



Petrochemical Industries
Design & Engineering Co.

PROJ. NO. : 1203

SABALAN METHANOL PROJECT

COVER SHEET



OWNER :

SABALAN PETROCHEMICAL
INDUSTRIES CO.

PROJ. NO. : 89/S-G/102

MATERIAL STANDARD SPECIFICATION FOR

HVAC Equipment

DOCUMENT NO : **1203-00-HV-MSS-781**

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**SABALAN PETROCHEMICAL
INDUSTRIES CO.**

PROJ. NO. : 89/S-G/102

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1. PURPOSE

This specification together with the referenced codes and standards define the minimum requirements for Heating, Ventilation and Air Conditioning Equipment and Installation for buildings of Sabalan Methanol Project, including:

- Main Control Building
- Main Substation
- Laboratory
- Administration
- Analyzer

2. STANDARDS AND CODES

IPS	IRANIAN PETROLEUM STANDARD
IPS-C-AR-110-2003	Construction Standard For Installation, Testing, Adjusting And Commissioning Of HVAC Systems
IPS-M-AR-125-2003	Material And Equipment Standard For Packaged Air Conditioners
IPS-M-AR-130-2000	Material And Equipment Standard For Humidification And Dehumidification Unit And System
IPS-M-AR-205-2001	Material And Equipment Standard For Fans, Filters And Air Distribution Units And Systems
IPS-M-AR-225-2006	Material And Equipment Standard For General HVAC Equipment
IPS-M-AR-235-2002	Material Standard For Insulation Of HVAC Field
ASHRAE	AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS
ASHRAE-2005	ASHRAE Handbook Fundamentals
ASHRAE-2007	ASHRAE Handbook HVAC Applications
ASHRAE-2008	ASHRAE Handbook HVAC Systems and Equipment
ASHRAE-2006	ASHRAE Handbook Refrigeration Systems and Applications
15-2004	Safety Standard for Refrigeration Systems
52.1-1992	Gravimetric and Dust Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
52.2-1999	Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
16-1983	Method of Testing for Rating Room Air Conditioners and Package Terminal Air Conditioners
116-1983.1	Method of Testing for Seasonal Efficiency of Unitary Air Conditioning and Heat Pump Equipment
ARI	AIR-CONDITIONING AND REFRIGERATION INSTITUTE
310	Packaged Terminal Air Conditioners
210	Unitary Air Conditioning Equipment
270	Sound Rating of Outdoor Unitary Equipment
275	Application of Sound Rated Outdoor Unitary Equipment
360	Commercial and Industrial Unitary Air Conditioning Equipment
340	Standard for Commercial and Industrial Unitary Air Conditioning Equipment
NFPA	NATIONAL FIRE PROTECTION ASSOCIATION
90A-2002	Standard for the Installation of Air-Conditioning and Ventilating Systems
101-2006	Life Safety Code
110-2005	Standard for Emergency and Standby Power Systems
5000-2006	Building Construction and Safety Code
API	AMERICAN PETROLEUM INSTITUTION
API RP 505	Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2

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ANSI	AMERICAN NATIONAL STANDARD INSTITUTE
ASME	AMERICAN SOCIETY OF MECHANICAL ENGINEERS
ASTM	AMERICAN SOCIETY OF TESTING AND MATERIALS
UBC	UNIFORM BUILDING CODE
INBC	IRANIAN NATIONAL BUILDING CODE

3. PACKAGE AIR HANDLING UNITS

Package Air Handling Units shall include:

- Air inlet
- Mixing box
- Filter section
- Cooling coil
- Humidifier (if any)
- Heating coil
- Supply Fan
- Compressor Section

Package unit shall be an outdoor, or roof mounted cooling unit utilising reciprocating semi-hermetic (or hermetic) compressor and electric heaters (heating coils). The unit shall be a direct expansion air conditioning system including the air handling section, which removes sensible and latent heat from air passing through the evaporator coil.

It shall be air-cooled type, factory assembled and tested, shipped with full operating refrigerant, equipped with lifting eyes and footpads for ease of transportation and installation. The control and safety devices shall be factory set, as factory wiring and piping.

Package unit's frame shall be constructed from hot dipped galvanized steel penta-post profiles with at least 4 mm thickness. The posts shall be of closed construction insulated with rock wool of density 100 Kg/m³ to help prevent condensation forming on the outside surface. The frame shall be jointed using stainless steel bolted flange arrangement to other sections & completed with waterproof mastic sealant, which shall be applied to all internal joints. The entire internal component shall be supported by cross bars connected to the frames. Frames shall be isolated from the casing by rubber vibration absorber. The framework design inside the panel shall create smooth internal surfaces without bolts and fixings.

The unit enclosure shall be constructed of sandwich panels, 50 mm thick minimum, constructed with two 1.5 mm minimum thickness heavy gauge galvanised steel sheets with expanded fire-proof polyurethane insulation hot injected, 40 kg/m³ density minimum (for compressor section no insulation is required) and a thermal conductivity not greater than 0.03W/mK, and shall be suitably sealed to prevent leakage of moisture and air into or out of the unit. Resilient sealing material shall be used around all access panels and openings to ensure airtight sealing. The panels shall be completely weatherised for outdoor installation and properly reinforced and brazed. Steel sheet panels shall be zinc-coated and galvanised by the hot-dip process, followed by baked-on electrostatic polyester dry powder coat.

The floor of each section shall be designed to carry maintenance personal with minimum deflection and shall be capable of supporting a minimum loading of 1.5 kN/m². The design of

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the floor shall not allow air bypass around filter or coil sections. The floor shall be constructed from galvanized steel. The drain pan shall be provided under cooling coil and supply fan. The drain pan shall be made of stainless steel grade 316L.

Compartments needing personnel access points for routine maintenance, the access door shall be provided with handles and lift-off type hinges. Locking shall be foreseen for each panel access door.

The Unit shall be completely weatherised for outdoor installation to suit corrosive & coastal environment and properly reinforced and brazed. Steel sheet panels shall be zinc-coated and galvanised by the hot-dip process, followed by baked-on electrostatic polyester dry powder coat. External and internal painting Specification shall be as follow:

- Primary epoxy coating thickness 70 micron
- Intermediate epoxy coating thickness 100 micron
- Final epoxy coating thickness 70 micron
- Total thickness (External) 240 micron
- Internal coating thickness shall be min. 100 micron

Refrigerant shall be a non-CFC/non-HCFC type such as R134-a for central HVAC units and R-134a/R-407c for split room air conditioner units. For small split room air conditioner units which cooling capacity is lower than 10 kW, Refrigerant R-22 may be agreed.

Indoor blower compartment interior surfaces shall be insulated with a minimum 15 mm thick flexible fibre-glass insulation coated in the air side, to prevent condensation from forming in the unit casing. Insulation shall meet the requirements of NFPA 90A and shall be protected against deterioration and erosion from air currents. Cabinet panels shall be easily removable for servicing.

The coil frame shall be made of stainless steel 316L and assembled by bolting or riveting. Corrugated plate fins should be used for additional turbulence and increase in heat transfer. It is recommended that on the inner surface of the copper tubes, micro fins with a spacing of 60 fins/in. All circuits shall have an even number of tubes to ensure that liquid and suction connections are on the same side. Coil shall be sized on a maximum air velocity through the face area of 2.5 meter per second. If more than 6 rows are required, the coil shall be split in two elements and a space of approximately 30 mm shall be reserved between coils. Fins spacing shall be less than 12 fins/inch. Differential manometer shall be provided for direct expansion (DX) coils. Exchange surface of cooling coil shall be up 10% on calculated value.

The evaporator shall be equipped with a freeze stat safety to prevent freezing of the coil. To prevent freeze up on evaporator a suitable defrost package shall be provided (where applicable).

The coils shall have tinned copper-fins mechanically bonded to seamless copper tubes and coated with Blygold or Heresite. The expected coils treatment shall be previously submitted for approval. Cooling coils sized at maximum 2.5-3 m/s through the face area.

Direct expansion (DX) cooling coil shall be designed and tested in accordance with ASHRAE 33 and ARI 410. On satisfactory completion of all works tests, coils shall be dehydrated, charged with a dry inert gas and sealed. The DX coil shall be tested at min 450 psig. Coils shall be burst tested and proof tested to 450 psig. After testing, insides of coils are to be dried, all connections are to be sealed, and DX coils shall be factory dehydrated and sealed prior to shipment. The total resistance to air flow through the wet coil and eliminator sections shall not exceed 250 Pa (1 inch WG) under wet coil conditions.

A drain tray shall be provided under DX cooling coil, supply and return lines, and control valves where condensation may occur. The tray shall be of sufficient size to catch all condensation

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from any part of the unit. Condensate pan shall be of stainless steel 316L and it shall be watertight. The pan shall be equipped with drain connection.

A removable standard flat cells eliminator or high velocity deflector type eliminator will be installed downstream side of coil. This droplet eliminator shall be made of PVC type and dismountable laterally. Efficiency: 100% at 4 m/s. Minimum distance between coil and eliminator shall be 300 mm.

Filters shall be accessible through an access panel. Hinged access doors and openings shall use stainless steel hinges. Housing panels, removable for maintenance access, must be rigid enough to prevent warping when removed and must use captive stainless steel fasteners or catches which provide a tight seal on closing. Holes shall be provided for rigging.

The fan section shall house a centrifugal fan, galvanised steel impeller wheel, with airfoil or backward curved blades, statically and dynamically balanced, self-aligning shaft with radial ball bearing, V-belt transmission with cast iron pulley, electric motor, common base for motor and fan; vibration elimination device shall be applied as requested by statical and dynamical loads.

The maximum air velocity through filter shall not exceed 2 m/s and maximum pressure drop across filter shall be as follows:

Pressure drop clean filter max 100 Pa

Pressure drop dirty filter max 250 Pa

Filter section shall have local pressure drop (type MAGNEHELIC).

Bulkhead light for filter, cooling coil and fan sections with an externally mounted operating switch and 200 mm diameter double wall viewing port for fan and filter sections to be considered.

Electric heater, of the multi-step type, shall be open type construction furnished with internal wiring, suitable for 150°C operation and designed for horizontal airflow. The heating element (80% nickel, 20% chromium) shall be centred in a heavy gauge spiral finned galvanised tube. The electric heating coil shall be designed for 10% over capacity.

Units with more than 4 kW capacities shall be pre-wired for gradual control (commercially known as "thyristor") and three phase 400V-50Hz. For capacities of less than 4 kW, a single phase 230V-50Hz power supply shall be used with a step controller or a 3-stage thermostat shall be used frequency Tolerances. All components shall be rated for voltage and frequency tolerances of +5%. The resistance to the airflow through the coil shall not exceed 25 ~ 60 Pa. The face velocity shall not exceed 6 m/s nor be less than 2 m/s. The surface temperature of the heating element shall not exceed 90°C in all configurations. The heating elements shall be rated for a maximum surface temperature of 150°C.

The Contractor shall ensure the terminations have been completed and tested at his works and the enclosures are securely fixed to heating coil casing. These tests shall include the following:

- Insulation resistance tests shall be conducted prior to and after executing high voltage tests. Insulation resistance shall be measured by applying a D.C. test voltage from a 'Megger' insulation meter or equal.
- High voltage testing shall be carried out by applying an A.C. power frequency voltage in accordance with the relevant International Standards.

The tube shall be filled with granular magnesium oxide insulation. Heater frame and control box shall be fabricated from heavy gauge galvanised steel with 30 mm flanges with predrilled holes designed for mounting between flanged sections of ductwork. Heater shall have over temperature protection by safety thermostat and airflow failure protection by pressure differential switch.

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Reciprocating semi-hermetic or hermetic compressors shall have factory-installed external spring or rubber vibration isolation or equivalent, for quiet and efficient operation. The factory-installed crankcase heater shall prevent refrigerant dilution of oil. The semi-hermetic compressors shall have unloading capability. Compressors are equipped with motor protection. Refrigerant lines to and from compressors shall include suitable flexible vibration isolation elements. Refrigerant circuit components shall include filters dryers and fixed expansion devices; service gauge connection on suction, discharge and liquid lines. Compressor motor shall be protected against overload, breakdown and short cycling. Compressors motor design to run on 400 Volt, 3 Phase, and 50 Cycle electricity shall be used. The protection class of compressor motor shall be at least IP54.

The oil pump of three-phase semi-hermetic compressors shall either operate equally well under each direction of rotation or have special arrangements made to prevent reverse rotation.

The following safeties shall be provided:

- Compressor over temperature, over current;
- Low pressure switch;
- High pressure switch.

Wiring and controls as necessary to get safe and automatic start-up, operation and shutdown of the refrigerant system at any cooling capacity from 20 to 100 of the rated capacity.

Electrical equipment of units shall be according to IEC codes and have IP54 class F built in thermal protection PTC as minimum. For motor requirements refer to electrical specification attached.

All parts of refrigerant gas cooled motors shall be proof against long-term contact with refrigerants and compressor lubricating oil. The motor of a compressor which is refrigerant gas cooled shall have in-built protection against inadequate cooling with an oil temperature sensor.

Air filters shall meet the efficiencies as specified in HVAC Design Criteria (HR-000-HV-SP-0005). Each filter shall consist of a fiberglass media, rot-proof, non-combustible and shall not generate smoke; a media support grid and stainless steel 316L frame with reinforced corners. Fasteners shall be of the type to be installed without the use of tools nuts or bolts. Filter Panels shall be mounted on stainless steel 316L guide rails and be easy removable.

Filters shall have gaskets to prevent the bypass of unfiltered air.

The Contractor shall ensure that front withdrawal filters, have direction of air flow pushing filter media against the frame. Having air flow pushing media away from the frame will not be acceptable.

The pleated panel filter shall have an initial clean static pressure loss not exceeding 75 Pa and a design final contaminated filter static pressure loss not exceeding 150 Pa at a face velocity of 2.5 m/s.

The bag filter shall have an initial clean state static pressure loss not exceeding 100 Pa at a face velocity of 2.5 m/s and a design final contaminated filter static pressure loss not exceeding 250 Pa.

Final Filter/ Efficiency: Final filter shall be comprised of pleated panel filter and bag filter. Filtration efficiency shall be for first filter (pleated panel filter) 25%-30% dust spot efficiency (EU 4) & for second filter (bag filter) 90-95% dust spot efficiency (EU 8) in accordance with ASHRAE 52.1.

Pre Filters/ Efficiency: Pre filters shall be heavy duty, double stage configuration and washable type. Aluminum washable type filter are installed inside mixing-box in Flat, V or W type arrangement efficiency of 80-85% arrestance.

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4. AIR-COOLED CONDENSER

Each Air Cooled Condenser unit shall comprise of but not limited to the following components assembled and mounted on frame:

(Based on relevant data sheet)

- Casing
- Condenser Coil coated with anti corrosion material
- Fan(s)
- Electric Motor(s)
- Mechanical Control Tools
- High & low pressure control, for suction and discharge pressure control of compressor
- Oil pressure control, for differential control of oil pressure with suction pressure of compressor
- Solenoid valve, for refrigeration flow control
- Safety valve and manual valve, charging valve
- Sight glass for observation the amount of gas and its humidity removing of refrigerant
- Filter drier
- Suction and discharge oil pressure indicators, containing glycerin, panel type electrical
- Oil separator
- Muffler
- Electrical Control Tools
- Contactors
- Timers
- Relay for compressors replacement
- One position switch and electrical heater switch
- Phase control, for Electricity flow break off in case that the flow is two-phase,
- Crankcase heater for heating the cartel case of compressor
- Electrical panel of safety protection degree IP 55
- Main switch
- Earth connection
- Self fault detector
- Elastic vibration absorber for preventing from vibrations
- Body made of high quality, galvanized sheet
- Body coated with a layer of polyurethane color resistance in front of moisture, with suitable thickness for preventing from corrosion and decay

Air-cooled condenser shall be factory assembled and tested shipped with full operating refrigerant. The control and safety devices shall be factory set, as factory wiring and piping contained in the unit enclosure. All electrical components shall be protected from the weather.

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The Unit shall be completely weatherised for outdoor installation to suit corrosive & coastal environment and properly reinforced and brazed. Casings should be constructed of heavy gauge galvanized steel sheet panels conforming to ASTM A653, zinc-coated and galvanised by the hot-dip process, followed by baked-on electrostatic polyester dry powder coat, equipped with lifting eyes and footpads for ease of transportation and installation.

The painting of casing shall take into account the environment atmosphere conditions and direct sun exposure of 87°C, and solar radiation of 750 W/m² with maximum relative humidity of 100%. Panels shall be paint finish internally and externally with anti corrosion material. Paint Specification shall be as follow:

- Primary epoxy coating thickness 70 micron
- Intermediate epoxy coating thickness 100 micron
- Final epoxy coating thickness 70 micron
- Total thickness (External) 240 micron
- Internal coating thickness shall be min. 100 micron

Refrigerant circuits shall be complete with filter drier with by-pass line having three valves for easy replacement of the filter, combined moisture indicator and sight glass, liquid line service valves, high and low pressure switches.

The condenser coil shall be multi-row copper tubes with copper fins. Copper and shall be complying with ASTM B75. Fins shall be mechanically bonded to tubes. Fins shall be continuous, corrugated, with corrugated edges. Suction headers and distributor shall be seamless copper tubes. Seamless copper tubes shall be oxygen free. Corrugated plate fins should be used for additional turbulence and increase in heat transfer. It is recommended that on the inner surface of the copper tubes, micro fins with a spacing of 60 fins/in. All circuits shall have a suitable number of tubes to ensure that liquid and suction connections are on the same side.

Allowable pressure drops shall be in accordance with ARI 410. Coil shall be sized on a maximum air velocity through the face area of 4.5 meter per second. Fins spacing shall be less than (10 fins/inch). Exchange surface of cooling coil shall be up 10% on calculated value.

The condenser coils shall have tinned copper-fins mechanically bonded to seamless copper tubes and coated with Blygold or Heresite. The maximum total dry film thickness (DFT) of the coating shall be approximately 1 mil. The coating shall show no sign of attack after 3,000 hours of salt spray test to ASTM B117 and B287. The coating shall be inherently resistant to ultra-violet radiation. The expected coils treatment shall be previously submitted for approval.

The condenser coil shall be designed and tested in accordance with ASHRAE 33 and ARI 410. On satisfactory completion of all works tests, coils shall be dehydrated, charged with a dry inert gas and sealed. The condenser coil shall be tested at min 450 psig. Coils shall be burst tested and proof tested to 450 psig.

After testing, insides of coils are to be dried, all connections are to be sealed, and condenser coil shall be factory dehydrated and sealed prior to shipment.

The condenser shall be provided with ultra-low noise axial fans, direct driven with motors protected by built-in magnetic-thermal circuit breakers. Air discharge shall be upwards and fans shall be complete with safety guards. Condenser fans shall be the low profile, slow speed, direct-drive, propeller-fan type for vertical discharge and individually statically and dynamically balanced at the factory. Complete fan assembly is provided with suitable acrylic coated fan guard made from heavy gauge galvanized wire. Large diameter fans having low tip speeds shall be used to achieve minimum sound levels. Low ambient control, fan speed control or fan cycling control shall be provided where applicable.

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The motor shall be suitable for vertical operation. All direct drive motors have sealed permanently lubricated ball bearings. (Each condenser fan shall have separate motor with constant speed).

Air-cooled condenser shall be capable of operating satisfactorily at the specified design conditions. The units shall have protections against abnormal operating conditions, compressor faults, high or low refrigerant pressure, low suction temperature, insufficient water flow, evaporator freeze-up, pump-down when the circuits shut down.

Each unit shall be capable of running continuously at the lowest step of cooling capacity without any adverse effect. The air cooled Condensing Unit shall be charged with lubricant and be provided with a holding charge of refrigerant or inert gas before dispatch from the Supplier's works where a full charge is impractical.

Winter pressure control, to keep a correct pressure on the thermostatic expansion valve when the temperature drops in the winter season.

Temperature Controller, to regulate automatically the internal temperature of the cold storage room.

5. FANS

Centrifugal Fans

Each centrifugal fan shall be SWSI or DWDI as required, furnished completely assembled and fitted with electric motor, V-belt drive, belt guard, inlet guard, flexible connections and vibration isolating base. The Centrifugal Fans shall be suitable for continuous operation at the design duty selected, with an efficiency of at least 75%. Fans shall be sized regarding to the performance requirements specified and shall be rated and certified in accordance with B.S. 848 Part 1; 1980. The vendor shall guarantee the fans performance will not be impaired when housed within the fan chamber of the air handling unit. Fan section shall be additionally reinforced with cross bars.

Base frame: The entire base frame and housing shall be constructed from continuously welded mild steel plate with a minimum thickness of 2mm; the casing shall be hot dipped galvanized after manufacture.

Fan housing: the fan housing shall be provided with an access hatch and drain plug located at the bottom of the casing. The fan wheel shall be fabricated from heavy gauge steel as a single all welded assembly.

Fan shaft: The fan shaft shall be stainless steel grade 316L. The fan shaft shall be accurately turned ground polished and ring gauged for accuracy

Blades: Blades shall be of the non-overloading double thickness with non-overloading power characteristic. The blades shall be staggered on each side of the center plate. The wheel shall be keyed to the stainless steel shaft and the key secured with setscrew.

Bearing: Bearing shall be self aligning grease lubricated double roll ball enclosed within two piece housing and supported on a pedestal either side of the fan via a tubular arm assembly. Bearing shall have a minimum design life of 100,000 hours.

The fan bearings shall be split pillow block; grease lubricated spherical roller bearing type.

Pulley: The fan pulleys shall be keyed and taper locked to the drive shaft.

Belts: Belts shall be of the anti static, fire resistant type and a guard shall be provided over the belts containing a small aperture for checking the belt tension. Fans shall be driven by a multi-belt drive with not less than 2 belts on the drive, with No. of belts=N+1. (N=No. Of belts required). Belt tensioning and motor alignment facilities shall be provided.

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Provision shall be provided for fan and motor speed checks via 50mm access holes, also a slot shall be provided so that belt tension checks can be made without the removal of fan belt drive guard. The fan motor shall be provided with an adjustable slide to accommodate belt adjustment.

Fans shall be selected to give a margin for adjustment of +10% performances without reaching critical shaft or impeller speeds. Fan motor shall be selected for maximum power plus 20% spare capacity.

Fan motor speed shall be selected in order not to exceed the required maximum noise criteria. Fan speed shall not exceed 1500 rpm. The motor shall operate at optimum rpm suitable for 400 volts, 3 phases and 50-cycle operation. Fan discharge velocity shall not exceed 10 m/s.

A flexible connection shall be provided between the fan outlet and the unit casing. The flexible connections shall be flame and oil resistant, suitable for temperature and pressure one and a half times maximum working conditions.

Axial Fans

Axial fans shall have casing and motor mounting arms manufactured in heavy gauge hot-dipped galvanized steel. Fans shall have non-overloading impeller blades, hubs and clamp plates in precision die cast aluminum, X-rayed prior to machining to assure quality of cast. Fans shall be statically and dynamically balanced.

For motor requirements refer also to CLAUSE 11, 13

Roof Type Fans

Roof exhaust fans shall be of the high efficiency, centrifugal or mixed flow (axial-centrifugal) type, direct-driven or belt-driven. The impeller shall be statically and dynamically balanced. The weather cap and base shall be in molded ultra-violet stabilized polyester resin, glass reinforced, rendered fire retardant, or in alternative shall be of aluminum construction with factory applied epoxy coating. Fans shall be provided with factory-assembled back draft dampers.

Cases shall be formed to facilitate a weatherproof fitting to the building structure. Adequate access to electrical supply terminals and lubrication points shall be provided by means of hinged cowls or other means as appropriate. Bird wire guards shall be provided as an integral part of the unit. Unless otherwise stated, selection of fans to be such that the operating point on the performance curves allows a minimum of 15% increases in duty. The motor is to be sized accordingly.

For motor requirements refer also to CLAUSE 11, 13

Propeller Fans

Propeller fans shall have impellers either one-piece polypropylene with airfoil blade section with built-in ultra-violet protection, or aluminum bonded steel or hot-dip galvanized steel. Mounting plates manufactured from mild steel with powder coat and arms/tie rods steel with polyester coat paint. Guards shall be from mild steel coated in plastic. Fans shall be provided with factory-assembled aluminum back draft dampers.

For motor requirements refer also to CLAUSE 11, 13

Bleed Fans

Bleed fans shall be properly sized for each assembly. Fans shall bear the AMCA certified rating seal. Fans that are not standard items shall be tested in accordance with AMCA Publication 210. The fan type shall be capable of developing required static pressures and continuously handling heavy dust and sand concentrations. Fans shall be direct-driven or belt-driven; for belt-driven fans, belt guards shall be constructed of 1.2 mm expanded galvanised sheet metal

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sides with 1.6 mm casing. All propeller-type fans shall be recessed below top of unit and are made of aluminum alloy sheet metal, directly driven by the electric motor.

For motor requirements refer also to CLAUSE 11, 13

6. FILTER UNIT

Filter unit shall be factory assembled and tested, encased in housings made of sandwich panels, 25 mm thick minimum, constructed with two heavy gauge galvanised steel sheets with expanded fire-proof polyurethane insulation hot injected, 40 kg/m³ density minimum. Casings shall be suitable for indoor or outdoor location, as applicable. The control and safety devices shall be factory set, as factory wiring contained in the unit enclosure. All electrical components shall be protected from the weather.

Filter units consist of sand trap louvers, pre-filters and final filters. Pre-filters and final filters shall meet the air filtration efficiencies as specified in HVAC Design Criteria (HR-000-HV-SP-0005). Filtering media shall be of self-extinguishing type, suitable for tropical climate. Approach air velocity through the filter face section shall not exceed 2.5 m/s.

The filter media area shall be much greater than the face area, with media velocity range from 0.03 to 0.40 m/s. The filters shall be capable to avoid blowing off agglomerates of collected dust. Filter section shall have local pressure drop (type MAGNEHELIC).

Filters must use captive fasteners or latches which provide a tight seal on closing and shall be accessible and removable for maintenance through hinged access panels.

The housing shall be fabricated of heavy gauge mild steel with all welded construction. The bleed air manifold shall be constructed of corrosion-resistant, high-strength, low-alloy, steel. The unit shall be self-cleaning type for minimum maintenance.

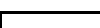
7. HUMIDIFIERS

One no. Humidifier common for both PAHU to be provided. Humidifiers to be installed in ducts shall steam humidifiers electronic type and shall be a manufactured package consisting of a steel cabinet which houses disposable steam cylinders, fill and drain solenoid valves, electrical compartment and controls. In addition to the components housed in the cabinet, steam distributors, steam supply and condensate hoses shall also be furnished.

The steam generating cylinder shall be a disposable plastic unit complete with grid type electrodes, sensing probes, quick change fittings for steam, electrical and fill-drain connections. The cylinder shall be designed to collect residual solids left by the evaporated water. The cylinder shall not require periodical servicing, and shall only require replacement when it is filled with residual solids, and can no longer produce the specified steam quantities. The electrodes shall heat the water to evaporation temperature. Sensing probes shall sense a high water level and actuate a safety control circuit.

The fill and drain assemblies shall consist of solenoid valves, one for fill and one for drain; fill cup with air gap between the fill pipe and cup. There shall be only one connection to the steam cylinder. The solenoid valves and piping components shall be constructed of high impact temperature resistant plastic. The fill solenoid valve shall have a built-in strainer, pressure and flow regulating orifice.

The humidifier cabinet shall be constructed of sheet steel with enamel finishing. Cabinet shall have hinged and locked access door on the electrical section and separate removable and lockable access door on the cylinder compartment. The cabinet shall contain the steam cylinder, fill and drain assembly and the electrical/control section. The electrical section shall contain the contactors, thermal overloads, control transformer and solid state control system.

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If any steam humidifying units are specified to have more than one steam generating cylinder, the cabinet shall contain separate fill and drain assemblies and electrical/control compartments for each cylinder.

The steam distributors shall be supplied by the humidifier manufacturer. The distributor shall consist of a steam discharge manifold, a condensate separator and a return leg to remove the condensate from the manifold. The steam distributors shall be supplied complete of steam supply hoses and shall be covered with a braided reinforced jacketing.

8. ELECTRIC DUCT HEATERS

Duct mounted electric heaters shall be the resistance open coil type construction furnished with internal wiring, suitable for 150°C operation and designed for horizontal and vertical airflow.

The heating element (80% nickel, 20% chromium) shall be centred in a heavy gauge spiral finned galvanised tube. The tube shall be filled with granular magnesium oxide insulation.

Heater frame and control box shall be fabricated from heavy gauge galvanised steel with flanges with pre-drilled holes designed for mounting between flanged sections of the ducts.

Heating output control shall be of the multi-step type. The heater shall have over temperature protection (safety thermostat) and airflow failure protection (by differential pressure switch), and be fabricated according to IEC standards, IP55 minimum protection.

The power of electric duct heaters shall be supplied by 4-wire system (3 phases with neutral).

Heaters shall be controlled by in the following steps ON-OFF action responding the room thermostats.

Heating capacity (Kw)	Number of control steps
Up to 5	1
6 to 10	2
Over 11	3

The controls shall include the following safety devices, at least;

- High temperature cutouts
- Air flow switches

All safety devices shall be serviceable through terminal box without removing the heaters from ducts.

The terminal boxes shall include disconnect switches, fuses, safety contactors, transformers for control voltages, pilot lights to indicate power on, terminal blocks for power supply and remote thermostats, and grounding lugs.

Earthing and bonding facilities shall be provided to minimize hazards to personnel and equipment from short circuits, lightning discharges, and static charges and shall be designed to limit or contain the adverse effects of electromagnetic interference on control systems.

The duct mounted electrical heating coils' temperature sensor which will be installed in battery rooms shall be explosion proof type EExed IIC T4.

9. NOISE AND VIBRATION CONTROL

The Maximum allowable sound pressure level, ref. 20 μ Pa at any location 1 meter from equipment surface should be 65 (dB). The related data sheet will be given on requisition.

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Sound Attenuation

Sound attenuators shall be of the factory fabricated type, constructed of galvanised steel sheet. The outer casing shall be not less than 0.8 mm thickness. Control plates on surface of splitters shall be made from galvanized steel sheet. Absorption material shall be fibrous glass, moisture repellent and abrasion-proof up to at least 20 m/s velocity. Sound absorbing material shall meet the fire hazard rating required for the duct insulation material. Perforated steel sheet shall be applied to avoid undesirable diffusion of fibrous glass material.

The net noise reduction values shall be selected in order that the radiating sound shall result within the sound level requirements. The sound attenuators shall be acoustically tested with metal duct inlet and outlet sections while under the rated airflow conditions. The noise reduction data shall include the effects of planking paths and vibration transmission.

The attenuators shall be constructed to be airtight when operating at the static pressure of the duct system but in no case less than 500 Pa. Attenuators shall be insulated to prevent sweating.

Duct internal acoustic lining shall not be used for hygienic reasons.

Vibration Control

All equipment shall be isolated from vibrations according to specific characteristics of the single components such as compressors, pumps, fans. Vibration control devices shall be as recommended in ASHRAE Handbook HVAC Systems and Equipment.

Equipment including compressors such as chillers and packaged air conditioning units shall be mounted on spring isolators, with rubber acoustical barrier to prevent transmission of very high frequency vibrations and noise. Isolators shall be corrosion protected if installed outdoors or in corrosive environment. For refrigerating machines with large weight variations restrained spring isolators shall be used to restrict movement and prevent strain on piping when water is removed.

Fans shall be mounted on vibration isolators. Air handling units and centrifugal fans boxes for pressurisation shall be mounted on rubber pads or mounts according to load capacities and expected deflections.

In piping lines flexible pipe connectors shall be used. They shall be of the rubber or metal hose type, or of the expansion joint (in rubber or Teflon) type, according to pipelines and equipment such as pumps necessities. All flexible connectors shall have an end restraint to counteract the pressure thrust.

10. PRESSURE GAUGES AND THERMOMETERS

Pressure gauges shall be Bourdon type, stainless steel construction, complete with pulsation dampener and shut-off cock. The manometer maximum measuring range shall have a value between 1.25 and 2 times the maximum working pressure.

Thermometers shall be of the bimetallic type, stainless steel case with a 100 mm diameter dial. The thermometer maximum measuring range shall have a value between 1.1 and 1.5 times the maximum working temperature.

11. ELECTRICAL MOTORS

For motor requirements refer to relevant Electrical Specification and motor data sheets.

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12. HVAC ELECTRICAL PANELS

HVAC panels shall be MCC type, IP55 protection degree minimum, designed for 50 kA R.M.S. short circuit current; main busses shall be 600 or 800 A and insulated with flame retardant non hydroscopic insulation. HVAC panel shall be floor mounted and shall suit the requirements of the hazardous areas. Panels shall comprise single dedicated sections for power distribution and automatic control of the HVAC equipment.

13. ELECTRICAL INSTALLATION

Electrical installation shall generally conform to IEC requirements. The installation shall also conform to the hazardous areas, HVAC design and selection of materials and equipment shall suit such classification.

14. IDENTIFICATION OF HVAC SYSTEMS

All HVAC equipment shall be identified with laminated plastic engraved tags.

15. PAINTING

Priming and painting of equipment, steelwork, and pipe work shall conform the requirements of Painting Specifications.

16. GENERAL

Standardization of Materials and Equipment

Where two or more items of the same kind or category of equipment or devices are required, these items shall be products supplied by the same manufacturer and shall also be interchangeable when they are of the same size, capacity, performance, specifications and standard. Materials and equipment shall be catalogued products of reputable manufacturers regularly engaged in production of such materials or equipment and shall be manufactured of latest design and must have been in satisfactory commercial industrial use.

No substitution of submitted materials and equipment.

No substitution of manufacturer and models of submitted materials and equipment that have been reviewed and accepted by the Client shall be implemented in supplying the items. Use of different type of items, shall be submitted to the Client for review and approval.