if specified in the Project documentation.

5. EQUIPMENT INSULATION

5.1 Refrigerant and Condensate Drain Pipe Insulation

1. The pipe covering and insulation shall be manufactured by a recognized manufacturer and shall be neatly installed to the following specification. The general intent is to provide a sealed insulation which will not permit sweating of the pipes and which will not retain moisture to the detriment of its insulating capability.

2. The refrigerant suction lines only shall be insulated with 19 mm thick foam rubber having a thermal conductivity factor of 0.036 W/m^2/K and a maximum water permeability of 0.09 µgm/NH. Alternatively, the pipes shall be insulated with 50 mm thick rigid fiberglass insulation and vapor sealed in the same manner as chilled water pipes as detailed in Part 5 of this Section.

3. The material shall be supplied as pre-formed pipe sections in tubular or pre slit form.

4. The insulation shall be installed accordingly to the manufacturer's recommendations using a non-flammable adhesive.

5. All exposed insulation shall be coated by two coats of chlorosulphonated polyethylene paint.

6. All condensate drains within plant rooms or other internal areas subject to damage or sweating shall be insulated using 25 mm thick rigid fiberglass or 10 mm thick foam rubber insulation. The insulation shall be vapor sealed.

5.2. Apparatus Casings

1. Insulate apparatus casings, which are not provided with insulation as follows: apply generally 50 mm of rigid polyurethane insulation, 24 kg/m^3 density. On the underside of coil sections, apply 50 mm thick polyurethane insulation, 24 kg/m^3 density. All joints are to be sealed in cold adhesive compound.

2. Ensure that any access panels are insulated to the same standard and are open able.

3. For small units, cover the entire outside assembly with waterproof self-adhesive glass fiber tape. This must be at least 75 mm minimum width and must overlap at least 50 % on each application, to achieve watertight conditions.

4. For larger units, provide a weather resistant enclosure outside the insulation, subject to Engineer's approval.

5. Ensure that all equipment meet these requirements, regardless of manufacturer's standard practice, and add insulation as required to the above standard.

6. Where insulation, re-installation or additional insulation is required to the casing of externally mounted air conditioning units, the insulation shall be covered with Aluminum sheet, of 0.9 mm or thicker.

7. Insulation of drain pans is specified for AHU and FCU regardless of the manufacturer's standard supply, the contractor shall re-insulate on site if necessary so that the specification is complied with in full.

(V) EXHAUST FANS

1. General

1.1 Scope
This Part details the requirements for all types of extract fans as specified in the contract.

1.2 References
The following Standards are referred to in this Part:
BS 848 Fans for general purpose
BS 5000 Rotating electrical machines of particular types or for particular applications.

2. EXHAUST FANS

2.1 General

1. The make and design of the exhaust fans shall be approved by the Engineer and evidence supporting the claimed noise efficiencies shall be submitted for approval prior to placing the order. Where fans are fitted with noise attenuators full details of the attenuators shall be given.

2. Belt driven fans shall be fitted with pulleys suitable for V-belts. The pulleys shall be fixed by taper lock type bushes and shall be secured to the fan and motor shaft by keys fitted into machined keyways.

3. All fans which are to large or heavy to be man handled safety shall be provided with eyebolts or other lifting facilities to enable mechanical lifting equipment to be used.

4. The whole fan assembly shall be fully finished against corrosion.

5. Access shall be provided to carry out all necessary maintenance required.

6. The electrical terminal box shall be located to allow for easy connection and disconnection the electrical supply.

7. Where required suitable guards shall be installed to protect against all moving parts including the motor.

8. All motors are to be positioned to permit effective ventilation of the motor and all components of the fan and motor are to be suitable to withstand the temperature conditions expected.

9. All fans shall be installed to avoid vibration and noise to the ductwork or building fabric.

10. Each fan motor shall be designed to drive its respective fan when the fan is operating at a speed or pitch angle 10 % in excess of that required to meet the fan performance.

11. Where required flexible connections shall be installed at both the inlet and outlet of each fan.

12. All extract fans shall have the direction of rotation discharge direction and arrangement to suit the space conditions.

13. All extract fans shall be provided with an electrical isolator adjacent to the unit.

14. The fan motors shall be insulated to a minimum of a Class 'B' insulation

15. All fans shall be capable of operating at ambient temperatures of 50 °C and the casing material shall be able to withstand sun radiation temperature up to 85° C.

16. The extract fans shall be axial, centrifugal or mixed flow as detailed in the Project Documentation.

2.2 Centrifugal Extract Fans

1. The centrifugal extract fans shall be of the non-overloading type.

2. The fan housing shall be rigidly built and braced. Where the fan scroll is 450 mm or more in width an access door with frame and gasket shall be provided. All access doors shall be fabricated so that the inner surface is flush with the inside of the fan scroll.

3. The fans shall not produce excessive noise as compared to units of like size and power when used with the specified vibration isolation.

4. The fan manufacturer shall provide for approval for each fan, certified sound power ratings with a octave band analysis and also the volume, horsepower, pressure characteristic curves from shut-off to free delivery.

5. The fan impeller shall have ample strength and shall be statically and dynamically balanced to avoid vibration.

6. The blades shall be designed to ensure quiet and efficient operation.

7. The fans shall be V-belt driven unless otherwise indicated.

8. The motor pulley shall be an adjustable type for two (2) grooves or less. Drives requiring three (3) grooves or more shall be the variable pitch type.

9. Drives for fractional horsepower motors may have one belt rated at 200 % of motor horsepower. All other fans shall have not less than two belts and shall have sufficient capacity to drive the fan with one belt broken.

10. The fans shall be provided with belt and pulley guards manufactured of perforated metal or other approved material. Covers shall be provided in the guard for the fan and motor shafts for ease of taking tachometer readings without removal of the guard.

11. The fan motor shall be sized to drive its respective fan when the fan is operating at a speed 10 % in excess of that required to meet the fan performance.

12. All fans discharging directly up though the roof shall be equipped with a 40 mm casing drain which shall be connected to the nearest floor drain.

13. All fans shall be factory coated with one coat of primer and one coat of machine enamel. The interior of the fans shall be painted as per the manufacturer's standard.

14. The fan shaft shall be supported by at least two roller or ball bearings with easy access to the lubrication points where required.

15. All fans scheduled to be located outdoors shall be furnished with weather proof motor and drive housings.

2.3 Axial Extract Fans

1. Axial flow fans shall be capable of giving the design flow when tested to BS 848.

2. The fan casing shall be constructed of mild steel plates with angle stiffeners, with the easing hot dip galvanized after manufacture.

3. The inlet and outlet of the axial flow fans shall be flanged for connection to the system.

4. The casing shall cover both impeller and motor so that the fan can be removed without disturbing adjacent ductwork or other components of the system.

5. A flame proof external terminal box shall be fitted on the casing.

6. All lubrication points shall be extended to outside the casing and in a position that will permit easy access.

7. The impellers shall be die cast in aluminum and x-rayed after manufacture.

8. The impeller shall be capable of running continuously at 20 % in excess of the rated speed.

9. The impeller shall be keyed and locked to the shaft, which shall be statically and dynamically balanced and tested at over speed prior to dispatch from the manufacturer's works.

10. The blade angle shall be adjustable over at least a 30° range with markings at the base to indicate the blade angle.

11. All motors are to be positioned to permit effective ventilation of the motor and all other components of the fan, motor to be suitable to withstand the temperature conditions expected.

12. A suitable support is to be provided for each fan. The frame is to be fabricated from rolled steel channel with adequate cross members for bolting the fan in position.

13. Anti-vibration mountings and flexible connection shall be provide to isolate the fans from the adjacent ductwork and building fabric.

2.4 Roof Mounted Extract Fans

1. The roof mounted extract fans shall meet the appropriate requirements as detailed in the general section.

2. The cowls and bases shall be of a weather proof material such as galvanized after manufacture, aluminum, aluminum magnesium alloy or glass fiber.

3. Cases shall be formed to ensure a weatherproof fitting.

4. Provision for access to the fan components shall be provided.

5. The fans shall be provided with back draught dampers and/or fire release dampers where indicated.

6. Bird guards of not greater than 25 mm mesh shall be provided as an integral part of the unit.

7. The fans shall be mounted on a weatherproof curb at least 200 mm above the finished roof level.

2.5. Twin Fan Toilet Extract Units

1. The unit casing shall be manufactured in epoxy coated aluminum alloy and shall house the twin fan assemblies.

2. Each fan shall be a double inlet forward curved centrifugal impeller running in an individual scroll.

3. The impeller may be either direct driven or belt driven depending upon the fan duty.

4. Direct driven fans shall incorporate a volume control damper on the suction side to regulate the volume to the required duty.

5. The motors shall be manufactured to BS 5000 TEFV type with sealed for life bearings.

6. The fans shall be fitted with air flow sensors and shall discharge into a common plenum through a linked shutter system.

7. Motors and flow sensors shall be pre-wired to a fitted isolator accessible from outside the nuts

8. The toilet extract units shall be supplied for either roof mounting duct mounting or installation within a plant room as indicated on the drawings.

9. The toilet extract units shall be supplied with auto-change over panels with duty/standby selector switch, run/fail indication lamps and cyclic relay for duty sharing.

2.6. Wall and Window Mounted Extract Fans

1. Extract fan shall be of the propeller type suitable for wall/window mounting.

2. The fan construction shall be of molded plastic.

3. Motors shall be of the shaded pole induction type enclosed in a aluminum alloy case and protected by a thermal over load cut out.

4. The motor bearings shall be self alignment sealed for life type.

5. The fans shall be provided with a solenoid operated back draught shutters. The solenoid shall open and close the back draught damper silently as the fan is switched ON and OFF.

2.7. Propeller Type Extract Fans

1. The impeller shall be of steel or aluminum and the blades shall be fixed to the hub or the blades and hub shall be formed in one piece.

2. The bearings shall be ball, roller or sleeve type sealed for life or with accessible lubrication points.

3. The propeller fans may be ring mounted diaphragm mounted or diaphragm mounted in a casing. The casing shall be longer than the length of the motor and fan.

4. The casing shall be of steel construction with flanged ends and shall incorporate an inspection door.

5. The terminal box shall be mounted externally on the casing.

6. The tip speed of the fans shall not exceed 20 m/s.

7. Inlet and outlet grilles shall be installed on the fans incorporating gravity back draught damper.

2.8. Kitchen and Smoke Extract Fans.

1. The fans shall be especially designed for smoke and kitchen extract.

2. The fans can be either belt or direct driven with the motor fixed on resilient mountings outside the air stream.

3. Kitchen extract fans shall be fitted with a housing drain and grease trap easily removable for cleaning.

4. The fans shall be suitable for removal of smoke and grease laden vapors.

2.9. Protectively Coated Extract Fans for Corrosive or Hazardous Use

1. Where the fans are required to handle corrosive toxic flammable explosive or high temperature gases the materials and construction shall be required to suit the application and all relevant safety regulations shall apply.

2. Bearing and lubrication arrangements shall be suitable for the conditions expected.

3. Where protective coating is required to use with corrosive gases the coating shall cover al parts of the complete fan, motor and casing assembly which will be in contact with the corrosive gase.

4. No fan shall be installed if the protective coating has been damaged in any way.

5. The impeller casing shall be as specified in the Project Documentation.

6. The fan motors for hazardous use or required to handle flammable or explosive gases shall be flame proof.

2.10. Bifurcated Extract Fans

1. Bifurcated extract fans shall be axial type fans.

2. The motor shall be completely out of this air stream.

3. The motor may be placed between the two halves of the casing in the external air or may be placed within the casing provided that effective ventilation is given to the motor.

4. The fan motor and bearings shall be suitably rated for operation at the temperature they may experience.

5. The fan construction and installation shall be specified for axial extract fans in Clause 8.2.3 of this Part.

2.11 In-Line Extract Fans

1. In-line extract fans shall be centrifugal, axial or mixed flow type fans as detailed in Project Documentation.

2. The construction and installation shall be as specified

(a) Centrifugal fans Clause 8.2.2

(b) Axial/mixed flow Clause 8.2.3.

3. The casing shall be rigidly constructed of mild steel or aluminum alloy and shall be stiffened and braced to avoid drumming and vibration.

4. Mounting feet shall be provided for bolting to a base or supports.

5. The inlet and outlet shall terminate with flanges to facilitate installation and removal.

6. Access panels shall be provided and shall be sized to facilitate maintenance.

(VI) UNITARY EQUIPMENT

1. GENERAL

1.1. SCOPE

This Part details the requirements for all types of unitary equipment as specified in the contract.

2. AIR-CONDITIONERS

2.1. Window type Air-conditioners

1. The unit offered in the tender shall be a reputed manufacturer who is represented locally and can provide an efficient maintenance and spare parts service.

2. The casing shall consist of a heavy gauge steel chassis with sheet metal casing. The minimum thickness shall be 1.2 mm. The whole unit shall be protected against corrosion and finished inside and outside with stoned primer and paint. The decorative front panel shall be of rigid plastic.

3. The unit shall be supplied completely packaged and ready for operation once connected to the suitable electrical supply

4. The fan shall be of the forward curved centrifugal type and be made of aluminum reinforced glass fiber, rigid plastic material, aluminum or steel.

5. The air filters shall be of nylon fiber, glass fiber material or as supplied by the manufacturer and approved by the Engineer.

6. The filter shall be easily removable for cleaning without removing the unit from the wall.

7. The fan motor shall have factory lubricated bearings sealed of the sealed for life type.

8. The fan motor windings and electrical components shall be impregnated or protected to avoid condensation problems.

9. The compressors shall be the hermetically sealed pattern complete with resilient mountings.
10. The condenser and evaporator coils shall be formed of copper primary tubes with aluminum or copper fins. If copper fins are used, they shall be electro-tinned after

manufacture. The fins shall be mechanically bonded to the tubes. Aluminum coils shall be guaranteed for five years.

11. The unit shall have control giving three running speeds and an off position.

12. The units shall incorporate a damper adjustable form the control panel to allow a percentage of fresh air to be included.

13. The units shall meet the specified duties for airflow and cooling capacity.

14. The units shall be installed according to the manufacturer's recommendations and installed on suitable galvanized supports where required.

15. The outlet grille shall be fully adjustable to enable the direction of airflow to be set to the desired direction.

16. The condensate drain shall be connected to the nearest floor gully or soak away.

17. The condensate pan shall be adequately treated against corrosion, insulated and pitched for positive drainage with the unit installed level.

18. The controls shall include the following:

    (a) High-low pressure switches

    (b) Oil pressure protection switch

    (c) Thermal overload cutout.

19. The air conditioners shall be quiet in operation. Sound level shall not exceed 55 dBA at low speed and 60 dBA at high speed when measured at 1 m distance in a room with normal furniture and occupancy.

20. The air conditioning unit shall be capable of handling the cooling loads when operating in ambient conditions of 46 °C.

21. The degree of cooling shall be adjustable from maximum to minimum.

2.2. Split Type Room Air-conditioners

1. The unit offered in the tender shall be by a reputed manufacturer who is represented locally and can provide an efficient maintenance and spare part service.

2. The casing shall consist of a heavy gauge steel chassis with sheet metal casing. The minimum thickness shall be 1.2 mm. The whole unit shall be protected against corrosion and finished inside and outside with stoned primer and paint.

3. The casing for the inside unit shall be the same as mentioned above or of rigid plastic as supplied by the manufacturer.

4. The fan shall be of the forward curved centrifugal type and be made of aluminum reinforced glass fiber or rigid plastic material.

5. The air filters shall be of nylon fiber glass or as supplied by the manufacturer and approved by the Engineer.

6. The filter shall be easily removable for cleaning.

7. The inside unit fan and condenser fan motors shall factory lubricated bearings of the sealed for life type.

8. The motor winding and electrical components shall be impregnated or protected to avoid problems with condensation.

9. The compressor in the outside unit shall be the hermetically sealed pattern complete with resilient mountings.

10. The condenser and evaporator coils shall be formed of copper primary tubes with aluminum or copper fins. If copper fins are used, they shall be electro-tinned after manufacture. The fins shall be mechanically bonded to the tubes. Aluminum coils shall be guaranteed for five years.

11. The unit shall have control giving three running speeds and an off position.

12. The outlet grille shall be fully adjustable to enable the direction of airflow to be set to the desired direction. Where the units are floor mounted the supply grilles shall be on the top of the unit.

13. The units shall be installed in accordance with the manufacturer s recommendations to unit location, refrigerant piping, power and condensate piping.

14. Error! No table of figures entries found.is provided for the removal of a complete unit.

15. The condensate pipe work shall be run to the nearest drain.

16. The units shall meet the specified duties for airflow and cooling capacities.

17. The controls shall include the following :

    (a) High-low pressure switches

    (b) Oil pressure protection switch.

    (c) Thermal overload cutout.

18. The units shall incorporate the following accessories:

    (a) suction-liquid heat exchanger

    (b) Inlet strainer

    (c) Electric crank case heater

    (d) Refrigerant filter dryer

    (e) Sight glass

    (f) Suction and discharge shut off valves

    (g) Changing, relief and purging valves

    (h) Gauge connections

    (i) Spring mounts for compressor.

19. The air conditioning unit shall be capable of handling the cooling loads when operating in ambient conditions of 50 °C at the medium speed.

20. The outdoor unit shall be designed to operate at outdoor ambient temperature of 50 °C.

21. The sound level shall not exceed 55 dBA at low speed and 60 dBA at high speed when measured at 1 m distance in a room with normal occupancy and furnishing.

22. The safety devices for the compressors shall be as per the manufacturer's recommendations.